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US ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

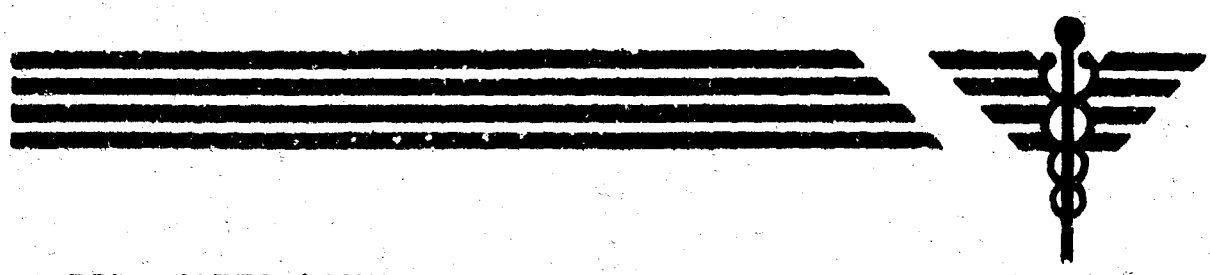
REPORT NO. 635

BASE LINE ENVIRONMENTAL RADIATION LEVELS--INCLUDING MORATORIUM AND POST-MORATORIUM VALUES--ON THE FORT KNOX RESERVATION

by

W. H. Parr, Ph. D.
Captain G. M. Lodde, MSC
and
D. W. McPeak, B. S.

27 September 1965



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ABSTRACT

BASE LINE ENVIRONMENTAL RADIATION LEVELS--INCLUDING MORATORIUM AND POST-MORATORIUM VALUES--ON THE FORT KNOX RESERVATION

OBJECT

An environmental radioactivity study was conducted for the first time on the Fort Knox Reservation for the purpose of establishing base line radiation levels. Comparisons of radiation levels during and after the nuclear moratorium (Jan 1960 - Jan 1963) are reported.

RESULTS

Air samples were collected in the laboratory area during the normal work week, whereas water, silt, and soil samples were routinely collected at monthly intervals from strategic locations. Descriptions of sampling procedures and radioactivity measuring techniques are included.

Activity measurements on the Reservation show that radiation levels are influenced by world-wide nuclear detonations. Low and relatively steady levels are correlated with the moratorium, while fluctuating but increasing values accompanied the resumption of the nuclear testing programs.

CONCLUSION

The results indicate that sampling of only two areas is sufficient for routine surveillance of radiation levels on the Reservation, thus simplifying the procedure for maintaining a monitoring operation.

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INTRODUCTION

With the rapidly expanding use of nuclear energy resources for both military and industrial purposes and with the uncertainties accompanying the release of radioactive material (accidental or otherwise), radioactive contamination in the biosphere has become a problem of increasing concern (1). To ascertain the magnitude and significance of changes in environmental radiation levels, world-wide surveillance network systems have been organized. This type of system generally involves widely separated sampling stations and is of limited value in a location removed from a sampling site.

Determination of radioactive contamination in the environment is usually approached through two routes (2). The first is concerned with measurements of gross radioactivity in specific media. This measurement indicates trends and changes taking place in the total radiation picture. The second approach includes identification of specific radionuclides along with quantitative measurements and consequently is of value in assessing potential radiation exposures. Such an approach is essential before nuclear facilities are placed in operation.

The environmental sampling program at USAMRL was designed to establish radioactivity levels on the Fort Knox Military Reservation (110,607 acres) which is located approximately 25 nautical miles southwest of Louisville, Kentucky. Data collected and documented are to serve as a basis for determining the trend and extent of any future changes in radiation levels.

Work associated with the sampling program was initiated in October 1959 and terminated in January 1963. All sampling sites were centered around a body of water (static or dynamic). Whenever possible, the collection routine consisted of taking (1) a water sample, (2) material from the bottom of the pond, lake or stream (bottom sediment), and (3) soil from the immediate vicinity. Initially, samples were collected from 10 different locations on the Reservation (Fig. 1), but since accessibility to the gunnery range was inconsistent, only eight locations were sampled after December 1961. Collections were made on the first Wednesday of every month with the use of a helicopter

(H-13) provided by the Aviation Command. On occasions, the scheduled routine was interrupted by flooded terrain, weather conditions, inaccessibility of sampling site, and non-availability of air transportation. Quantitative air sampling was restricted primarily to the laboratory area.

METHODS

All samples collected were assayed for radioactivity with Nuclear Measurements Corporation proportional gas-flow counters. Model PCC-11A was used for counting soil, water and silt samples, and Model PCC-12A was used for counting air samples. Since the counting chamber of the PCC-12A Model was unshielded, a wooden box with lead wall coverings 6 mm thick was designed to house the instrument; this lowered background counts by approximately 30 per cent. The counting gas consisted of a mixture of 10 per cent methane - 90 per cent argon. All radioactivity measurements were made with stainless steel counting planchets.

Instruments were calibrated for over-all counting efficiency by measuring count rates of predetermined quantities of radioactive material mixed thoroughly in different thicknesses of calcium carbonate media. Thallium^{204} was used as the calibrating standard simulating fission products found in soil, bottom silt and water (3). Strontium^{90} Yttrium^{90} preparations deposited on round plastic discs 4 inches in diameter and 1/8 inch thick, were used as calibrating standards in counting air samples (4). All samples collected were held for 7 days before counting to allow for the decay of short-lived radionuclides. Net count rates were determined and converted to picocuries per liter or gram at the 95 per cent confidence level after corrections had been made for counter efficiency (5).

Air: Sampling of airborne particulate radioactivity was accomplished by two different methods. In the earlier part of the study (1959, 1960, and 1961) a scoop was attached to the landing gear of the helicopter and flown for two-hour periods at an altitude of about 1700 feet above sea level at a speed of approximately 60 knots. The flight pattern covered all ground-level sampling sites (Fig. 1). The scoop included 8x10-inch Army Chemical Corps type filter paper, the measured collection efficiency of which was essentially 100 per cent for particles 0.3 microns and larger (6).

To improve the effectiveness of the air sampling program, the procedure after March 1961 utilized a Staplex high volume air sampler

with TFA #810 filter papers. Collections were made 3 feet above ground level upwind in the open field behind the Biophysics Laboratory, Building T-1017. Air flow through the calibrated orifice of the sampler usually ranged from 45 - 55 cubic feet per minute. Sampling was carried out daily during the normal duty week from 0830 to 1630 hours. During rainstorms the procedure was stopped and then resumed with the cessation of rain. Sample collecting filters were stored for the routine 7-day period in an oven at 30°C, then cooled in a desiccator and counted.

Water: Rivers and ponds were sampled by taking grab samples of surface water in one liter, wide-mouth, polyethylene jars. Sampling stations for flowing bodies of water such as Mill Creek, Salt River, and Rolling Fork River were established at the streams' points of entry on the Reservation and again at either the points of exit from the Reservation or where identity was lost by confluence with another body of water (Fig. 1).

Samples were prepared for radioassay by evaporating the water without boiling in a Pyrex beaker until an almost dry residue was obtained. The residue and rinse liquids (distilled water and 1 N HCl) were then transferred to a weighed planchet, dried at 103°C, weighed and counted.

Surface Soil: Samples were collected in one liter, polyethylene jars from the top 2-inch layer of ground surface and prepared for radioactive measurements as follows: After all extraneous material (grass, roots, etc.) had been removed, the soil was dried and pulverized. To obtain a homogeneous mixture and a uniform particle size, the soil was then thoroughly mixed and sieved through a #100 mesh brass screen. Aliquots of 200, 300, and 400 mg (3 each), dried at 103°C, were transferred to counting planchets, mixed with distilled water and spread evenly as a thin slurry, redried at 103°C, cooled in a desiccator and counted.

Bottom Sediment: Bottom samples were taken from the middle of streams, ponds, and lakes by using a specially modified Eckman's dredge. The material was then handled and prepared for counting in the same manner as soil samples.

Gamma Spectral Analyses: All water, surface soil and bottom sediment samples collected in January 1963 were gamma scanned. Because of equipment failure, air samples were not analyzed.

RESULTS AND DISCUSSION

Air: Radioactivity measurements of airborne material collected by the air scoop sampling procedure (1959, 1960, and 1961) indicated an increase in atmospheric radioactivity after the French test in the Sahara (13 February 1960) and after the resumption of nuclear weapons testing by the USSR (1 September 1961). However, for comparative quantitative purposes, more precise sampling methods are necessary.

Figure 2 shows average monthly fallout values of material collected by the Staplex air sampler (March 1961 through December 1963). Units of picocuries per cubic meter of air (pCi/m^3) are employed for easy comparison with data reported by the Public Health Radiation Surveillance Network (7). The peaks of radioactivity are in good temporal agreement with those reported by Lockhart (9) for the Northern Hemisphere.

The monthly averages in 1961 ranged from approximately 1.48 pCi/m^3 in June to 4.45 pCi/m^3 in September, and in 1962 ranged from 0.94 pCi/m^3 in August to 9.14 pCi/m^3 in November. The average measurement in 1962 increased from the 2.55 pCi/m^3 level in 1961 to 3.96 pCi/m^3, a difference of 1.4 pCi/m^3. When evaluated for occupational exposure (8), the values for 1961 and 1962 represent about 0.26 per cent and 0.40 per cent, respectively, of the maximum permissible concentration for an unknown mixture of radionuclides in air $(MPCU)_a$. In terms of neighborhood population exposure, these values will then be 2.6 per cent and 4.0 per cent of the $(MPCU)_a$.

Water, Surface Soil, and Bottom Sediment: Results of radioactive measurements (including limits of random error at the 95 per cent confidence level) on water, soil, and sediment samples are listed in Tables 1 - 8 (double dash (--) indicates no sample radioassayed). Ordinarily, the activity values were well below established permissible levels. During the annual spring and fall floods radionuclides are subject to considerable movement and intermixing, and consequently are difficult to evaluate properly. A graphic presentation of the data (Figs. 3 - 10) is included since it readily shows possible trends and changes in the relative levels of radioactive materials. During the moratorium, activity measurements of like media were relatively constant and compared favorably with each other. After the resumption of atmospheric nuclear testing, fluctuations and variations became prevalent.

Concentrations of radioactivity in surface soil and bottom sediment exceeded, with a few exceptions, those found in water.

Accumulations in water were, as a whole, uniformly low, especially during the nuclear moratorium. On a few occasions following the moratorium the accumulations exceeded the suggested maximum permissible interim level of 100 pCi/l of water for unknown radioisotopes (8). This, however, does not mean that the water was necessarily hazardous, but a knowledge of the important radioactive isotopes present is required for a determination of the extent of the hazard. No attempt was made to carry out such an analysis since subsequent radioactivity measurements were below the suggested permissible levels.

The average radioactive content of the different media sampled in each area during 1960, 1961, and 1962 is summarized in Figures 11 - 13. An annual increase in environmental radiation levels, which can be related to the resumption of nuclear testing, is adequately illustrated. The increase in sedimentary radioactivity in Area 4 (from approximately 43 pCi/l in 1960 and 1961 to 73 pCi/l in 1962) is of particular interest for several reasons: 1) Area 4 is the only location sampled not vulnerable to high flood water. 2) The lake in the area is the only body of water sampled that was not in existence prior to the first nuclear detonation (Tobacco Leaf Lake impounded in 1952), thus limiting the build-up of radiomaterials. 3) The lake is unique in that it was constructed to utilize the natural rolling terrain to avoid overflow, hence providing a sedimentary basin for the concentration of radioactive material.

Following the resumption of nuclear testing, the highest average values for sediment were those representative of dynamic water bodies with the exception of Mill Creek (Area 3). This was not always the case during the moratorium, although Tobacco Leaf Lake (a static site) at this time had the lowest value. The low values shown for Mill Creek and Tobacco Leaf Lake (Fig. 13) probably can be attributed partially to the sand content of the sediment (10) in the creek and the relative newness of the lake.

Characteristic gamma spectra for the three different types of samples are shown in Figures 14 - 16. All show evidence of a prominent Zr^{95} - Nb^{95} peak, while small peaks occurred in the regions corresponding to $Ru^{103\text{-}106}$ and $Ce^{141\text{-}144}$. These isotopes are normally identified with fallout products. A qualitative examination of the gamma scans shows that water has less gamma activity than the corresponding sediment and soil.

CONCLUSIONS

The primary purpose of this study is to report and document, for the first time, data pertaining to radiation levels in air, surface soil, water, and bottom silt on the Fort Knox Reservation and not to evaluate possible radiation hazards. However, comparisons of the higher radioactive concentrations with MPCU (8) establish that the observed radiation levels, in most cases, are well below the suggested permissible tolerance levels.

The contribution of radioactive fallout from world-wide nuclear testing to local concentration levels is evident. Low and relatively constant levels are correlated with the absence of nuclear detonations, while fluctuating but increasing values accompany testing programs. The influence of seasons on deposition and accumulation of radioactive material is implied, as is also the importance of the clay content of the media for retention of radioactivity.

The results also indicate that sampling of only two sites, Areas 4 and 5, is sufficient for routine surveillance of radiation levels on the Fort Knox Reservation, thus simplifying the procedure for maintaining a monitoring operation. Sampling of the unique Tobacco Leaf Lake location (Area 4) would result in measurements indicative of radiomaterial accumulations in an undisturbed area, whereas values from Area 5 (Salt River's exit) could presumably be representative of the maximum radioactivity to be expected on the Reservation when above average atmospheric radioactive contaminations prevail.

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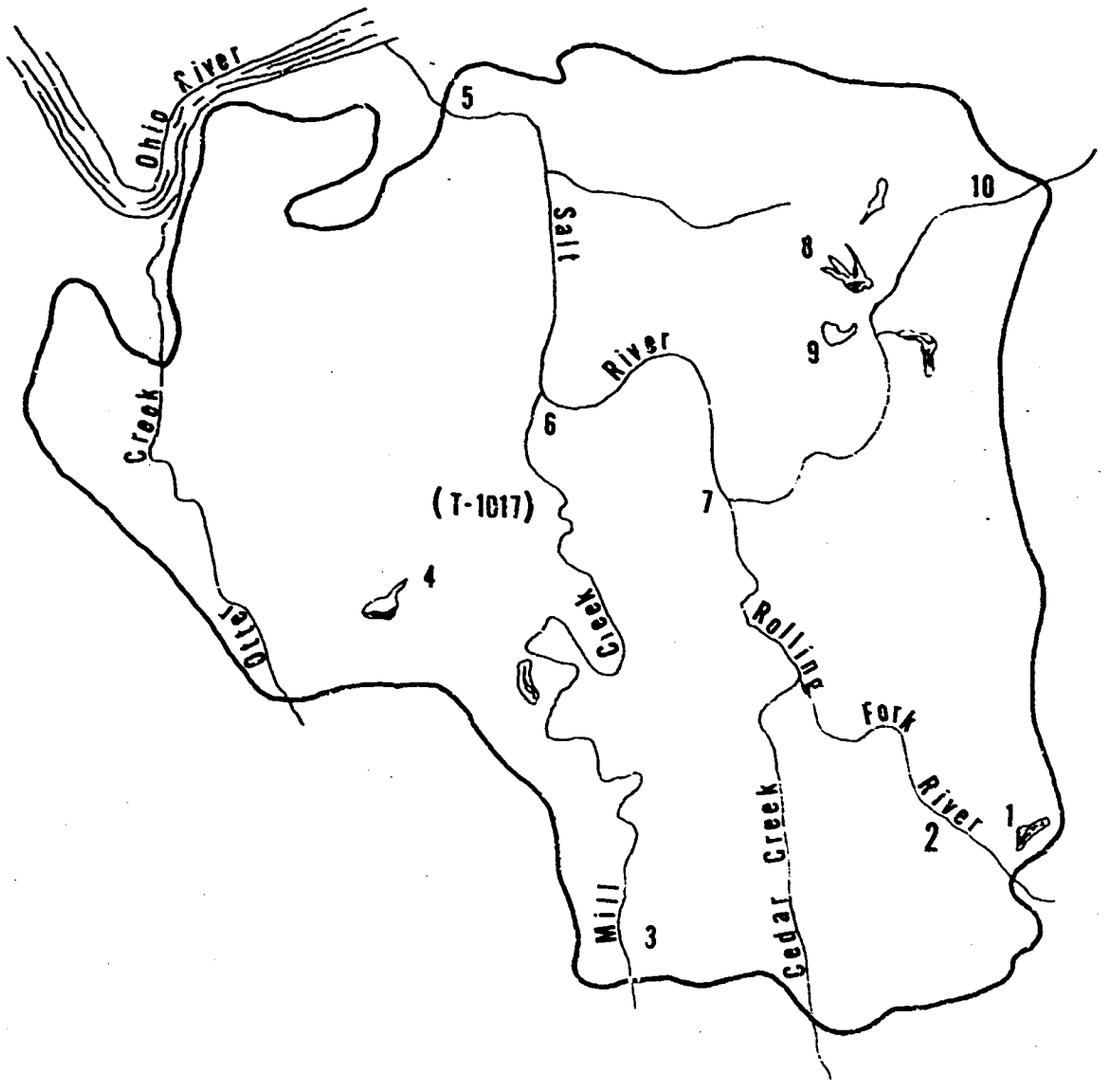

AREAS SAMPLED

Fig. 1. Areas sampled on the Fort Knox Reservation.

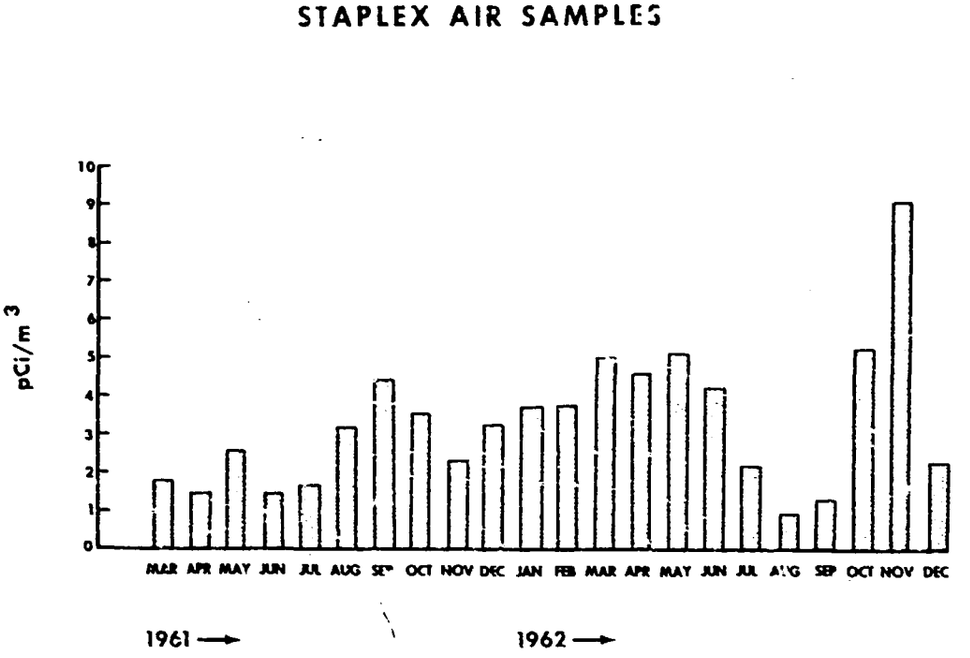

Fig. 2. Radioactivity measurements of airborne material collected with the Staplex air sampler.

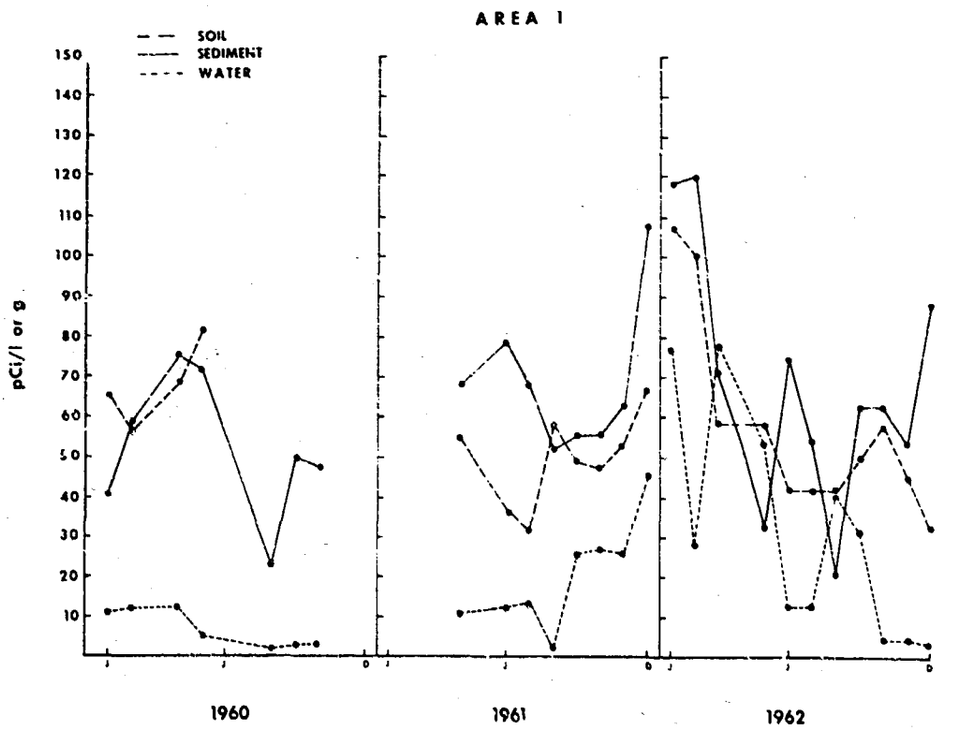

Fig. 3. Average concentration of radioactive material in soil, sediment, and water from Area 1.

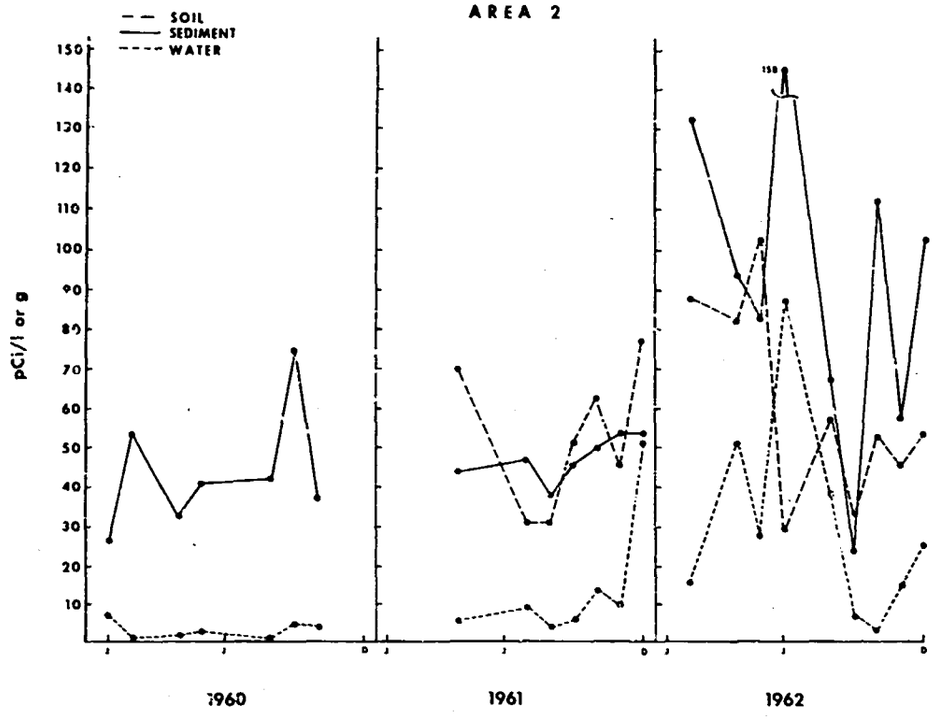

Fig. 4. Average concentrations of radioactive material in soil, sediment, and water from Area 2.

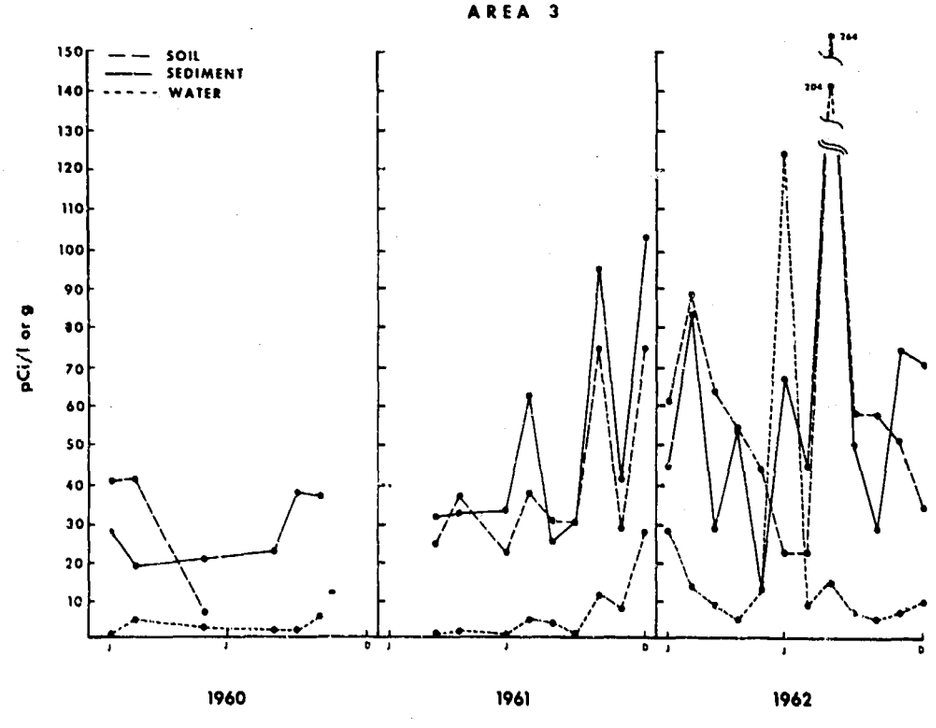

Fig. 5. Average concentrations of radioactive material in soil, sediment and water from Area 3.

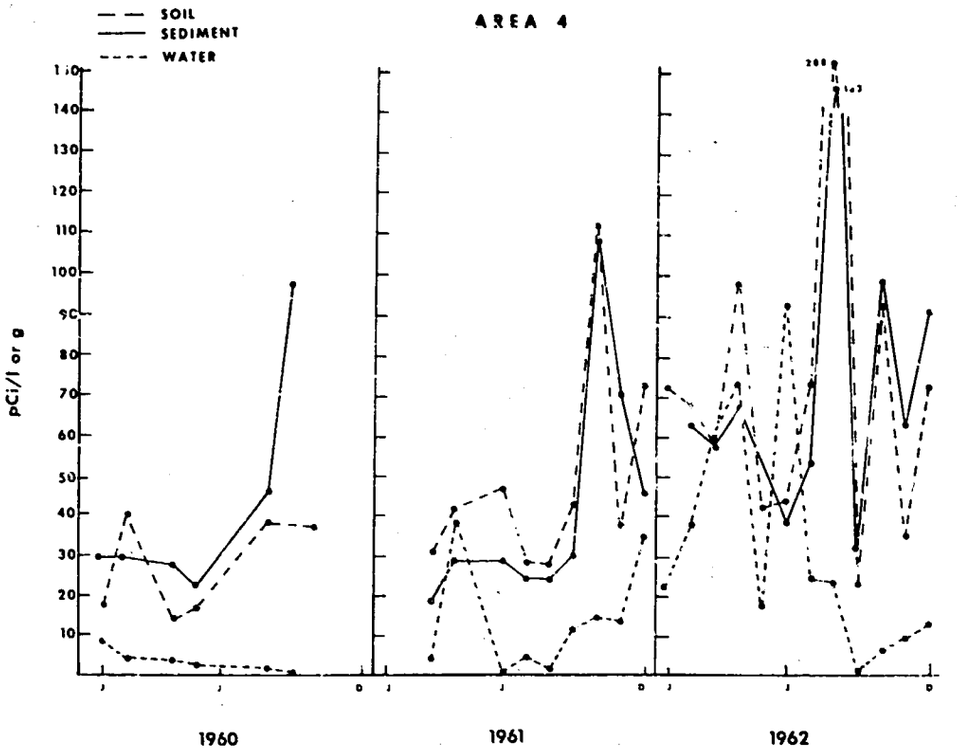

Fig. 6. Average concentrations of radioactive material in soil, sediment, and water from Area 4.

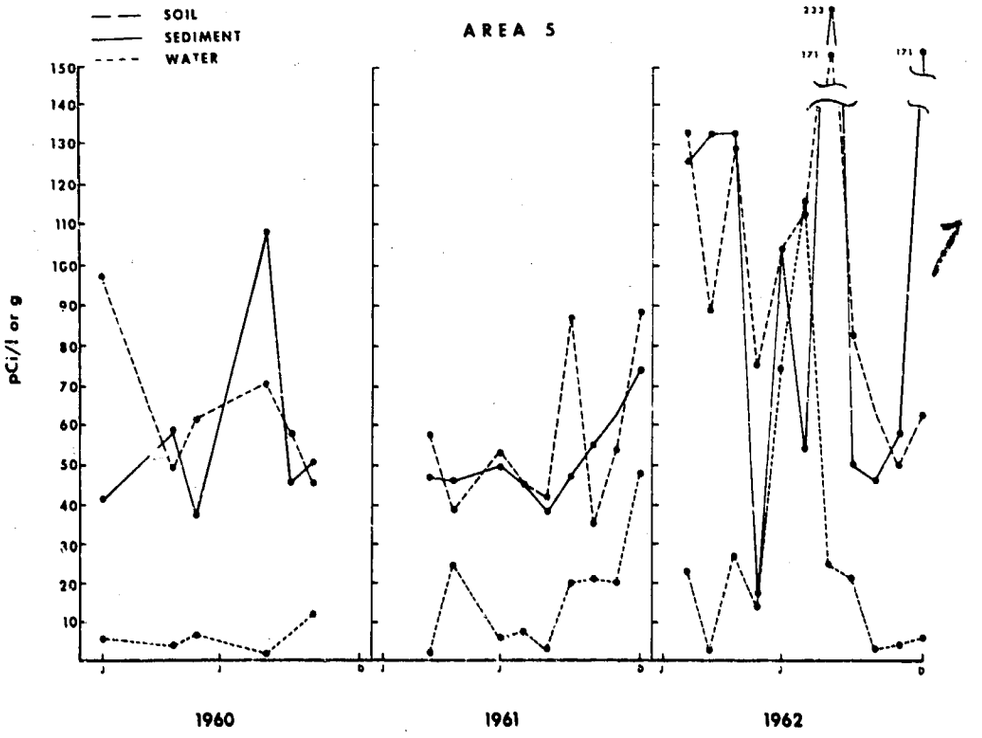

Fig. 7. Average concentrations of radioactive material in soil, sediment, and water from Area 5.

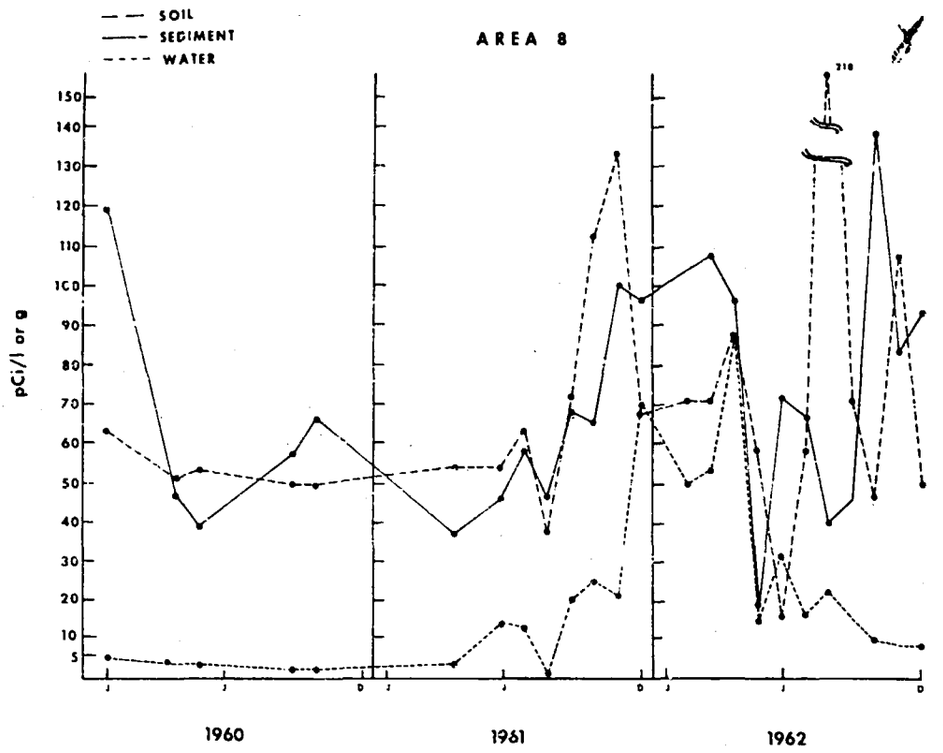

Fig. 8. Average concentrations of radioactive material in soil, sediment, and water from Area 8.

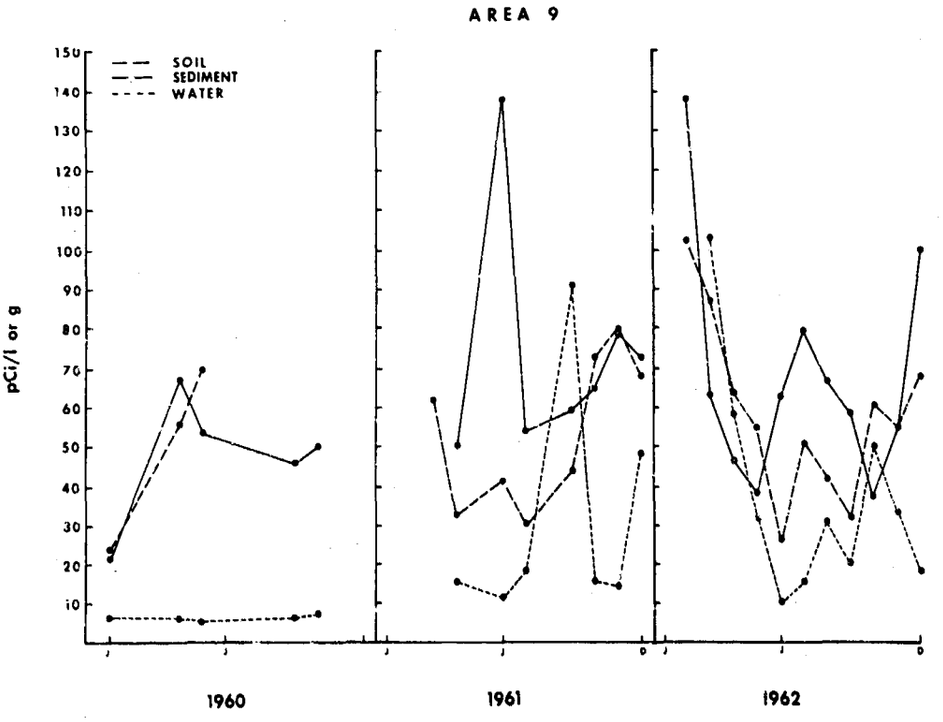

Fig. 9. Average concentrations of radioactive material in soil, sediment, and water from Area 9.

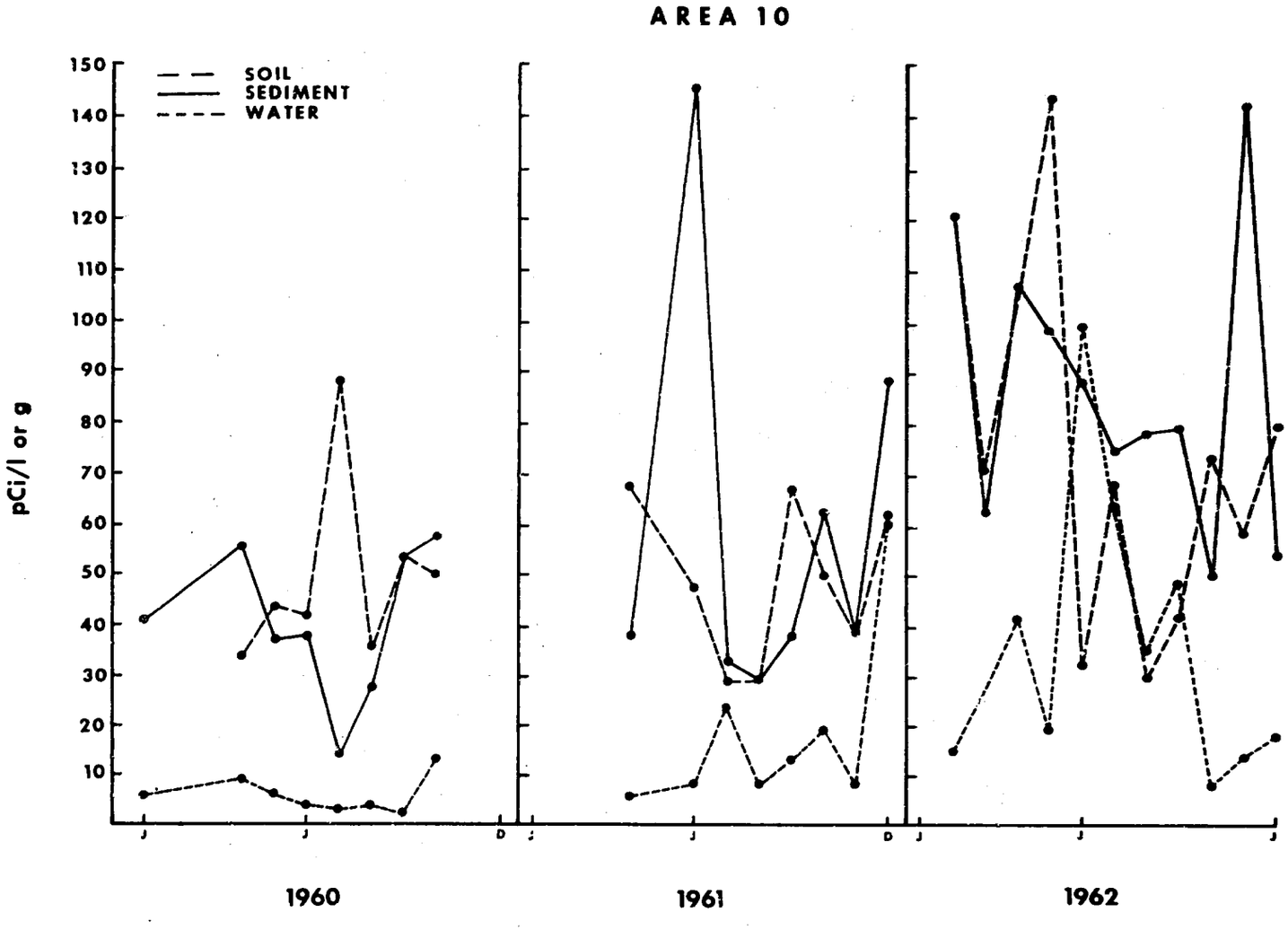

Fig. 10. Average concentrations of radioactive material in soil, sediment, and water from Area 10.

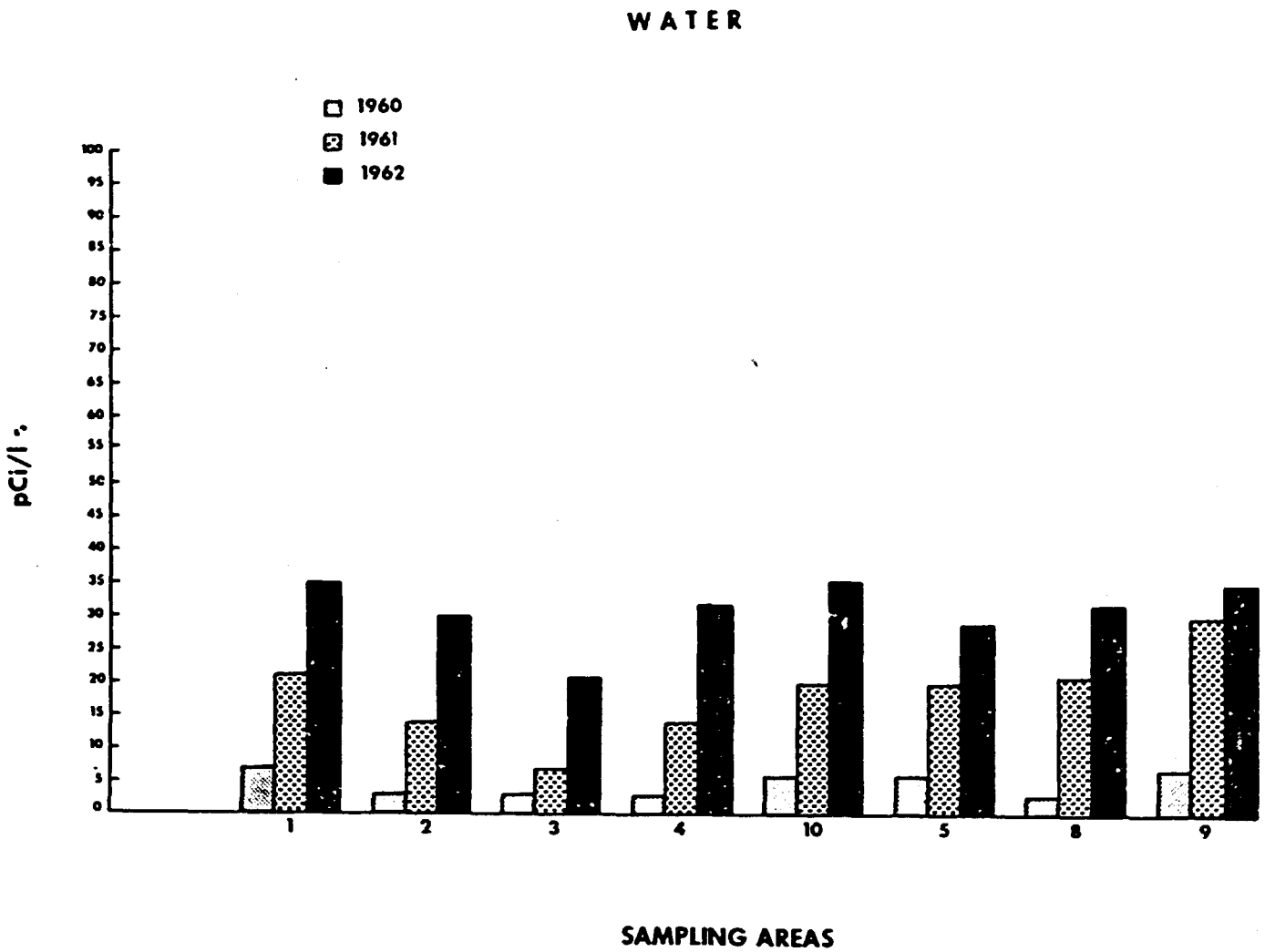

Fig. 11. Average concentrations of radioactive material in water samples from each Area (1960, 1961, and 1962).

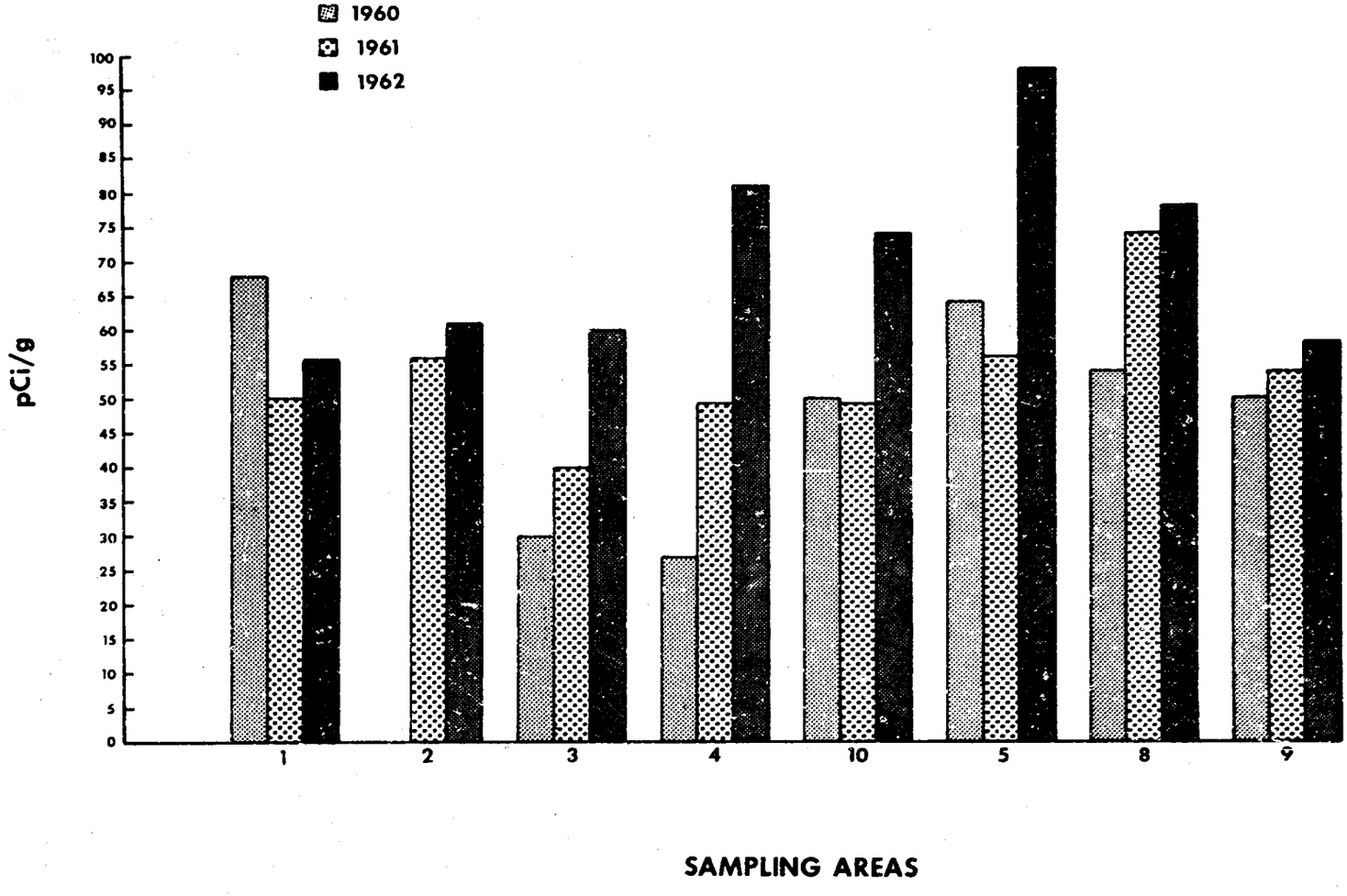

Fig. 12. Average concentrations of radioactive material in soil samples from each Area (1960, 1961, and 1962).

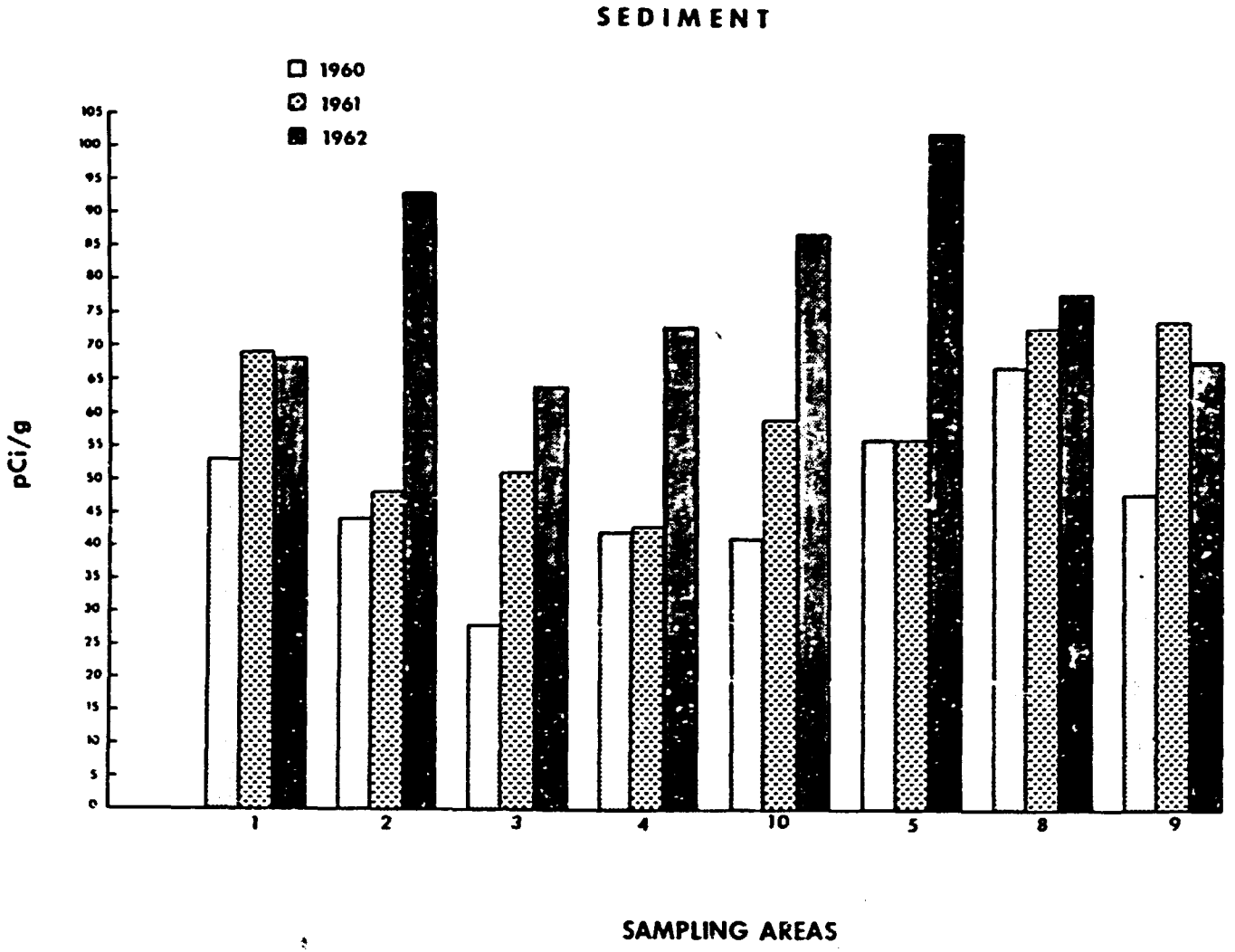

Fig. 13. Average concentrations of radioactive material in sediment samples from each Area (1960, 1961, and 1962).

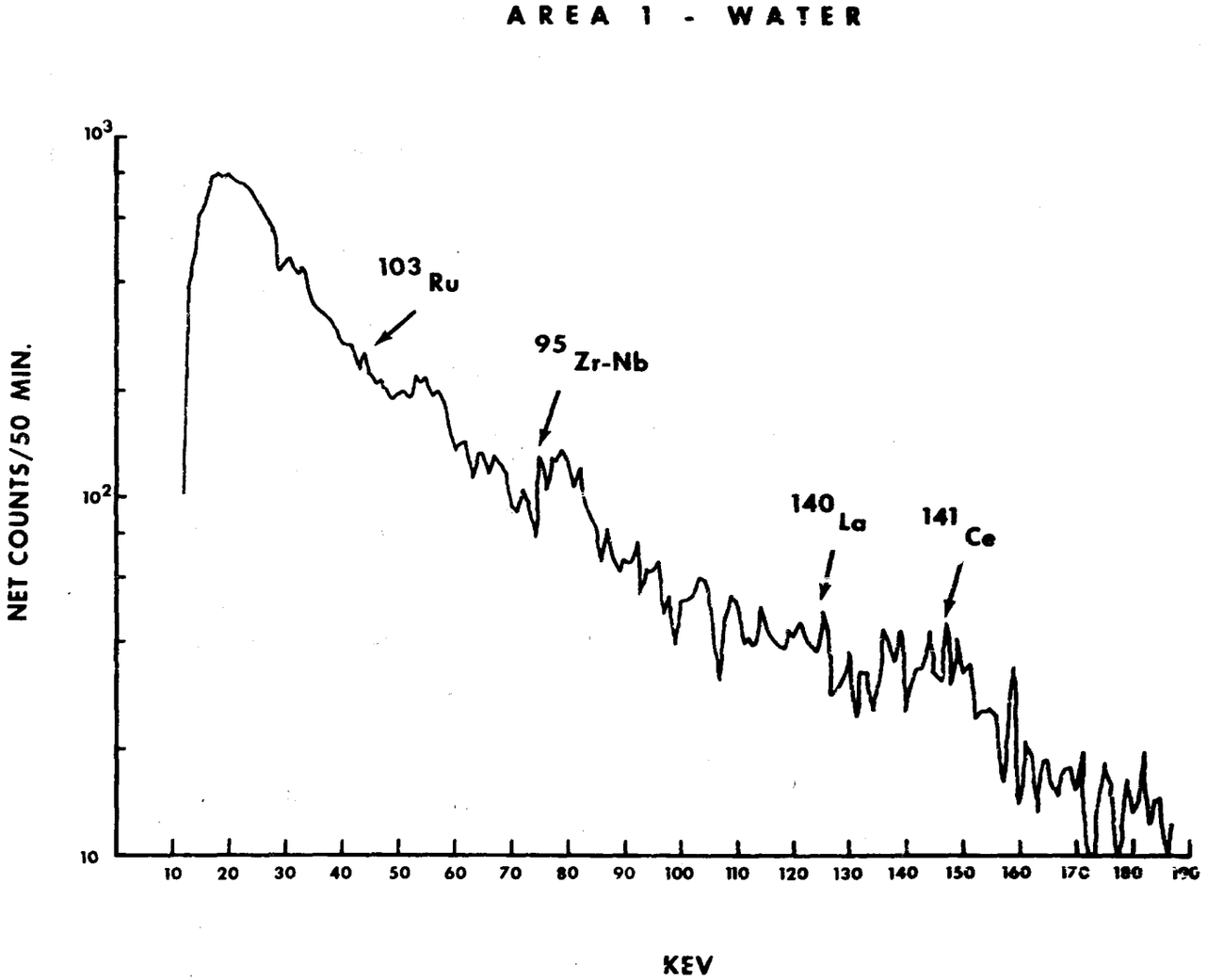

Fig. 14. Gamma spectrum of water sample from Area 1 (January 1963).

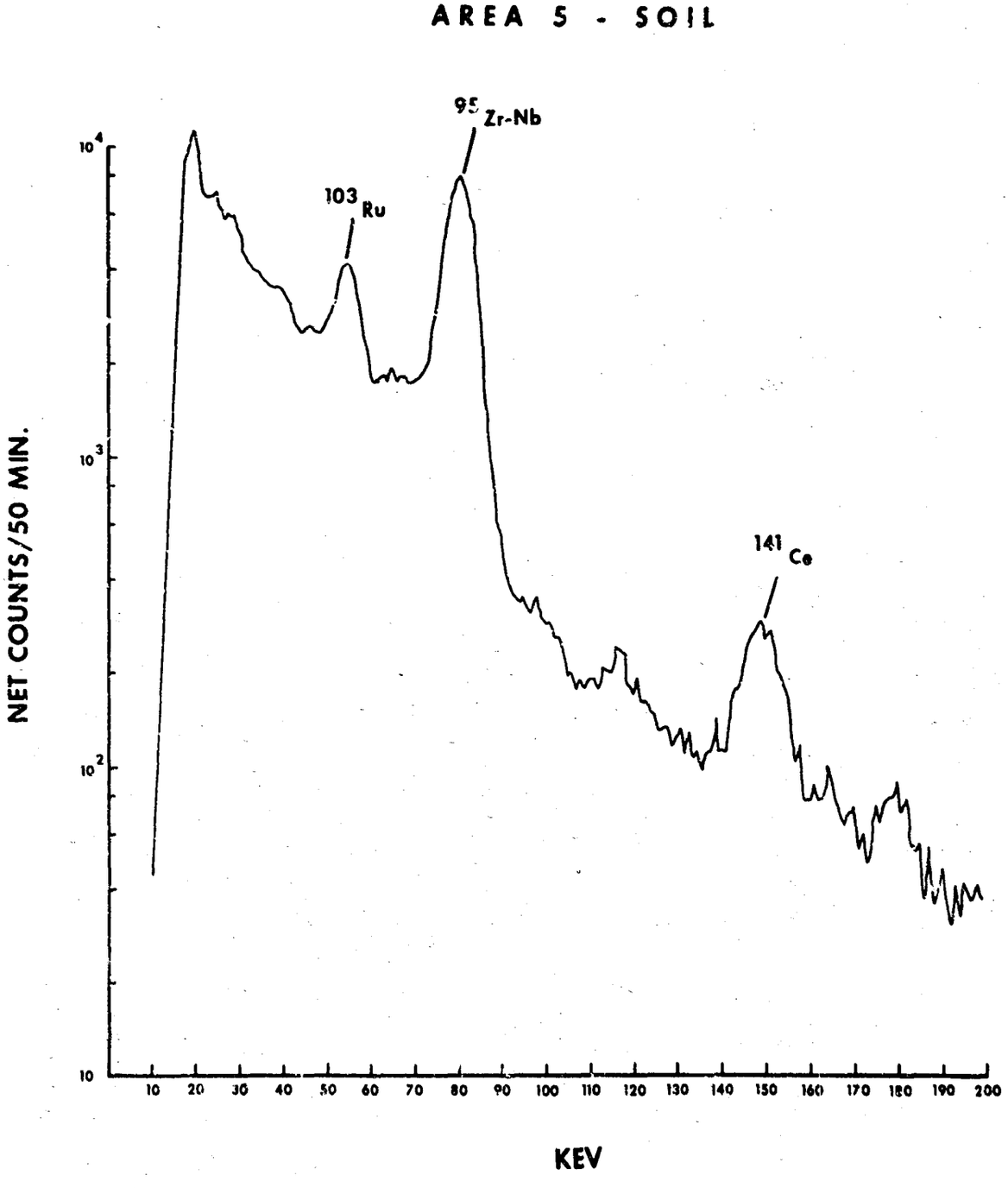

Fig. 15. Gamma spectrum of a soil sample from Area 5 (January 1963).

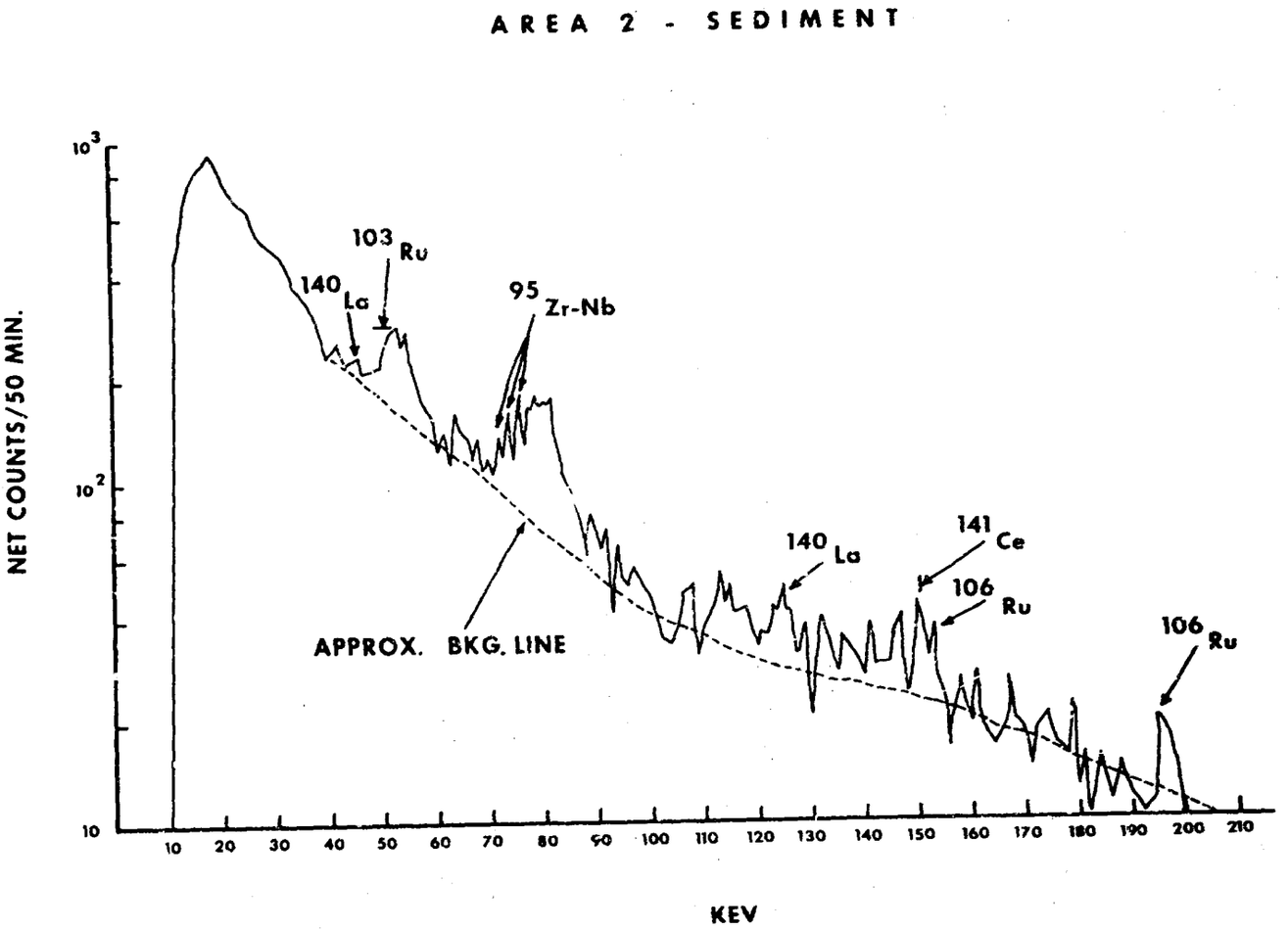

Fig. 16. Gamma spectrum of a bottom sediment sample from Area 2 (January 1963).

TABLE I

GROSS RADIOACTIVITY IN AREA 1 (Lebanon Junction Pond)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	66 ± 18	42 ± 18	11 ± 2	--	--	--	108 ± 14	118 ± 15	77 ± 1
Feb	56 ± 18	59 ± 12	12 ± 4	--	--	--	100 ± 11	120 ± 17	28 ± 2
Mar	--	--	--	--	--	--	58 ± 14	71 ± 13	78 ± 2
Apr	68 ± 19	75 ± 12	12 ± 3	55 ± 12	68 ± 18	11 ± 4	58 ± 12	54 ± 12	66 ± 3
May	82 ± 20	72 ± 19	5 ± 3	--	--	--	58 ± 13	33 ± 14	54 ± 2
Jun	--	--	--	37 ± 18	79 ± 19	13 ± 4	42 ± 14	75 ± 14	13 ± 6
Jul	--	--	--	31 ± 18	68 ± 19	14 ± 4	42 ± 13	54 ± 13	13 ± 1
Aug	--	23 ± 4	20 ± 2	58 ± 19	52 ± 18	2 ± 5	42 ± 13	21 ± 12	41 ± 3
Sep	--	50 ± 16	3 ± 1	49 ± 12	56 ± 13	26 ± 4	50 ± 13	63 ± 16	32 ± 6
Oct	--	48 ± 15	3 ± 1	47 ± 15	56 ± 12	27 ± 6	58 ± 13	63 ± 16	5 ± 1
Nov	--	--	--	54 ± 15	63 ± 15	26 ± 6	46 ± 13	54 ± 13	5 ± 2
Dec	--	--	--	67 ± 16	108 ± 17	46 ± 5	33 ± 13	88 ± 14	4 ± 2

TABLE 2

GROSS RADIOACTIVITY IN AREA 2 (Rolling Fork River - Entry on Reservation)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	--	27 ± 18	7 ± 2	--	--	--	--	--	--
Feb	--	54 ± 19	1 ± 2	--	--	--	88 ± 13	133 ± 14	15 ± 2
Mar	--	--	--	--	--	--	--	--	--
Apr	--	33 ± 18	2 ± 1	71 ± 15	44 ± 9	6 ± 5	83 ± 13	94 ± 16	52 ± 2
May	--	41 ± 18	3 ± 1	--	--	--	104 ± 13	83 ± 14	29 ± 2
Jun	--	--	--	--	--	--	29 ± 14	158 ± 15	87 ± 6
Jul	--	--	--	31 ± 19	47 ± 18	9 ± 4	--	--	--
Aug	--	42 ± 14	1 ± 2	31 ± 15	38 ± 12	4 ± 6	58 ± 13	67 ± 13	38 ± 5
Sep	--	75 ± 16	5 ± 1	52 ± 15	46 ± 14	6 ± 4	33 ± 13	25 ± 13	7 ± 2
Oct	--	37 ± 19	4 ± 2	63 ± 16	50 ± 16	14 ± 5	54 ± 12	113 ± 14	3 ± 4
Nov	--	--	--	46 ± 15	54 ± 15	9 ± 5	46 ± 12	58 ± 13	15 ± 3
Dec	--	--	--	79 ± 16	54 ± 15	52 ± 7	54 ± 13	104 ± 14	26 ± 4

TABLE 3

GROSS RADIOACTIVITY IN AREA 3 (Mill Creek - Entry on Reservation)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	41 ± 17	28 ± 17	1 ± 2	--	--	--	61 ± 10	45 ± 10	28 ± 5
Feb	42 ± 12	19 ± 17	5 ± 2	--	--	--	88 ± 13	83 ± 13	14 ± 2
Mar	--	--	--	25 ± 14	32 ± 7	1 ± 2	64 ± 10	29 ± 12	9 ± 2
Apr	--	--	--	37 ± 18	33 ± 5	2 ± 2	55 ± 10	54 ± 12	5 ± 2
May	7 ± 14	21 ± 17	3 ± 2	--	--	--	45 ± 10	13 ± 14	14 ± 2
Jun	--	--	--	23 ± 11	34 ± 7	1 ± 3	23 ± 11	67 ± 14	124 ± 6
Jul	--	--	--	38 ± 15	63 ± 19	5 ± 4	23 ± 10	45 ± 10	9 ± 3
Aug	--	23 ± 11	2 ± 3	31 ± 18	26 ± 18	4 ± 4	164 ± 13	204 ± 16	16 ± 2
Sep	--	38 ± 15	2 ± 2	31 ± 17	31 ± 17	1 ± 1	58 ± 10	50 ± 13	7 ± 3
Oct	--	37 ± 18	6 ± 2	75 ± 16	96 ± 17	12 ± 5	58 ± 10	29 ± 12	5 ± 3
Nov	--	--	--	29 ± 11	42 ± 15	8 ± 4	51 ± 10	75 ± 13	7 ± 4
Dec	--	--	--	75 ± 16	104 ± 17	28 ± 6	35 ± 10	71 ± 13	10 ± 5

TABLE 4

GROSS RADIOACTIVITY IN AREA 4 (Tobacco Leaf Lake)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	17 ± 10	30 ± 12	9 ± 2	--	--	--	73 ± 16	--	24 ± 3
Feb	40 ± 18	30 ± 12	5 ± 2	--	--	--	68 ± 16	63 ± 13	37 ± 2
Mar	--	--	--	31 ± 10	19 ± 7	5 ± 3	58 ± 13	58 ± 13	60 ± 2
Apr	14 ± 14	28 ± 14	4 ± 2	42 ± 17	29 ± 14	39 ± 7	99 ± 16	67 ± 13	74 ± 2
May	17 ± 19	23 ± 17	3 ± 1	--	--	--	42 ± 10	53 ± 13	17 ± 2
Jun	--	--	--	47 ± 19	29 ± 14	1 ± 2	44 ± 8	38 ± 13	94 ± 6
Jul	--	--	--	29 ± 14	25 ± 14	5 ± 3	73 ± 17	54 ± 13	25 ± 3
Aug	38 ± 15	46 ± 14	2 ± 1	29 ± 15	25 ± 14	2 ± 1	288 ± 21	183 ± 15	24 ± 3
Sep	--	97 ± 16	1 ± 2	43 ± 15	31 ± 15	12 ± 4	23 ± 10	33 ± 13	1 ± 1
Oct	--	--	--	113 ± 20	108 ± 17	15 ± 5	94 ± 16	99 ± 13	6 ± 1
Nov	--	--	--	37 ± 19	71 ± 16	14 ± 6	35 ± 10	63 ± 13	10 ± 2
Dec	--	--	--	73 ± 20	46 ± 15	35 ± 14	73 ± 16	92 ± 13	14 ± 3

TABLE 5

GROSS RADIOACTIVITY IN AREA 10 (Sa! River - Entry on Reservation)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	--	41 ± 17	6 ± 2	--	--	--	--	--	--
Feb	--	--	--	--	--	--	121 ± 14	121 ± 14	15 ± 2
Mar	--	--	--	--	--	--	71 ± 13	63 ± 13	27 ± 2
Apr	34 ± 17	56 ± 14	4 ± 2	67 ± 15	38 ± 15	6 ± 4	104 ± 14	108 ± 14	42 ± 2
May	44 ± 19	37 ± 19	6 ± 2	--	--	--	142 ± 15	98 ± 14	19 ± 2
Jun	42 ± 18	38 ± 19	4 ± 2	47 ± 18	146 ± 17	8 ± 5	32 ± 11	88 ± 14	99 ± 6
Jul	88 ± 7	15 ± 7	3 ± 2	29 ± 15	33 ± 15	24 ± 6	58 ± 10	75 ± 14	65 ± 15
Aug	35 ± 8	27 ± 6	4 ± 2	29 ± 15	29 ± 15	8 ± 6	30 ± 9	78 ± 8	35 ± 4
Sep	54 ± 15	54 ± 15	2 ± 2	67 ± 15	38 ± 14	13 ± 5	42 ± 13	79 ± 13	49 ± 3
Oct	50 ± 15	58 ± 15	13 ± 2	50 ± 16	63 ± 15	19 ± 6	74 ± 10	50 ± 12	8 ± 4
Nov	--	--	--	38 ± 15	39 ± 11	8 ± 5	58 ± 13	142 ± 14	14 ± 5
Dec	--	--	--	63 ± 15	88 ± 16	71 ± 7	79 ± 14	54 ± 13	18 ± 4

TABLE 6

GROSS RADIOACTIVITY IN AREA 5 (Salt River - Departure from Reservation)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	97 ± 19	41 ± 18	6 ± 2	--	--	--	--	--	--
Feb	--	--	--	--	--	--	133 ± 14	126 ± 17	23 ± 3
Mar	--	--	--	57 ± 14	47 ± 15	2 ± 2	88 ± 13	133 ± 14	2 ± 2
Apr	49 ± 15	58 ± 15	4 ± 2	38 ± 14	46 ± 15	25 ± 6	129 ± 14	133 ± 14	27 ± 2
May	62 ± 19	37 ± 18	7 ± 2	--	--	--	75 ± 15	17 ± 14	14 ± 2
Jun	--	--	--	54 ± 15	50 ± 14	6 ± 3	104 ± 15	104 ± 14	74 ± 5
Jul	--	--	--	46 ± 15	46 ± 15	8 ± 5	113 ± 14	54 ± 13	116 ± 7
Aug	71 ± 15	108 ± 14	2 ± 2	42 ± 15	38 ± 15	3 ± 2	171 ± 15	233 ± 16	25 ± 4
Sep	58 ± 15	46 ± 14	7 ± 2	87 ± 15	47 ± 15	20 ± 6	83 ± 14	50 ± 13	21 ± 4
Oct	46 ± 15	51 ± 14	12 ± 2	35 ± 15	56 ± 16	21 ± 5	67 ± 13	46 ± 12	3 ± 2
Nov	--	--	--	54 ± 15	63 ± 14	8 ± 5	50 ± 14	58 ± 13	4 ± 2
Dec	--	--	--	88 ± 16	75 ± 16	48 ± 6	63 ± 13	171 ± 15	6 ± 4

TABLE 7

GROSS RADIOACTIVITY IN AREA 8 (Wilcox Lake)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	63 ± 18	124 ± 20	5 ± 2	--	--	--	--	--	--
Feb	--	--	--	--	--	--	71 ± 10	104 ± 14	50 ± 2
Mar	--	--	--	--	--	--	71 ± 13	108 ± 13	54 ± 2
Apr	52 ± 15	47 ± 15	3 ± 1	54 ± 14	38 ± 15	3 ± 2	88 ± 14	96 ± 13	87 ± 2
May	53 ± 18	39 ± 18	3 ± 2	--	--	--	58 ± 13	17 ± 14	14 ± 2
Jun	--	--	--	54 ± 15	46 ± 15	14 ± 4	25 ± 14	71 ± 13	32 ± 3
Jul	--	--	--	63 ± 15	58 ± 15	13 ± 5	58 ± 16	67 ± 13	16 ± 2
Aug	--	--	--	38 ± 15	46 ± 15	1 ± 3	217 ± 16	40 ± 12	22 ± 3
Sep	50 ± 17	58 ± 15	1 ± 2	72 ± 17	68 ± 15	21 ± 42	71 ± 13	46 ± 13	15 ± 4
Oct	50 ± 15	67 ± 15	1 ± 1	112 ± 16	65 ± 16	25 ± 6	46 ± 12	138 ± 15	9 ± 2
Nov	--	--	--	133 ± 17	100 ± 16	21 ± 5	108 ± 13	83 ± 13	8 ± 1
Dec	--	--	--	67 ± 16	96 ± 16	70 ± 7	50 ± 13	92 ± 14	8 ± 2

TABLE 8

GROSS RADIOACTIVITY IN AREA 9 (Pearl Lake)

	1960			1961			1962		
	pCi/g		pCi/l	pCi/g		pCi/l	pCi/g		pCi/l
Month	Soil	Sediment	Water	Soil	Sediment	Water	Soil	Sediment	Water
Jan	24 ± 3	21 ± 16	7 ± 2	--	--	--	--	--	--
Feb	--	--	--	--	--	--	103 ± 11	138 ± 14	9 ± 2
Mar	--	--	--	62 ± 15	--	--	87 ± 11	63 ± 16	103 ± 2
Apr	56 ± 2	68 ± 15	7 ± 2	33 ± 14	50 ± 15	16 ± 5	64 ± 10	46 ± 12	58 ± 2
May	70 ± 19	54 ± 18	6 ± 3	--	--	--	55 ± 11	38 ± 14	32 ± 2
Jun	--	--	--	42 ± 15	138 ± 17	11 ± 4	26 ± 11	63 ± 13	10 ± 3
Jul	--	--	--	30 ± 15	54 ± 16	18 ± 5	51 ± 10	79 ± 13	16 ± 2
Aug	--	--	--	--	--	--	42 ± 10	67 ± 12	31 ± 4
Sep	--	46 ± 14	7 ± 2	44 ± 15	59 ± 12	91 ± 40	32 ± 10	58 ± 13	20 ± 3
Oct	--	50 ± 15	8 ± 2	73 ± 13	65 ± 16	16 ± 4	61 ± 10	37 ± 16	50 ± 4
Nov	--	--	--	80 ± 13	79 ± 16	14 ± 3	55 ± 10	54 ± 13	34 ± 3
Dec	--	--	--	68 ± 12	73 ± 20	48 ± 4	68 ± 11	100 ± 14	18 ± 4

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