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**SEMIANNUAL REPORT OF ENVIRONMENTAL LEVELS
OF RADIOACTIVITY IN THE VICINITY OF THE
LAWRENCE LIVERMORE LABORATORY
JANUARY THROUGH JUNE 1971**

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Foreword

This report was prepared for submission to the U.S. Atomic Energy Commission by the Environmental Evaluation Section of the Hazards Control Department at the Lawrence Livermore Laboratory. The analyses of the samples were performed by various groups within the Laboratory, such as the Hazards Control Department Analytical and Radiation Counting Laboratories, the Radiochemistry Department, and the Bio-Medical Division. Data were also obtained from reliable outside sources.

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Abstract

An environmental surveillance program was conducted within the Livermore Valley and Site 300 areas to determine the effect of the Lawrence Livermore Laboratory operations on the surrounding environment. Analyses for gross radioactivity and for specific radionuclides of interest in a variety of environmental samples were performed. The results of these analyses are provided in the report.

Air particulates, soil, water, and sewage samples showed similar gross radioactivities to those measured during

the past year. Gamma spectral measurements of on-site airborne particulates revealed detectable activities of the typical gamma emitters observed in global fallout. Isotopic uranium analyses of particulates collected on air filters at Site 300 indicate the uranium in the particulates was depleted in ^{235}U with respect to that for natural uranium. Soil samples subjected to plutonium, strontium and gamma spectral analyses showed no detectable buildup of these activities in the off-site environment.

Introduction

The Lawrence Livermore Laboratory is located about 50 miles southeast of San Francisco in the Livermore-Amador Valley. Shielded from the ocean by the western hills, the valley has a warm, dry climate. Annual rainfall is about 14 inches and occurs primarily during the winter months in connection with Pacific storms. Surface water drainage from the valley is from east to west through various arroyos, with outflow near Sunol in the southwestern corner of

the valley. Prevailing winds are from the west and southwest during April through September and from the northeast during the remainder of the year.

The Livermore Laboratory occupies an area of one square mile, situated approximately 3 miles east of Livermore. Site 300, a high explosives test area, is located 8 miles southwest of Tracy in sparsely populated hills of the Diablo range which separates the Livermore and San Joaquin Valleys. The population of

Livermore is approximately 40,000 and the Livermore-Amador Valley population is estimated at 80,000.

Agriculture is still an important activity in the valley although new housing developments and light industries are rapidly absorbing a sizable portion of the rural landscape. Roses, grain, grapes, hay, cattle, and sheep are the major agricultural products.

An environmental surveillance program is continually being conducted by the Laboratory in order to detect any increase in environmental radioactivity above natural background levels as a result of Laboratory operations. The program includes the collection of airborne particulates, soil, water, sewer effluent,

milk, and vegetation samples. These samples are analyzed for gross radioactivities as well as for the activity of specific radionuclides of interest. In addition, the terrestrial background radiation is measured at numerous locations in the vicinity of the Livermore Laboratory by means of thermoluminescent detectors.

The results of the analyses are provided in this report. When appropriate for the sake of brevity and clarity only the maximum and average concentrations are given. Error limits, when included, only reflect the uncertainties in the analyses at the 68% confidence level due to counting statistics.

Environmental Levels of Radioactivity—Livermore Laboratory

ATMOSPHERIC RADIOACTIVITY

The concentrations of various airborne radioactive substances were measured at 16 air sampling stations situated throughout the Livermore Valley. Their locations are shown in Figs. 1 and 2. The six samples located on the Laboratory perimeter use 80 square-inch Whatman filters. The average sampling rate is 25 cfm. The remaining samplers, located off-site, use 36 square-inch HV-70 filters and operate at an average flow rate of 4 cfm. These sampling stations are situated in such a manner that a significant release of airborne particulate radioactivity from the Laboratory would be detected regardless of the local meteorology at the time of the release. Filters are changed weekly during the

winter months and twice weekly during the summer to avoid excessive mass loading. An automatic radiation detection system with gas flow proportional detectors is used to determine gross alpha and beta activities deposited on the filters. The filters are also assayed for gamma emitting radionuclides by means of a specially designed environmental system using a Ge(Li) detector equipped with Compton suppression.¹

No gross alpha activity above the 0.001 pCi/m^3 detection limit was observed on the filters. The gross beta activities averaged over three-month periods are shown in Table 1 for each sampling location. A significant fraction of the beta activity deposited on the filters is due to global fallout produced by nuclear weapons tests and by cosmic-ray

Fig. 1. Lawrence Livermore Laboratory off-site environmental sampling locations.

Fig. 2. Lawrence Livermore Laboratory on-site environmental sampling stations.

interactions with the atmosphere. This is shown in Table 2 which lists the activities of the more abundant gamma emitting nuclides in monthly composite samples collected by the six Laboratory perimeter samplers. These composite filters were also subjected to plutonium and uranium analyses by dry ashing and complete dissolution of the filters and subsequent

radiochemical separation of the elements. The plutonium was isolated by ion exchange techniques and counted by alpha spectrometry. The isotopic uranium analyses were performed by mass spectrographic methods. The results are provided in Table 3. Inspection of the data reveals that the relative activities of ^{238}Pu and ^{239}Pu approximate those normally observed in global

Table 1. Gross airborne particulate beta activity within the Livermore Valley (pCi/m³).

Sampling stations ^a	January - March		April - June	
	Maximum	Average	Maximum	Average
1	0.45 ± 1%	0.10 ± 3%	0.24 ± 1%	0.18 ± 2%
2	0.25 ± 1%	0.083 ± 3%	0.25 ± 1%	0.18 ± 1%
3	0.15 ± 6%	0.073 ± 9%	0.17 ± 3%	0.13 ± 4%
4	0.55 ± 2%	0.14 ± 5%	0.31 ± 2%	0.23 ± 2%
5	0.34 ± 2%	0.084 ± 8%	0.26 ± 2%	0.16 ± 3%
6	0.30 ± 2%	0.14 ± 4%	0.17 ± 3%	0.12 ± 4%
7	0.051 ± 12%	0.031 ± 19%	0.16 ± 3%	0.12 ± 4%
8	0.10 ± 6%	0.042 ± 14%	0.24 ± 2%	0.13 ± 4%
9	0.35 ± 2%	0.098 ± 6%	0.22 ± 3%	0.18 ± 3%
10	0.30 ± 3%	0.096 ± 7%	0.24 ± 2%	0.13 ± 4%
11	0.30 ± 2%	0.073 ± 9%	0.19 ± 3%	0.12 ± 4%
12	0.41 ± 1%	0.11 ± 3%	0.28 ± 1%	0.21 ± 2%
13	0.33 ± 2%	0.10 ± 3%	0.28 ± 1%	0.19 ± 1%
14	0.81 ± 1%	0.20 ± 3%	0.56 ± 1%	0.41 ± 1%
15	0.38 ± 1%	0.097 ± 3%	0.26 ± 1%	0.19 ± 2%
16	0.53 ± 2%	0.11 ± 7%	0.24 ± 3%	0.16 ± 3%

^aSee Fig. 1 for location of stations.Table 2. Results of gamma-ray spectral measurements of Livermore perimeter air filters. (Activities in pCi/m³).

Month	¹⁴⁴ Ce	¹⁴¹ Ce	¹²⁵ Sb	⁷ Se	¹⁰³ Ru	¹⁰⁶ Ru	¹³⁷ Cs	⁹⁵ Zr
January	8.5 × 10 ⁻³ ± 3%	2.8 × 10 ⁻³ ± 6%	6.7 × 10 ⁻⁴ ± 16%	4.7 × 10 ⁻² ± 4%	3.3 × 10 ⁻³ ± 8%	3.1 × 10 ⁻³ ± 25%	8.4 × 10 ⁻⁴ ± 9%	3.3 × 10 ⁻³ ± 4%
February	1.4 × 10 ⁻² ± 3%	4.2 × 10 ⁻⁵ ± 5%	1.1 × 10 ⁻³ ± 20%	4.6 × 10 ⁻² ± 5%	6.1 × 10 ⁻³ ± 6%	5.3 × 10 ⁻³ ± 26%	1.0 × 10 ⁻³ ± 12%	1.5 × 10 ⁻³ ± 3%
March	4.0 × 10 ⁻³ ± 1%	1.5 × 10 ⁻² ± 2%	2.4 × 10 ⁻³ ± 11%	7.1 × 10 ⁻² ± 4%	2.2 × 10 ⁻² ± 2%	1.6 × 10 ⁻² ± 9%	3.1 × 10 ⁻³ ± 6%	3.1 × 10 ⁻² ± 1%
April	5.3 × 10 ⁻² ± 1%	1.3 × 10 ⁻² ± 2%	2.8 × 10 ⁻³ ± 15%	7.5 × 10 ⁻² ± 5%	1.4 × 10 ⁻² ± 3%	2.4 × 10 ⁻² ± 12%	3.9 × 10 ⁻³ ± 6%	3.9 × 10 ⁻² ± 1%
May	1.2 × 10 ⁻¹ ± 1%	1.7 × 10 ⁻³ ± 2%	7.8 × 10 ⁻³ ± 1%	1.1 × 10 ⁻¹ ± 4%	3.4 × 10 ⁻² ± 6%	4.1 × 10 ⁻² ± 6%	6.1 × 10 ⁻³ ± 6%	7.3 × 10 ⁻³ ± 1%
June	6.2 × 10 ⁻² ± 2%	6.2 × 10 ⁻³ ± 6%	3.2 × 10 ⁻³ ± 22%	4.8 × 10 ⁻² ± 9%	1.2 × 10 ⁻¹ ± 5%	2.7 × 10 ⁻² ± 17%	4.3 × 10 ⁻³ ± 10%	3.2 × 10 ⁻² ± 2%

Table 3. Plutonium and uranium concentrations in Livermore perimeter air filters.

Month	Activity (pCi/m ³)		²³⁸ Pu/ ²³⁹ Pu	Mass (ng/m ³)		²³⁵ U/ ²³⁸ U
	²³⁹ Pu	²³⁸ Pu		²³⁵ U	²³⁸ U	
January	3.4 × 10 ⁻⁶ ± 6%	2.4 × 10 ⁻⁵ ± 3%	1.4 × 10 ⁻¹	2.2 × 10 ⁻⁴ ± 2%	4.7 × 10 ⁻² ± 1%	4.7 × 10 ⁻³
February	8.3 × 10 ⁻⁷ ± 6%	9.2 × 10 ⁻⁶ ± 3%	9.0 × 10 ⁻²	7.0 × 10 ⁻⁵ ± 1%	1.0 × 10 ⁻³ ± 2%	6.8 × 10 ⁻³
March	3.6 × 10 ⁻⁵ ± 6%	3.4 × 10 ⁻⁴ ± 4%	1.1 × 10 ⁻¹	1.3 × 10 ⁻³ ± 1%	1.7 × 10 ⁻¹ ± 1%	7.6 × 10 ⁻³
April	9.1 × 10 ⁻⁶ ± 7%	7.9 × 10 ⁻⁵ ± 4%	1.3 × 10 ⁻¹	2.5 × 10 ⁻⁴ ± 1%	3.6 × 10 ⁻² ± 2%	8.9 × 10 ⁻³
May	5.7 × 10 ⁻⁶ ± 7%	1.1 × 10 ⁻⁴ ± 4%	5.4 × 10 ⁻²	6.3 × 10 ⁻⁴ ± 1%	1.0 × 10 ⁻¹ ± 1%	6.3 × 10 ⁻³

fallout. Similarly the $^{235}\text{U}/^{238}\text{U}$ ratio approximates that observed in natural uranium.

The weekly average beta activities on the air filters from all the Livermore sampling stations are shown in Fig. 3. The well known spring increase in surface air activity levels due to enhanced transport of stratosphere air into the troposphere is verified by the data.

SOIL

A soil sampling program has recently been initiated to determine the surface distribution of various radionuclides that have been deposited within the Livermore Valley as a result of global fallout from atmospheric weapons tests as well as from possible Laboratory effluent discharges. A core sampling method was

Fig. 3. Weekly average beta activity on air filters from Livermore sampling stations.

used to obtain the soil samples at various depths down to 20 cm for activity/depth profile studies. Each sample was collected over a surface area ranging between 250 cm² to 1000 cm² by means of combining a minimum of 10 separate cores obtained over a roughly 30 m² area.

The samples were thoroughly dried and homogenized before undergoing analyses for radionuclides of interest. A minimum of 50 grams of soil were subjected to either the HASL acid leach method² or a complete dissolution method for the analysis of ²³⁸Pu, ²³⁹Pu, and ⁹⁰Sr. Analysis of the leach residues from several samples for quality control purposes indicated that approximately 90% of the total plutonium activity in the samples was removed by this leach method. Gamma spectral analyses were made by placing approximately 300 grams of soil on a Ge(Li) detector equipped with Compton suppression systems.¹ These analyses provided quantitative data regarding the concentrations of ¹³⁷Cs, ¹⁴⁴Ce, and ⁹⁵Zr in Livermore soils.

The results of the analyses are provided in Table 4, and the sampling locations are shown in Fig. 4. The depth profile studies show that the radionuclides, including plutonium, do not penetrate appreciably into the soil, probably as a result of leaching or mechanical mixing. Generally the activity in the 15-20-cm layer is about a factor of 10 less than that in the top 1-cm layer, although wide variations may be observed in the data. The resulting deposition concentrations are shown in Table 5. The higher activities shown at the on-site locations 2 to 7 are due to their close proximity to the area being used for solar evaporation

of low-level radioactive waste liquids. At this time there is no evidence of any off-site contamination.

In addition, soil samples consisting of the top 1-cm layer were collected quarterly in the Livermore Valley at the 19 sampling locations shown in Figs. 1 and 2. These samples were digested in a mixture of perchloric and nitric acids, evaporated to dryness, redissolved in hydrogen peroxide and plated onto stainless steel plates for gross alpha and gross beta counting. The average alpha activity of all the samples was $2.8 \pm 45\%$ pCi/g with a high value of $4.7 \pm 35\%$ pCi/g. The beta activities exhibited an average value of $7.2 \pm 17\%$ pCi/g with a maximum value of $13 \pm 12\%$ pCi/g. These activities are within the normal range for soil in the Livermore Valley as determined by surveillance during previous years.

LABORATORY SEWER EFFLUENT

The liquid and solid effluent discharged through the Laboratory sanitary sewer system is treated at the City of Livermore Sewage Treatment Plant. The liquid and sludge are separated on entering this plant. The sludge passes into one of two digesters where it is broken down by bacterial action. Methane gas is evolved and burned, and the remaining sludge is released to large sludge ponds and retained for subsequent use as a soil conditioner. The purified water is used for irrigating the Livermore golf course and nearby agricultural land with the excess being discharged into the Los Positas Arroyo.

Sewage samples were collected daily at the Laboratory point of discharge into

Table 4. Activity levels of various radionuclides in soil (pCi/g).

Sampling stations ^a	Depth (cm)	²³⁸ Pu	²³⁹ Pu	⁹⁰ Sr	¹³⁷ Cs	⁹⁵ Zr	¹⁴⁴ Co
1	0 - 5		$2.7 \times 10^{-2} \pm 5\%$	$1.1 \times 10^{-1} \pm 16\%$	$1.7 \times 10^{-1} \pm 13\%$		
	5 - 10		$7.3 \times 10^{-3} \pm 10\%$	$8.2 \times 10^{-2} \pm 18\%$	$8.2 \times 10^{-2} \pm 21\%$		
	10 - 15		$5.5 \times 10^{-3} \pm 10\%$	$6.4 \times 10^{-2} \pm 18\%$	$8.0 \times 10^{-2} \pm 24\%$		
2	0 - 15	$2.2 \times 10^{-2} \pm 2\%$	$3.4 \times 10^{-2} \pm 2\%$	$1.5 \times 10^{-1} \pm 7\%$			
3	0 - 15	$1.8 \times 10^{-2} \pm 3\%$	$1.0 \times 10^{-1} \pm 3\%$	$1.4 \times 10^{-1} \pm 4\%$			
4	0 - 15	$8.6 \times 10^{-2} \pm 3\%$	$3.0 \times 10^{-1} \pm 3\%$	$1.0 \times 10^{-1} \pm 2\%$			
5	0 - 15	$2.7 \times 10^{-1} \pm 4\%$	$8.6 \times 10^{-1} \pm 4\%$	$1.1 \times 10^{-1} \pm 7\%$			
6	0 - 15	$2.4 \times 10^{-3} \pm 5\%$	$9.5 \times 10^{-3} \pm 3\%$	$1.4 \times 10^{-1} \pm 7\%$			
7	0 - 15	$4.2 \times 10^{-3} \pm 3\%$	$1.3 \times 10^{-2} \pm 3\%$	$1.0 \times 10^{-1} \pm 4\%$			
8	0 - 15	$1.3 \times 10^{-3} \pm 5\%$	$8.6 \times 10^{-3} \pm 3\%$	$8.2 \times 10^{-2} \pm 13\%$			
9	0 - 1		$1.0 \times 10^{-2} \pm 14\%$	$1.8 \times 10^{-1} \pm 13\%$	$2.4 \times 10^{-1} \pm 8\%$	$4.5 \times 10^{-2} \pm 20\%$	$1.2 \times 10^{-1} \pm 34\%$
	1 - 5		$7.7 \times 10^{-3} \pm 12\%$	$1.0 \times 10^{-1} \pm 20\%$	$3.1 \times 10^{-1} \pm 7\%$		
	5 - 10		$3.2 \times 10^{-3} \pm 30\%$	$1.0 \times 10^{-1} \pm 20\%$	$1.1 \times 10^{-1} \pm 18\%$		
	10 - 15		$2.3 \times 10^{-3} \pm 20\%$	$5.5 \times 10^{-2} \pm 25\%$	$\leq 3.0 \times 10^{-2}$		
	15 - 20		$6.4 \times 10^{-4} \pm 22\%$	$1.8 \times 10^{-2} \pm 25\%$			
10	0 - 1		$6.8 \times 10^{-3} \pm 5\%$	$1.8 \times 10^{-1} \pm 3\%$	$3.1 \times 10^{-1} \pm 7\%$	$5.3 \times 10^{-2} \pm 17\%$	$1.2 \times 10^{-1} \pm 5\%$
	1 - 5		$5.0 \times 10^{-3} \pm 5\%$	$1.0 \times 10^{-1} \pm 3\%$	$1.6 \times 10^{-1} \pm 11\%$		
	5 - 10		$3.3 \times 10^{-3} \pm 7\%$	$1.8 \times 10^{-1} \pm 3\%$	$1.7 \times 10^{-1} \pm 13\%$		
	10 - 15		$1.4 \times 10^{-3} \pm 12\%$	$5.0 \times 10^{-2} \pm 3\%$	$5.2 \times 10^{-2} \pm 20\%$		
	15 - 20		$7.3 \times 10^{-4} \pm 13\%$	$1.7 \times 10^{-2} \pm 5\%$	$2.8 \times 10^{-2} \pm 43\%$		
11	0 - 1	$1.0 \times 10^{-3} \pm 32\%$	$9.5 \times 10^{-3} \pm 7\%$		$2.9 \times 10^{-1} \pm 8\%$	$4.0 \times 10^{-2} \pm 27\%$	$1.7 \times 10^{-2} \pm 33\%$
	1 - 5	$3.3 \times 10^{-4} \pm 59\%$	$8.2 \times 10^{-3} \pm 5\%$		$2.3 \times 10^{-1} \pm 10\%$		
	5 - 10	$7.7 \times 10^{-4} \pm 36\%$	$7.7 \times 10^{-3} \pm 7\%$		$8.2 \times 10^{-2} \pm 21\%$		
	10 - 15	$9.5 \times 10^{-4} \pm 28\%$	$1.5 \times 10^{-2} \pm 8\%$		$3.9 \times 10^{-2} \pm 35\%$		
	15 - 20	$2.1 \times 10^{-4} \pm 89\%$	$4.3 \times 10^{-3} \pm 8\%$		$\leq 3.0 \times 10^{-2}$		
12	0 - 1	$6.8 \times 10^{-4} \pm 44\%$	$8.2 \times 10^{-3} \pm 4\%$	$1.6 \times 10^{-1} \pm 3\%$	$1.5 \times 10^{-1} \pm 16\%$	$6.0 \times 10^{-2} \pm 24\%$	$3.8 \times 10^{-1} \pm 22\%$
	1 - 15	$1.0 \times 10^{-4} \pm 40\%$	$2.7 \times 10^{-3} \pm 4\%$	$6.7 \times 10^{-2} \pm 2\%$	$5.4 \times 10^{-2} \pm 24\%$		
13	0 - 1	$3.3 \times 10^{-4} \pm 25\%$	$5.1 \times 10^{-3} \pm 4\%$	$1.5 \times 10^{-1} \pm 2\%$	$2.0 \times 10^{-1} \pm 11\%$	$1.1 \times 10^{-1} \pm 12\%$	$1.4 \times 10^{-1} \pm 48\%$
	1 - 15	$1.0 \times 10^{-4} \pm 40\%$	$2.5 \times 10^{-3} \pm 4\%$	$7.5 \times 10^{-2} \pm 2\%$	$7.4 \times 10^{-2} \pm 17\%$		
14	0 - 1	$7.3 \times 10^{-4} \pm 10\%$	$7.1 \times 10^{-3} \pm 3\%$	$1.8 \times 10^{-1} \pm 2\%$	$2.0 \times 10^{-1} \pm 13\%$	$1.1 \times 10^{-1} \pm 14\%$	$4.0 \times 10^{-1} \pm 16\%$
	1 - 15	$6.3 \times 10^{-5} \pm 54\%$	$2.8 \times 10^{-3} \pm 5\%$	$7.5 \times 10^{-2} \pm 2\%$			

^aSee Fig. 1 for location of stations.

Fig. 4. Livermore Valley soil sampling locations. Location 1 (not shown) is about 5 miles west of the Laboratory.

Table 5. Deposition levels of various radionuclides in soil (activities in mCi/km²).

Sampling stations ^a	²³⁸ Pu	²³⁹ Pu	⁹⁰ Sr	¹³⁷ Cs	⁹⁵ Zr	¹⁴⁴ Ce
1		2.7	18	23		
2	4.8	7.5	33			
3	3.4	22	31			
4	18	63	21			
5	56	180	23			
6	0.65	2.6	38			
7	1.2	3.7	29			
8	0.29	1.9	18			
9		1.5	21	29	0.51	1.6
10		0.76	20	31	0.72	1.6
11	0.16	2.6	19	26	0.54	0.23
12	0.028	0.65	16	13	0.60	3.8
13	0.024	0.57	17	17	1.3	1.6
14	0.018	0.65	17			

^aSee Fig. 1 for location of stations.

Table 6. Results of laboratory sewer effluent monitoring.

Month	Alpha activity (pCi/liter)		Beta activity (pCi/liter)		Tritium activity (pCi/liter)		Mixed iodine (pCi/liter)	
	High	Average	High	Average	High	Average	High	Average
January	26 ± 14%	7.2 ± 29%	160 ± 2%	54 ± 5%	2.3 × 10 ⁵ ± 1%	2.9 × 10 ⁴ ± 3%	1100 ± 1% ^a	74 ± 5%
February	11 ± 18%	4.7 ± 30%	120 ± 2%	42 ± 11%	1.2 × 10 ⁴ ± 5%	5.9 × 10 ³ ± 25%	33 ± 10%	17 ± 62%
March	17 ± 17%	7.2 ± 45%	1400 ± 1%	200 ± 4%	6.7 × 10 ⁴ ± 4%	8.6 × 10 ³ ± 40%	53 ± 8%	17 ± 63%
April	19 ± 16%	4.8 ± 31%	130 ± 3%	39 ± 5%	3.4 × 10 ⁴ ± 13%	9.1 × 10 ³ ± 20%	5 ± 50%	2.6 ± 54%
May	10 ± 18%	5.0 ± 20%	75 ± 4%	35 ± 10%	2.0 × 10 ⁴ ± 5%	5.0 × 10 ³ ± 34%	28 ± 18%	3.5 ± 45%
June	18 ± 15%	5.9 ± 31%	160 ± 3%	36 ± 22%	7.0 × 10 ³ ± 10%	3.4 × 10 ³ ± 23%	5.1 ± 50%	3.5 ± 50%

^aThis value resulted from an individual who had been receiving an ¹³¹I medical exposure.

the Livermore sewer system. These samples were prepared for alpha and beta counting by techniques similar to those used to prepare soil samples for the gross activity measurements. In addition, 1 milliliter of each sample was analyzed for tritium activity by direct liquid scintillation counting. A separate portion of each sample was subjected to inorganic iodine analysis by radiochemically separating the iodine by a standard organic extraction and precipitation procedure.

The resulting precipitate was then beta counted. The results of these analyses for each month are given in Table 6.

A portion of each of the daily samples was composited during each month. These monthly composite samples were subjected to ⁹⁰Sr, ²²⁶Ra, and ²²⁸Ra analyses. The strontium determinations were performed by radiochemically separating the strontium activity from the samples. After ⁹⁰Sr/⁹⁰Y equilibrium had been established, the ⁹⁰Y was

separated for beta counting. The ^{226}Ra activities were obtained by collecting the ^{222}Rn released from the samples over a two week period. The radon gas was then counted in a zinc sulfide scintillation detector. The ^{228}Ra , on the other hand, was radiochemically separated and beta counted. The results of the analyses are given in Table 7. Samples were also collected at the Livermore Sewage Treatment Plant to determine that no significant build-up of radioactivity occurred at the plant. Weekly samples were collected from each digester and the aeration tank for gross radioactivity analyses. Approximately three samples per week were obtained of the liquid effluent discharged from the plant. These were analyzed for gross activity and tritium, and a monthly composite sample of the effluent was analyzed for ^{90}Sr . The results of these analyses, averaged over one month periods, are given in Table 8.

Table 7. Activities of ^{90}Sr , ^{226}Ra , and ^{228}Ra in monthly composite Laboratory sewer samples.

Month	Average activities (pCi/liter)		
	^{90}Sr	^{226}Ra	^{228}Ra
January	$1.8 \pm 11\%$	$0.11 \pm 110\%$	$1.2 \pm 16\%$
February	$0.9 \pm 50\%$	$0.10 \pm 110\%$	$0.9 \pm 50\%$
March	$2.2 \pm 9\%$	$0.07 \pm 130\%$	$0.6 \pm 23\%$
April	$1.0 \pm 15\%$	$0.07 \pm 43\%$	$0.3 \pm 50\%$
May	$1.2 \pm 20\%$	$0.03 \pm 71\%$	$0.5 \pm 33\%$

WATER

Monthly samples were collected from various sources of water in the Livermore Valley to determine that no buildup of radioactivity occurred in local water supplies. These samples were analyzed for gross alpha, gross beta, and tritium activities by techniques similar to those listed for sewer samples. No sample showed an alpha activity above the limit of detection of 1.2 pCi/liter. The average

Table 8. Livermore Sewage Treatment Plant sampling results.

Month	Gross alpha activity (pCi/liter)						Tritium activity (pCi/liter)		
	Digesters		Aeration tank		Effluent		Effluent		
	High	Average	High	Average	High	Average	High	Average	
January	$380 \pm 20\%$	$250 \pm 23\%$	$57 \pm 10\%$	$48 \pm 23\%$	$22 \pm 50\%$	$13 \pm 53\%$	$1.4 \times 10^4 \pm 5\%$	$1.1 \times 10^4 \pm 17\%$	
February	$230 \pm 24\%$	$160 \pm 28\%$	$29 \pm 28\%$	$27 \pm 44\%$	$80 \pm 50\%$	$28 \pm 66\%$	$4.1 \times 10^3 \pm 50\%$	$3.6 \times 10^3 \pm 50\%$	
March	$180 \pm 42\%$	$150 \pm 41\%$	$49 \pm 41\%$	$39 \pm 37\%$	$32 \pm 50\%$	$14 \pm 61\%$	$2.4 \times 10^5 \pm 3\%$	$4.3 \times 10^4 \pm 7\%$	
April	$190 \pm 23\%$	$190 \pm 21\%$	$31 \pm 27\%$	$29 \pm 28\%$	$11 \pm 50\%$	$54 \pm 57\%$	$8.0 \times 10^3 \pm 14\%$	$4.2 \times 10^3 \pm 21\%$	
May	$350 \pm 20\%$	$210 \pm 23\%$	$74 \pm 22\%$	$49 \pm 23\%$	$27 \pm 50\%$	$11 \pm 60\%$	$3.4 \times 10^5 \pm 2\%$	$5.8 \times 10^4 \pm 5\%$	
June	$510 \pm 13\%$	$260 \pm 18\%$	$52 \pm 21\%$	$48 \pm 22\%$	$5.6 \pm 50\%$	$2.7 \pm 64\%$	$1.8 \times 10^3 \pm 50\%$	$1.7 \times 10^3 \pm 50\%$	

Month	Gross beta activity (pCi/liter)						^{90}Sr activity (pCi/liter)	
	Digesters		Aeration tank		Effluent		Effluent	
	High	Average	High	Average	High	Average	Average	
January	$1.4 \times 10^3 \pm 5\%$	$530 \pm 8\%$	$60 \pm 4\%$	$49 \pm 5\%$	$48 \pm 15\%$	$17 \pm 32\%$	$0.5 \pm 50\%$	
February	$9.7 \times 10^2 \pm 4\%$	$360 \pm 8\%$	$45 \pm 5\%$	$27 \pm 15\%$	$19 \pm 43\%$	$37 \pm 80\%$	$1.5 \pm 20\%$	
March	$1.1 \times 10^3 \pm 6\%$	$580 \pm 8\%$	$120 \pm 5\%$	$71 \pm 5\%$	$88 \pm 14\%$	$35 \pm 22\%$	$0.6 \pm 21\%$	
April	$1.0 \times 10^3 \pm 4\%$	$530 \pm 6\%$	$84 \pm 5\%$	$48 \pm 6\%$	$40 \pm 9\%$	$17 \pm 24\%$	$1.6 \pm 16\%$	
May	$3.4 \times 10^2 \pm 8\%$	$280 \pm 6\%$	$52 \pm 5\%$	$37 \pm 6\%$	$51 \pm 17\%$	$17 \pm 28\%$	$6.4 \pm 50\%$	
June	$1.1 \times 10^3 \pm 4\%$	$390 \pm 7\%$	$41 \pm 5\%$	$36 \pm 6\%$	$17 \pm 24\%$	$15 \pm 25\%$		

Table 9. Gross beta activities in Livermore water samples.

Sampling stations ^a	January - March Average gross beta activity (pCi/liter)	Sampling stations ^a	April - May Average gross beta activity (pCi/liter)
1	4.3 ± 41%	1	2.1 ± 50%
2	3.6 ± 48%	2	2.7 ± 38%
3	2.9 ± 34%	10	4.7 ± 19%
4	2.2 ± 45%	11	4.3 ± 20%
5	2.7 ± 36%	12	4.6 ± 20%
6	2.0 ± 51%	13	12 ± 11%
7	3.1 ± 32%	14	3.1 ± 26%
8	2.4 ± 42%	15	11 ± 11%
9	2.6 ± 39%	16	1.8 ± 50%

^aSee Fig. 1 for location of stations.

beta activities are given in Table 9. Locations 1 to 9 represent deep well water sources and commercial water sources of unknown origin. Locations 10 to 15 represent surface sources such as ponds (available to cattle), lakes and reservoirs. Location 16 is a deep well. The activities range over a factor of about 6, with the higher activities generally being found in samples from surface sources. This is to be expected because of the intimate contact these sources have with the atmosphere, which contains large quantities of radioactivity produced by natural cosmic ray interactions and nuclear weapons detonations. The average tritium activity in all of the samples was $4.0 \times 10^3 \pm 29\%$ with a maximum value of $1.1 \times 10^4 \pm 6\%$ pCi/liter.

VEGETATION

Gross samples were collected from nine locations in the Livermore Valley during January, April, and May. Each sample was dried in ambient air for about one week and then pressed into a

5-inch diameter and 1-inch thick pellet weighing approximately 200 grams. This pellet was analyzed for various gamma emitting radionuclides by placing it between two 8 × 4 inch NaI(Tl) crystals. A portion of each sample was also freeze-dried and the collected water was analyzed for tritium activity by direct scintillation counting. The concentrations of the gamma emitting radionuclides are listed in Table 10. The average tritium

Table 10. Radionuclide concentrations in vegetation samples.

Radionuclide	Activity (pCi/g)		Limit of detection (pCi/g)
	High	Average	
¹³⁷ Cs	0.24	0.18	0.01
¹⁰⁶ Ru/ ¹⁰⁶ Rh	0.64	≤ 0.34	0.02
¹⁴⁴ Ce	2.4	1.4	0.02
⁹⁵ Zr/ ⁹⁵ Nb	1.4	0.63	0.01
⁵⁴ Mn	0.04	≤ 0.02	0.01
⁷ Be	2.4	1.8	0.01
¹⁰³ Ru	0.15	≤ 0.07	0.02
¹²⁵ Sb	0.04	≤ 0.02	0.02

activity of the freeze dried water was 2.5×10^4 pCi/liter with a maximum of 2.7×10^5 pCi/liter.

MILK

Samples were collected each month from dairies in the Livermore and Site 300 areas respectively. The Livermore Valley dairy is about 6 miles west of the Laboratory and the dairy in the Site 300 area is about 3 miles north of the Site. The samples were concentrated with a vacuum-operated, foam entrainment evaporator so that about 9 liters of whole milk were condensed to 2 liters.³ The resulting samples were gamma-counted in Plexiglass containers placed between two 8×4 inch NaI(Tl) crystals. In addition, each sample was analyzed for tritium activity by counting 1 milliliter of the distillate directly in a standard liquid scintillation detector. The average activities of ^{137}Cs , ^{144}Ce , and tritium are listed in Table 11.

ACCIDENTAL RELEASE OF TRITIUM GAS

Continuous air sampling is maintained on the stack effluent from the Gaseous Chemistry Building. On April 12, 1971, a small amount of tritium was released from this facility. An extensive sampling

program was conducted to evaluate the effects of the release on the environment. Vegetation, atmospheric water vapor and water samples were collected and analyzed for tritium activity. The vegetation samples were freeze-dried and the collected water was subjected to scintillation counting. Other samples were counted directly in the same manner. Detectable activities were observed in some off-site vegetation and water vapor samples. The maximum activity in vegetation samples was 1.6×10^5 pCi/liter with the average activity of all the samples being $\leq 2.5 \times 10^4$ pCi/liter. The atmospheric water vapor samples indicated a maximum activity of 5.9×10^3 pCi/m³ and an average value of 2×10^3 pCi/m³. Thus, even the highest measured concentrations as well as the calculated maximum credible ground level air concentration that could have resulted during passage of the tritium cloud were well below the off-site maximum permissible concentration for continuous exposure.

EXTERNAL RADIATION MEASUREMENTS

Terrestrial background radiation was measured with thermoluminescent dosimeters at the nine on-site locations shown in Fig. 2. The dosimeters, consisting of CaF_2 : Dy chips, were placed

Table 11. Activities observed in milk samples (pCi/liter).

	^{137}Cs		^{144}Ce		^3He	
	High	Average	High	Average	High	Average
Livermore dairy	9.1	4.9	19	9.8	1.0×10^5	2.4×10^4
Site 300 dairy	5.6	3.5	13	3.9	6.7×10^3	5.2×10^3

Fig. 5. Locations of thermoluminescent dosimeter locations in the vicinity of Lawrence Livermore Laboratory.

about 1 meter above the ground and were exposed over a period of three months. The integrated exposures over the consecutive three-month periods are given in Table 12. The higher exposures measured at locations 1, 3, and 5 are undoubtedly due to their close proximity to a linear accelerator, a ^{60}Co facility and a physics building, respectively.

Similar measurements were made at 29 off-site locations (shown in Fig. 5) in the immediate vicinity of the Laboratory over the period of March 15 to June 15, 1971. The resulting exposures ranged from 7.9 to 14 mR over the three-month period with a median of 11 mR. The frequency distribution of the exposures is shown in Fig. 6.

Table 12. Terrestrial background radiation levels measured during three-month periods (mR/3-mo).

Stations ^a	January - March	April - June
1	13	13
2		12
3	18	14
4	10	12
5	41	18
6	10	12
7	10	10
8	10	11
9	10	10

^aSee Fig. 2 for location of stations.

Fig. 6. Frequency distribution of TLD measurements from the locations shown in Fig. 4.

Fig. 7. Site 300 and vicinity environmental sampling locations.

Environmental Levels of Radioactivity—Site 300

ATMOSPHERIC RADIOACTIVITY

The concentrations of various airborne radioactive substances were measured continuously at 11 air sampling stations located as shown in Fig. 7. Ten of the samplers were located within the boundaries of Site 300 because electric power is not available off-site. The remaining sampler is located in Tracy, the primary population center of concern. The on-site samplers are operated continuously at about 25 cfm, and have Whatman filters while the sampler in Tracy has HV-70 filters and operates at a flow rate of about 4 cfm. The filters are changed weekly during the winter months and twice weekly during the summer to avoid excessive mass loading. The filters are analyzed in a similar

manner to that previously described for filters used in the Livermore Valley.

No gross alpha activity above the 0.001 pCi/m³ detection limit was observed on these filters. The gross beta activities, averaged over three-month periods, are shown in Table 13 for each sampling location. The average activities are slightly higher than those measured in the Livermore Valley. Gamma spectral measurements made on monthly composite samples of the on-site filters reveal measurable quantities of various gamma-emitting radionuclides as may be seen in Table 14. The activity levels are essentially identical with those measured in the Livermore Valley. The results of isotopic plutonium and uranium analyses, performed by the techniques described previously, are provided in Table 15.

Table 13. Airborne particulate activity around LRL Site 300.

Sampling stations ^a	January - March Gross beta activity (pCi/m ³)		April - June Gross beta activity (pCi/m ³)	
	Maximum	Average	Maximum	Average
1	0.42 ± 1%	0.090 ± 2%	0.33 ± 1%	0.26 ± 1%
2	0.40 ± 1%	0.095 ± 3%	0.34 ± 1%	0.22 ± 1%
3	0.33 ± 1%	0.086 ± 3%	0.29 ± 1%	0.20 ± 1%
4	0.18 ± 2%	0.065 ± 3%	0.30 ± 1%	0.23 ± 1%
5	0.43 ± 1%	0.090 ± 2%	0.27 ± 1%	0.20 ± 1%
6	0.42 ± 2%	0.12 ± 5%	0.31 ± 2%	0.23 ± 2%
7	0.38 ± 1%	0.089 ± 4%	0.32 ± 1%	0.21 ± 1%
8	0.27 ± 1%	0.077 ± 3%	0.29 ± 1%	0.24 ± 1%
9	0.65 ± 1%	0.13 ± 2%	0.45 ± 1%	0.33 ± 1%
10	0.44 ± 1%	0.11 ± 2%	0.39 ± 1%	0.29 ± 1%
11	0.28 ± 1%	0.10 ± 2%	0.61 ± 1%	0.37 ± 1%

^aSee Fig. 7 for location of stations.

Table 14. Results of gamma-ray spectral measurements of Site 300 air filters (pCi/m³).

Month	¹⁴⁴ Ce	¹⁴¹ Ce	¹²⁵ Sb	⁷ Be	¹⁰³ Ru	¹⁰⁶ Ru	¹³⁷ Cs	⁹⁵ Zr
January	$7.5 \times 10^{-3} \pm 2\%$	$1.8 \times 10^{-3} \pm 7\%$	$9.5 \times 10^{-4} \pm 12\%$	$3.5 \times 10^{-2} \pm 3\%$	$2.0 \times 10^{-3} \pm 7\%$	$3.4 \times 10^{-3} \pm 12\%$	$8.3 \times 10^{-4} \pm 5\%$	$2.4 \times 10^{-3} \pm 3\%$
February	$1.2 \times 10^{-3} \pm 2\%$	$3.9 \times 10^{-3} \pm 4\%$	$9.1 \times 10^{-4} \pm 14\%$	$4.0 \times 10^{-2} \pm 4\%$	$5.5 \times 10^{-3} \pm 4\%$	$3.8 \times 10^{-3} \pm 10\%$	$1.2 \times 10^{-3} \pm 7\%$	$6.3 \times 10^{-3} \pm 2\%$
March	$4.0 \times 10^{-2} \pm 1\%$	$1.5 \times 10^{-3} \pm 2\%$	$2.2 \times 10^{-3} \pm 10\%$	$7.8 \times 10^{-2} \pm 3\%$	$2.2 \times 10^{-2} \pm 2\%$	$1.5 \times 10^{-2} \pm 8\%$	$3.3 \times 10^{-3} \pm 4\%$	$2.8 \times 10^{-2} \pm 1\%$
April	$3.0 \times 10^{-2} \pm 1\%$	$9.3 \times 10^{-3} \pm 2\%$	$2.0 \times 10^{-3} \pm 2\%$	$5.2 \times 10^{-2} \pm 4\%$	$1.8 \times 10^{-2} \pm 3\%$	$8.1 \times 10^{-3} \pm 10\%$	$2.8 \times 10^{-3} \pm 8\%$	$2.8 \times 10^{-2} \pm 1\%$
May	$1.0 \times 10^{-1} \pm 1\%$	$1.4 \times 10^{-3} \pm 7\%$	$5.8 \times 10^{-3} \pm 7\%$	$1.0 \times 10^{-1} \pm 3\%$	$2.8 \times 10^{-2} \pm 2\%$	$4.3 \times 10^{-2} \pm 5\%$	$7.5 \times 10^{-3} \pm 3\%$	$6.1 \times 10^{-3} \pm 1\%$
June	$7.4 \times 10^{-2} \pm 13\%$	$8.0 \times 10^{-3} \pm 3\%$	$4.0 \times 10^{-3} \pm 13\%$	$6.0 \times 10^{-2} \pm 5\%$	$1.5 \times 10^{-2} \pm 3\%$	$7.4 \times 10^{-2} \pm 5\%$	$4.8 \times 10^{-3} \pm 8\%$	$4.0 \times 10^{-2} \pm 1\%$

Table 15. Plutonium and uranium concentrations in Site 300 air filters.

Month	Activity (pCi/m ³)			Mass (ng/m ³)		
	²³⁸ Pu	²³⁹ Pu	²³⁸ Pu/ ²³⁹ Pu	²³⁵ U	²³⁸ U	²³⁵ U/ ²³⁸ U
January	$3.5 \times 10^{-6} \pm 6\%$	$2.7 \times 10^{-5} \pm 3\%$	1.3×10^{-1}	$1.8 \times 10^{-3} \pm 2\%$	$9.3 \pm 2\%$	2.0×10^{-3}
February	$3.8 \times 10^{-6} \pm 6\%$	$3.1 \times 10^{-5} \pm 3\%$	1.2×10^{-1}	$1.5 \times 10^{-4} \pm 2\%$	$5.4 \times 10^{-2} \pm 2\%$	2.8×10^{-3}
March	$6.2 \times 10^{-6} \pm 7\%$	$9.5 \times 10^{-5} \pm 4\%$	8.6×10^{-2}	$3.4 \times 10^{-4} \pm 1\%$	$8.3 \times 10^{-2} \pm 1\%$	4.1×10^{-3}
April	$4.8 \times 10^{-6} \pm 6\%$	$5.7 \times 10^{-5} \pm 4\%$	7.2×10^{-2}	$1.9 \times 10^{-3} \pm 1\%$	$9.0 \times 10^{-1} \pm 1\%$	2.1×10^{-3}
May	$4.5 \times 10^{-6} \pm 7\%$	$7.4 \times 10^{-5} \pm 4\%$	6.1×10^{-2}	$2.5 \times 10^{-4} \pm 4\%$	$6.5 \times 10^{-2} \pm 4\%$	3.8×10^{-3}

The relative abundance of ²³⁸Pu to ²³⁹Pu is approximately that expected in global fallout. The uranium content of airborne debris, on the other hand, is greatly depleted relative to that of natural uranium and the concentrations are at times significantly greater than those measured in the Livermore Valley. This is not unexpected in view of the sizable quantities of depleted uranium that have been expended over the years as a result of the high explosive detonations at the site. However, these concentrations are nevertheless far lower than the current concentration guide levels set forth in AECM 0524.

The weekly average gross beta activities on the air filters are shown in Fig. 8. Again, the spring increase in surface air activity is evident.

WATER

Monthly samples were collected from on-site wells which supply water to the site and from various on-site streams and ponds. The locations of these sources are shown in Fig. 6. No sample showed an alpha activity above 1.2 pCi/liter, the limit of detection. The average beta activities are shown in Table 16. Locations 1 to 7 represent deep-well water sources and locations 8 and 9 represent creek sources. The activities were similar to those observed within the Livermore Valley.

An additional number of samples were collected twice a week from on-site springs and ponds and composited over two-month periods. These composite samples were analyzed for tritium

Fig. 8. Weekly average beta activity of air filters from Site 300 sampling stations.

Table 16. Average gross beta activities in Site 300 water samples (pCi/liter).

Sampling stations ^a	January-March	April-May
1	5.5 ± 36%	3.5 ± 40%
2	11 ± 17%	4.8 ± 30%
3	8.7 ± 20%	6.6 ± 22%
4	5.9 ± 34%	4.1 ± 32%
5	4.8 ± 19%	5.2 ± 27%
6	6.2 ± 26%	4.6 ± 32%
7	4.0 ± 49%	4.6 ± 32%
8	8.2 ± 20%	11 ± 16%
9	4.8 ± 31%	3.4 ± 41%

^aSee Fig. 7 for location of stations.

activities. The samples containing low tritium activities were vacuum distilled, electrolytically enriched and analyzed by liquid scintillation counting.

The results are shown in Table 17. Inspection of the results reveals that all the activities, except for those in samples collected from sources E and F, are within the normal fluctuations observed during previous sampling periods. Sources E and F, which are springs, exhibit unusually high activities. However, no explanation is available regarding these activities since the

Table 17. Tritium activities in Site 300 water samples (pCi/liter).

Sampling stations ^a	January-February	March-April	May-June
A	$3.1 \times 10^2 \pm 19\%$		
B	$3.7 \times 10^2 \pm 34\%$		
C	$2.4 \times 10^2 \pm 27\%$	$3.4 \times 10^2 \pm 7\%$	$4.1 \times 10^2 \pm 15\%$
D	$2.6 \times 10^2 \pm 21\%$		
E	$6.8 \times 10^5 \pm 1\%$	$8.2 \times 10^4 \pm 1\%$	$6.1 \times 10^5 \pm 1\%$
F	$3.8 \times 10^1 \pm 36\%$	$4.1 \times 10^1 \pm 22\%$	$2.8 \times 10^5 \pm 2\%$
G	$1.2 \times 10^1 \pm 85\%$	$7.7 \times 10^1 \pm 18\%$	$1.5 \times 10^2 \pm 330\%$
H	$2.0 \times 10^2 \pm 11\%$	$5.0 \times 10^1 \pm 22\%$	$1.5 \times 10^3 \pm 24\%$

^aSee Fig. 7 for location of stations.

origins of the springs are presently unknown.

Summary

An environmental surveillance program was conducted in the Livermore Valley and Site 300 areas to ascertain the effect of the Laboratory's operations on the environment. Samples of airborne particulates, soil, water, sewage, milk, and vegetation were collected and analyzed for gross radioactivity as well as for specific radionuclides of interest. The gross alpha and beta activities in airborne particulates, soil, water, and sewage samples were similar to those measured during the past year. Gamma spectral measurements of particulate debris collected by on-site air samplers revealed measurable activities of the typical gamma emitters present in global fallout. The relative activities of ^{238}Pu to ^{239}Pu in debris deposited on the filters were similar to those observed in global fallout, however, isotopic uranium analyses indicate the uranium contained in the particulates collected on the air filters at Site 300 was depleted with respect to that for natural uranium. This is un-

SOIL

Soil samples were collected quarterly at the nine on- and off-site locations shown in Fig. 6. Only the top 1-cm layer was collected for analysis of gross alpha and gross beta activities. The average alpha activity of all the samples was $3.5 \pm 41\%$ pCi/g with a maximum value of $5.1 \pm 33\%$ pCi/g. The beta activities indicated an average value of $7.5 \pm 17\%$ with a high of $8.5 \pm 15\%$ pCi/g.

doubtedly due to the expenditure of relatively large quantities of depleted uranium in high explosive detonations at Site 300.

Livermore Valley soil samples, subjected to plutonium, strontium and gamma spectral analyses, revealed some on-site contamination in the vicinity of the area being used for solar evaporation of radioactive liquids, but no off-site contamination was indicated.

Milk and vegetation samples revealed no gamma-emitting radionuclides other than those present in global fallout. Their activities were similar to those observed during previous reporting periods.

The stack sampling program indicated a small amount of tritium did escape accidentally into the environment from the Gaseous Chemistry Building, however, on- and off-site tritium concentrations in atmospheric water vapor, vegetation and water samples collected downwind from the source were well below MPC levels.

Thus, the radioactivity within the environment remained below the

appropriate concentration guide levels listed in AEC Manual Chapter 0524.

Appendix

Environmental Activity Guide Levels

The Standards for Radiation Protection (AEC Manual Chapter 0524, issued 11/8/68) state that if there is a mixture in air and water of radionuclides whose identity and concentrations are unknown, the average activity should not exceed the following values:

1. Air (controlled area) 6 pCi/m³
2. Air (uncontrolled area) 0.02 pCi/m³
3. Water (controlled area) 400 pCi/liter
4. Water (uncontrolled area) 30 pCi/liter

If it is known that alpha emitters and ²²⁷Ac are not present, the following guide values may be used to determine the permissible average activity:

5. Air (controlled area) 30 pCi/m³
6. Air (uncontrolled area) 1 pCi/m³

If it is known that ¹²⁹I, ²²⁶Ra, and ²²⁸Ra are not present, the following values may be used:

7. Water (controlled area) 3000 pCi/liter
8. Water (uncontrolled area) 100 pCi/liter

The air and water samples are subjected to gross alpha and gross beta measurements. The average annual alpha activities may not exceed those listed under points 1 through 4 above. Since the alpha emitters have been accounted for in the gross alpha measurements, and the assumption is made that ¹²⁹I, ²²⁷Ac, ²²⁶Ra, and ²²⁸Ra are not present in the samples, the annual average gross beta activities of the samples may not exceed the activities listed under points 5 through 8 above. The assumption that ¹²⁹I, ²²⁷Ac, ²²⁶Ra, and ²²⁸Ra are not present in air and water samples is reasonable in view of the minute quantities of these radionuclides available at the Laboratory. AEC Manual Chapter 0524 also states that the average tritium activities in off-site water samples may not exceed 3×10^6 pCi/liter.

Since analyses for ¹²⁹I, ²²⁶Ra, and ²²⁸Ra activities are made on sewer effluent samples, the average monthly alpha and beta activities of these samples should not exceed the guide value of 3000 pCi/liter listed under point 7 above, and the tritium activity should not exceed 10⁸ pCi/liter.

The annual external whole body radiation dose to workers in controlled areas may not exceed 5 rem; while that to an individual in an uncontrolled area may not exceed 500 mrem. An average annual dose of 170 mrem may not be exceeded for a group of individuals in an uncontrolled area.

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