BNL 807 (T-310)

1962 ENVIRONMENTAL RADIATION LEVELS AT BROOKHAVEN NATIONAL LABORATORY

A.P. HULL

May 1963

BROOKHAVEN NATIONAL LABORATORY

ASSOCIATED UNIVERSITIES, INC.

under contract with the

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BNL 807 (T-310)
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PREFACE

Environmental monitoring data have been obtained in the vicinity of Brookhaven National Laboratory since 1949. Except for the limited amount appearing since 1960 in semiannual press releases, little of this information has been generally available.

Following the resumption of atmospheric testing of nuclear devices in the latter part of 1961, considerable data have been obtained on fallout levels in the environment. Many persons have suggested that these data are of widespread interest beyond the Laboratory. Most of the information for 1962 is summarized in the following report. The publication of regular annual reports is planned. Some of the information gathered during the period between 1949 and 1961 is also being reviewed for possible publication in these future reports.

1962 ENVIRONMENTAL RADIATION LEVELS AT BROOKHAVEN NATIONAL LABORATORY

INTRODUCTION

The monitoring of environmental radioactivity in the vicinity of the Brookhaven National Laboratory site is performed by the Area Survey Section of the Health Physics Division. Laboratory operations contribute three principal additions to the natural background radiation in the vicinity: radiation that reaches the ground from the Ar^{41} in the cooling-air effluent of the Brookhaven Graphite Research Reactor (BGRR); radiation from an ecology field gamma source; and the low levels of radioactivity contained in liquid wastes released to a small stream that forms one of the headwaters of the Peconic River. Natural background and radiation levels attributable to Laboratory operations during 1962 are summarized in this report.

Fallout from the atmospheric testing of nuclear weapons has been prominent in many types of environmental samples. Although its identification has been only an incidental aspect of the Area Survey Section's activities, such information about fallout radioactivity levels as has been obtained is also summarized.

EXTERNAL EXPOSURE MONITORING

Environmental radiation levels, including natural background and increments attributable to the BGRR cooling-air effluent and the ecology forest source, are monitored continuously at nine fixed area survey stations. As indicated in Figure 1, three of these stations are on site, four are on or near the perimeter, and two are off site. Included in the equipment of each station is an ion chamber and dynamic condenser electrometer assembly, which has been described in detail elsewhere.[1] These units are capable of accurately measuring $<10\ \mu r/hr$ and of detecting changes of the order of $1\ \mu r/hr$.

Monthly average gross external radiation levels are given in Table 1. For convenience in making comparisons in this and the immediately following summaries, the stations have been grouped according to location on site, at the perimeter, and off site.

Since the yearly average maximum permissible occupational exposure of 100 mr/wk to persons employed at the Laboratory and the yearly average maximum permissible nonoccupational exposure of 10 mr/wk to persons living in the vicinity of the Laboratory are in addition to natural background, it is of interest to determine the latter. "Natural" background levels, as measured by roof-mounted six-liter ion chambers which reflect some deposition of fallout radioactivity from the atmospheric testing of nuclear devices, are indicated in Table 2. The composite monthly aver-

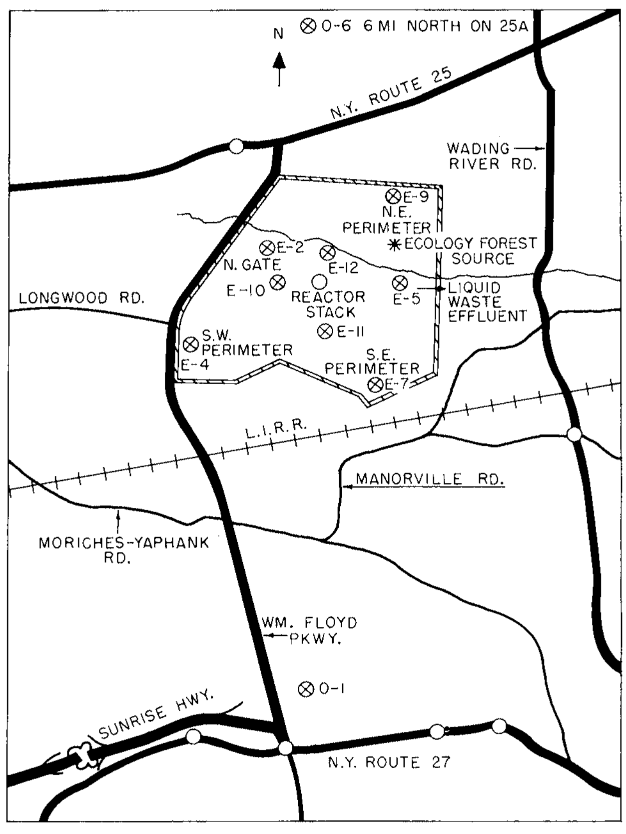

Figure 1. Location of BNL area survey stations.

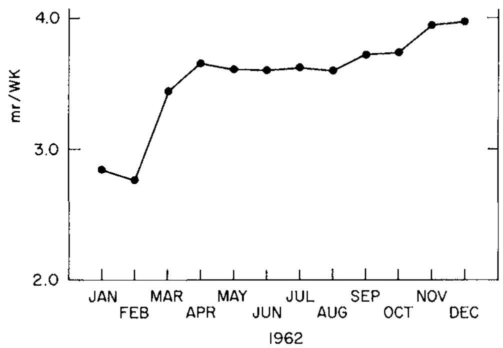

Figure 2. Natural background radiation levels, composite monthly average.

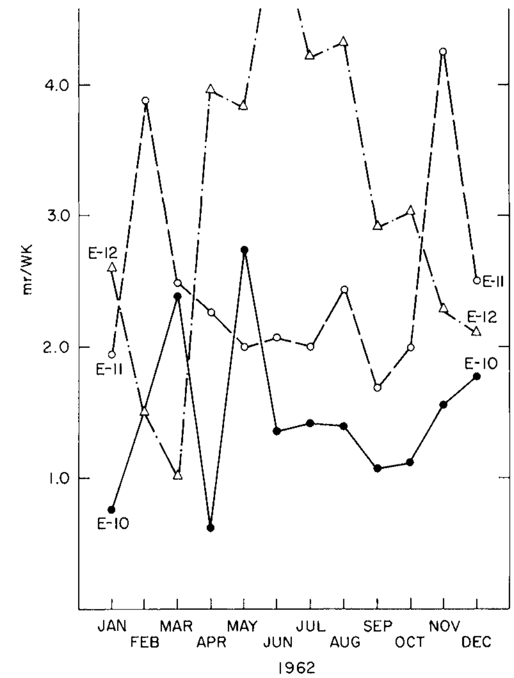

Figure 3. Ar^{41} monthly average radiation levels, on-site stations.

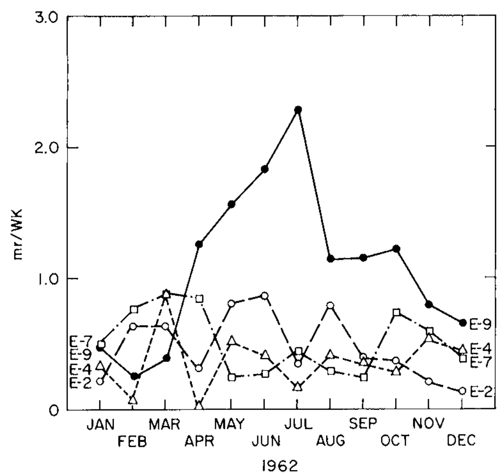

Figure 4. Ar^{41} monthly average radiation levels, perimeter stations.

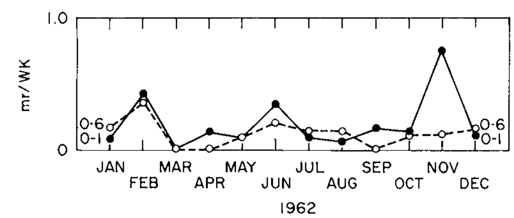

Figure 5. Ar^{41} monthly average radiation levels, off-site stations.

Table 1

1962 BNL Area Survey
Monthly Average Gross Radiation Levels, mr/wk

	On site			Perimeter				Off site	
Month	E-10	E-11	E-12	E-2	E-4	E-7	E-9	O-1	O-6
Jan.	3.83	4.88	5.54	3.20	3.85	3.52	4.50	2.88	2.61
Feb.	4.74	6.76	3.95	3.45	3.67	3.71	4.26	3.02	2.74
Mar.	6.31	6.13	4.10	3.93	4.73	4.48	5.19	3.51	3.09
April	4.75	6.18	7.33	3.85	4.13	4.76	6.44	3.84	3.13
May	6.86	5.85	7.33	4.41	4.59	4.37	6.79	3.87	3.24
June	5.41	6.06	8.71	4.51	3.50	4.56	6.73	3.90	3.22
July	5.47	5.92	7.50	3.99	3.30	3.84	7.91	3.87	3.29
Aug.	5.44	6.57	7.62	4.47	3.57	3.57	7.13	3.50	3.36
Sept.	5.33	5.75	6.56	4.30	3.61	3.66	7.11	3.39	3.41
Oct.	5.32	6.26	6.74	4.44	3.61	4.18	7.01	3.21	3.40
Nov.	5.89	8.10	5.92	4.65	4.24	4.44	6.83	4.12	3.91
Dec.	6.17	6.49	6.31	4.26	4.06	4.35	6.30	3.75	3.52
Av	5.46	6.25	6.47	4.12	3.91	4.12	6.35	3.57	3.27

Estimated error, ±0.30 mr/wk.

Month	On site			Perimeter				Off site		All stations, av
	E-10	E-11	E-12	E-2	E-4	E-7	E-9	O-1	O-6	
Jan.	3.08	2.94	2.94	2.99	2.62	3.01	2.76	2.80	2.45	2.84
Feb.	3.22	2.87	2.45	2.82	2.67	2.94	2.81	2.59	2.38	2.75
Mar.	3.92	3.64	3.08	3.29	2.96	3.62	3.56	3.57	3.29	3.44
Apr.	4.13	3.92	3.36	3.54	3.23	3.92	3.87	3.71	3.15	3.65
May	4.13	3.85	3.50	3.61	3.16	4.13	3.07	3.78	3.15	3.60
June	4.06	3.99	3.36	3.65	3.09	4.30	3.27	3.55	3.01	3.59
July	4.06	3.92	3.29	3.66	3.13	3.41	4.18	3.78	3.15	3.62
Aug.	4.06	4.13	3.29	3.68	3.15	3.29	4.07	3.43	3.22	3.59
Sept.	4.27	4.06	3.64	3.92	3.26	3.41	4.27	3.22	3.43	3.72
Oct.	4.20	4.27	3.71	4.08	3.33	3.45	4.15	3.08	3.29	3.73
Nov.	4.34	3.85	3.64	4.44	3.71	3.84	4.54	3.36	3.78	3.94
Dec.	4.41	3.99	4.20	4.13	3.61	3.97	4.34	3.64	3.36	3.96
Av	3.99	3.79	3.37	3.66	3.16	3.61	3.74	3.38	3.14	3.54

Estimated error, ±0.15 mr/wk, at 90% confidence level.

Table 3

1962 BNL Area Survey
Ar^{41} Radiation Levels, mr/wk

Month	On site			Perimeter				Off site	
	E-10	E-11	E-12	E-2	E-4	E-7	E-9	O-1	O-6
Jan.	0.75	1.94	2.60	0.21	0.33	0.51	0.47	0.08	0.16
Feb.	1.52	3.89	1.50	0.63	0.06	0.77	0.25	0.43	0.36
Mar.	2.39	2.49	1.02	0.64	0.87	0.86	0.39	0	0
Apr.	0.62	2.26	3.97	0.32	0	0.84	1.26	0.13	0
May	2.73	2.00	3.83	0.80	0.51	0.24	1.56	0.09	0.09
June	1.35	2.07	5.35	0.86	0.40	0.26	1.83	0.35	0.21
July	1.41	2.00	4.21	0.34	0.17	0.44	2.27	0.09	0.14
Aug.	1.38	2.44	4.33	0.79	0.42	0.28	1.14	0.07	0.14
Sept.	1.06	1.69	2.92	0.38	0.35	0.24	1.15	0.17	0
Oct.	1.12	1.99	3.03	0.36	0.28	0.73	1.21	0.13	0.11
Nov.	1.55	4.25	2.28	0.21	0.53	0.60	0.80	0.76	0.13
Dec.	1.76	2.50	2.11	0.13	0.45	0.38	0.66	0.11	0.16
Av	1.47	2.46	3.10	0.47	0.36	0.51	1.08	0.19	0.13

Estimated error, ±0.25 mr/wk, at 90% cofidence level.

age of all stations is shown in Figure 2. The "natural background" at a given station is assumed to be the radiation level prevailing during the portion of the week when meteorological records indicate that the reactor effluent, with its Ar^{41} content, has not been present. BGRR shutdowns, as well as the operation of the ecology forest source, are also taken into consideration.

The only detectable increase above natural background of significance at all but one of the monitoring stations is due to the activated Ar^{41} component of the BGRR cooling air. Kanne chamber measurements indicate an average Ar^{41} stack concentration of 1.7×10^{-3} μC/cc and a total discharge of 22,000 curies of 110-min half-life Ar^{41} per day. Net radiation levels at each of the stations attributable to Ar^{41} are shown in Table 3 and in Figures 3, 4, and 5.

Late in 1961, a 10,000-curie Cs^{137} gamma source was installed in the ecology forest in the

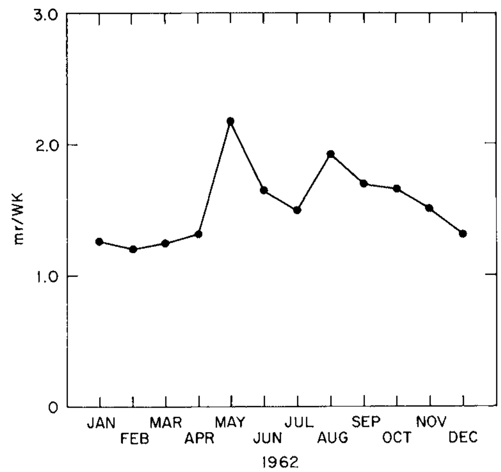

Figure 6. Monthly average radiation level at Station E-9 from ecology forest source.

Month	E-9
Jan.	1.27
Feb.	1.20
Mar.	1.24
Apr.	1.31
May	2.16
June	1.63
July	1.46
Aug.	1.91
Sept.	1.69
Oct.	1.65
Nov.	1.50
Dec.	1.30
Av	1.53

Estimated error, Jan. to July, ±0.40 mr/wk; after July, ±0.15 mr/wk.

northeast area of the Laboratory site, about 800 meters equidistant from the north and east boundaries (see Figure 1). The source is maintained above ground 20 hr/day. Monthly average radiation levels at Station E-9 (on the northeast perimeter) attributable to this source are given in Table 4 and are plotted in Figure 6. Cowan and Meinhold[2] indicate that most of the effect at 800 meters from the source is from scattered rather than from direct radiation. As they predict, some seasonal variation is apparent. More detailed examination of the raw data was begun in August, and a more precise measurement of this variation should be possible after collection of a full year's data.

AIR PARTICULATE MONITORING

Continuous moving-tape air particulate monitors are operated at the following area survey stations: E-10 (on site), E-9 (perimeter), and O-1 and O-6 (off site). These monitors, described in more detail in reference 1, include an end-window, GM tube, beta-gamma detector. Apparent monthly average gross beta air concentrations, at 4 hr postcollection, are indicated in Table 5. These should be regarded as upper limits, especially at the onsite and perimeter locations, since the detectors are not corrected for occasional increases in background due to Ar^{41} in the BGRR stack plume.

At Station O-6 a second count was made 30 hr postcollection in order to minimize the activity from the naturally occurring Pb^{212} (10.6-hr half-life) thoron daughter. This has permitted a more precise determination of the air particulate activity attributable to fallout from the atmospheric testing of nuclear devices. These 30-hr-delay concentrations are given in the last column of Table 5 and in Figure 7.

The concentrations of certain isotopes have been determined by gamma spectroscopy of the collection from a fixed-filter, high-volume sampler operated at the E-10 station. Monthly average concentrations of Zr^{95}-Nb^{95}, the largest component of these samples, are shown in Table 6 and in Figure 7.

An I^{131} stack monitor is operated by Health Physics Division personnel at the Hot Laboratory. Their data indicate an I^{131} concentration of $\approx 8 \times 10^{-10}$ μC/cc in normal stack discharge. Micrometeorological considerations suggest that the average stack dilution is such that the anticipated average ground concentrations, <0.001 $\mu\mu C/m^3$, are too low to be measurable. This conclusion is at least in part documented by the negative result obtained from January through June of 1962 on a charcoal "trap" operated in series with the moving-tape air particulate monitor at the E-9 station. The lower limit of detection of the setup used was estimated to be 0.005 $\mu\mu C/m^3$. A continuously operating high-volume sampler was installed at the former E-5 station location (see Figure 1) in mid-July. The average I^{131} concentrations in air of these samples, as determined by gamma spectral analysis of a 4-in.-diam, fixed particulate filter (MSA Comfo Respirator, BM #2133) and a

Month	On site E-10	Perimeter E-9	Off site O-1	O-6	O-6*
Jan.	7.8	8.2	9.8	8.7	7.8
Feb.	6.3	6.8	7.4	6.8	6.4
Mar.	5.7	6.2	6.6	5.0	4.9
Apr.	8.3	8.9	9.7	8.2	7.9
May	9.5	8.9	9.0	6.2	6.0
June	9.4	8.5	9.9	7.2	5.8
July	8.6	10.0	9.9	8.4	4.8
Aug.	6.7	8.0	10.8	8.1	3.5
Sept.	8.5	11.8	12.4	13.2	8.0
Oct.	10.2	9.9	14.6	11.1	6.5
Nov.	13.2	13.5	16.9	14.5	9.1
Dec.	9.6	10.4	11.6	10.2	6.6
Av	8.7	9.3	10.7	9.0	6.4

Estimated error, ±1.5 $\mu\mu C/m^3$, at 90% confidence level.
*Measurements taken 30 hr postcollection; all others taken 4 hr postcollection.

Table 6

1962 BNL Area Survey
Zr^{95}-Nb^{95}, Average Monthly
Air Particulate Concentration

Month	Concentration, $\mu\mu C/m^3$	% of Total
Jan.	2.9	37
Feb.	1.8	28
Mar.	2.6	53
Apr.	2.8	36
May	3.5	64
June	3.5	63
July	2.1	44
Aug.	0.9	25
Sept.	1.2	15
Oct.	0.8	13
Nov.	3.0	33
Dec.	3.2	32
Av	2.4	37

Estimated error, ±0.03 $\mu\mu C/m^3$.

charcoal filter (MSA Organic Vapor, BM #2306), are shown in Table 7. Monthly averages also appear in Figure 7. Although quantitative determinations of Ba^{140}-La^{140} were not made, these isotopes became discernible in air particulate collection concurrently with the I^{131} and were prominent in all subsequent 1962 collections; this suggests that most, if not all, of the I^{131} observed was produced by fallout rather than by the BGRR.

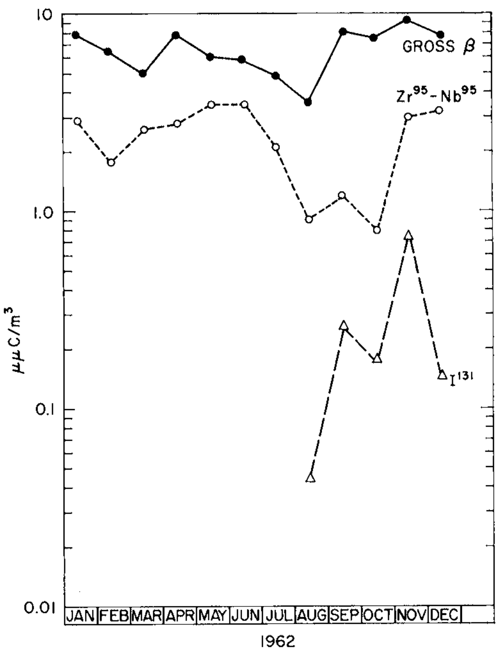

Figure 7. Monthly average air concentration at Station O-6, 30 hr postcollection.

Table 7

1962 BNL Area Survey
I^{131} Average Concentrations,
Area Survey Station E-5, $\mu\mu C/m^3$

Period	Particulate	Charcoal	Total
7/19– 8/ 2	—	0.019	—
8/ 2– 8/16	0.007	0.027	0.034
8/16– 8/27	0.040	0.013	0.053
8/27– 9/13	0.230	0.107	0.337
9/13– 9/20	0.270	0.164	0.434
9/20–10/ 1	0.032	0.074	0.106
10/ 1–10/ 8	0.055	0.051	0.106
10/ 8–10/15	0.071	0.044	0.115
10/15–10/22	0.109	0.036	0.145
10/22–10/29	0.237	0.098	0.335
10/29–11/ 5	0.098	0.042	0.140
11/ 5–11/12	0.357	0.080	0.438
11/12–11/19	0.611	0.224	0.835
11/19–11/26	0.145	0.086	0.231
11/26–12/ 3*	0.880	0.268	1.148
12/ 3–12/10*	0.115	0.072	0.187
12/10–12/17*	0.111	0.042	0.153
12/17–12/31*	0.091	0.027	0.118

Estimated error, ±15%, with a minimum detection limit for particulates of 0.005 $\mu\mu C/m^3$ and for charcoal filter of 0.002 $\mu\mu C/m^3$.
*Unit relocated at E-7 station.

Activity in Rain and Settled Dust Collection

Week ending	mC/mi²	$\mu\mu C/m^2$	Concentration, $\mu\mu C/l$
1/4/62	4	1,700	None
1/11	104	40,200	4.84×10^2
1/18	35	13,200	1.03×10^3
1/25	44	17,300	2.33×10^3
2/1	41	15,800	2.98×10^3
Total	228	88,200	
2/8	18	7,100	3.13×10^3
2/15	143	55,300	1.53×10^3
2/22	102	39,400	1.60×10^3
3/1	349	135,000	2.41×10^3
Total	612	236,800	
3/8	6	2,400	9.19×10^2
3/15	82	31,700	5.55×10^2
3/22	42	16,300	1.51×10^3
3/29	2	900	3.53×10^2
Total	132	51,300	
4/5	40	15,400	1.13×10^3
4/12	113	43,800	2.07×10^3
4/19	19	7,200	1.52×10^3
4/26	4	1,400	None
Total	176	67,800	
5/3	73	28,000	2.13×10^3
5/10	24	9,400	2.62×10^3
5/17	46	17,900	1.39×10^3
5/24	97	37,600	2.46×10^3
5/31	8	3,000	None
Total	248	95,900	
6/7	19	7,400	7.37×10^2
6/14	67	25,700	7.32×10^2
6/21	170	65,600	3.99×10^3
6/28	37	14,300	4.18×10^2
Total	293	113,000	
7/5	2	900	None
7/12	46	17,800	1.13×10^3
7/19	11	4,400	2.31×10^3
7/26	77	29,600	1.16×10^3
8/2	3	1,300	None
Total	139	54,000	
8/9	45	17,300	3.60×10^2
8/16	9	3,600	6.94×10^2
8/23	84	32,400	1.03×10^3
8/30	52	20,000	1.73×10^2
Total	190	73,300	
9/6	81	31,400	1.15×10^3
9/13	3	1,300	None
9/20	106	41,000	2.40×10^3
9/27	65	24,900	4.70×10^2
Total	255	98,600	

Activity in Rain and Settled Dust Collection

Week ending	mC/mi²	$\mu\mu C/m^2$	Concentration $\mu\mu C/l$
10/4	81	31,400	8.70×10^2
10/11	71	27,600	1.50×10^3
10/18	6	2,400	2.51×10^3
10/25	168	64,900	3.66×10^3
11/1	176	67,800	1.67×10^3
Total	502	194,100	
11/8	87	33,500	2.29×10^3
11/15	244	94,100	2.68×10^3
11/20	267	103,000	2.65×10^3
11/29	89	34,300	8.50×10^2
Total	687	264,900	
12/6	116	44,900	2.58×10^3
12/13	24	9,400	8.08×10^3
12/19	63	24,200	8.43×10^3
12/27	174	67,100	2.28×10^3
1/3/63	67	25,900	2.29×10^3
Total	444	171,500	
Monthly Av	326	126,000	1.34×10^3

Estimated sampling error, ±10%.

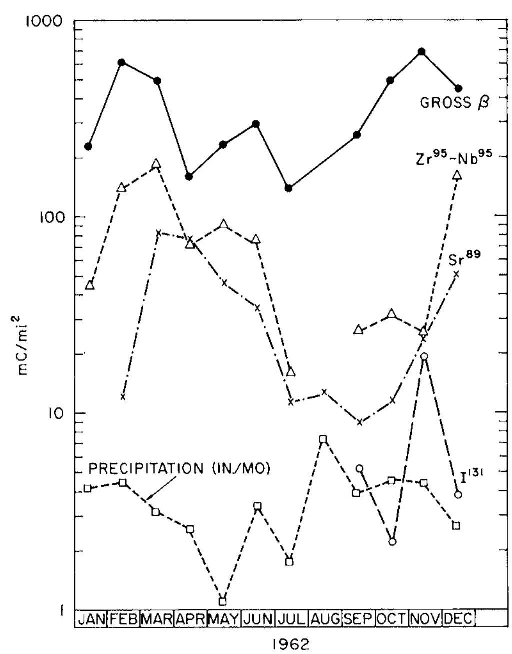

Figure 8. Total monthly collection of rain and settled dust, showing average Zr^{95}-Nb^{95}, Sr^{89}, Sr^{90}, I^{131}, and gross beta concentrations.

Table 9

1962 BNL Area Survey
Rain and Settled Dust Collection
Average Monthly Zr^{95}-Nb^{95}, Sr^{89}, Sr^{90}, I^{131}, and Gross Beta Concentrations, mC/mi^2

Month	Zr^{95}-Nb^{95}	Sr^{89}	Sr^{90}	I^{131}	Gross β	Precipitation, in.
Jan.	44	N.A.	N.A.		183	4.14
Feb.	141	12.1	1.8		615	4.54
Mar.	191	83.9	0.9		496	3.13
Apr.	72.8	78.0	N.A.		159	2.63
May	90.8	46.1	N.A.		230	1.20
June	76	34.2	0.8		297	3.37
July	16	11.5	1.2		143	1.81
Aug.	N.A.	12.9	N.A.		181	7.45
Sept.	26	9.0	0.9	5.2*	255	3.97
Oct.	31.7	11.4	2.3	2.2	493	4.53
Nov.	25.4	23.6	N.A.	19.1	668	4.42
Dec.	160	50.2	8.4	3.8	444	2.63
Av					347	3.65
Total					4164	43.82
Estimated error	±15%	±25%	±25%	±25%	±10%	

N.A. = not available.
*Weekly I^{131} analysis commenced in May; insufficient collection for analysis prior to September.

RAIN AND SETTLED DUST COLLECTION

A daily collection is made from a pot-type rain collector (surface area, 0.33 m^2) located adjacent to the E-10 station. A standard amount of distilled water is used to wash down the collector if it is not raining at the time the daily sample is terminated. Weekly totals and average concentrations are indicated in Table 8.

Monthly composite samples were analyzed for Zr^{95}-Nb^{95}, Sr^{89}, and Sr^{90}. The results, along with monthly totals and average concentrations, are shown in Table 9 and are plotted in Figure 8.

STREAM SAMPLING

Monthly "grab" samples are routinely obtained at several points along the upper tributary of the Peconic River, into which the Laboratory discharges low-level liquid wastes. Reference grab samples are concurrently obtained from other nearby streams and from bodies of water which are outside the Laboratory's surface drainage area. The sampling locations, indicated in Figure 9, are as follows:

A. Shultz Road, 1 mile downstream from the Laboratory.
B. Manorville, 2 miles downstream from the Laboratory.
C. Manorville, 4 miles downstream from the Laboratory.
D. Calverton, 5.5 miles downstream from the Laboratory.
E. Gauging station, just upstream from the Laboratory.
F. North tributary of the Peconic River (independent of Laboratory drainage).
G. Carmans River, Middle Island.
H. Carmans River, at Yaphank Lake.
I. Artist Lake (maintained by water table, no surface outflow).
J. Lake Panamoka (maintained by water table, no surface outflow).

Stream concentrations found during 1962 are summarized in Table 10. The calculated concentration of the Peconic River's west tributary at the site boundary is also indicated for purposes of comparison.

WELL SAMPLING

Most of the Laboratory's potable water wells and cooling water supply wells are $\approx$100 ft deep, or $\approx$50 ft below the water table in the Long Island surface layer of glacial till. Well locations

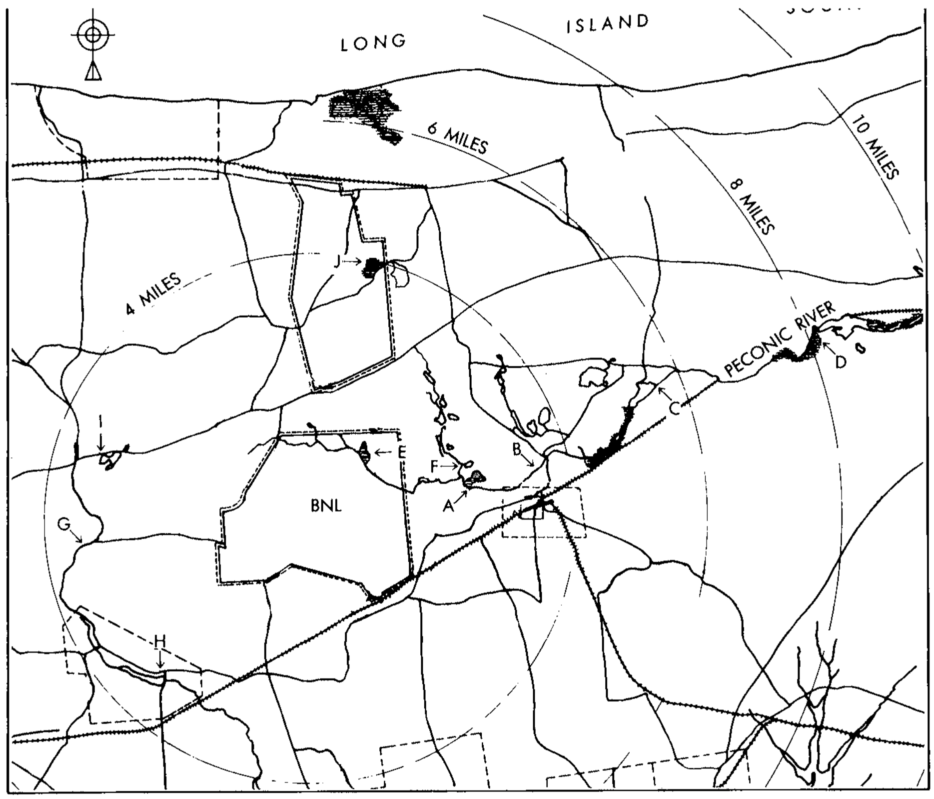

Figure 9. Area survey stream sampling points.

Table 10

1962 BNL Area Survey
Monthly Stream Sample Concentrations, $\mu\mu C/l$

	Peconic River							Carmans River		Artist Lake	Lake Panamoka
Month	Perimeter*	A	B	C	D	E	F	G	H	I	J
Jan.	100	38	29	47	39	9	34	6	45	77	48
Feb.	121	106	43	102	66	26	38	17	159	78	55
Mar.	83	33	20	18	16	26	35	15	25	52	27
Apr.	58	12	19	18	34	11	13	< 3	19	37	27
May	75	44	11	20	16	8	6	4	16	28	25
June	145	25	23	22	27	74	118	50	67	48	82
July	108	48	21	28	19	15	43	17	26	25	22
Aug.	147	38	26	20	17	48	16	18	32	18	10
Sept.	152	47	69	33	65	55	71	40	17	41	26
Oct.	96	30	15	15	23	15	4	5	6	34	28
Nov.	120	40	26	104	44	129	30	19	11	47	37
Dec.	108	105	65	40	24	37	12	57	10	39	62
Av	109	47	31	39	33	38	35	23	36	44	38

Estimated error, at 90% confidence level: <10 $\mu\mu C/l$, ± 5; 10 to 25 $\mu\mu C/l$, ± 10; 25 to 100 $\mu\mu C/l$, ± 15; >100 $\mu\mu C/l$, ± 25.

*Calculated.

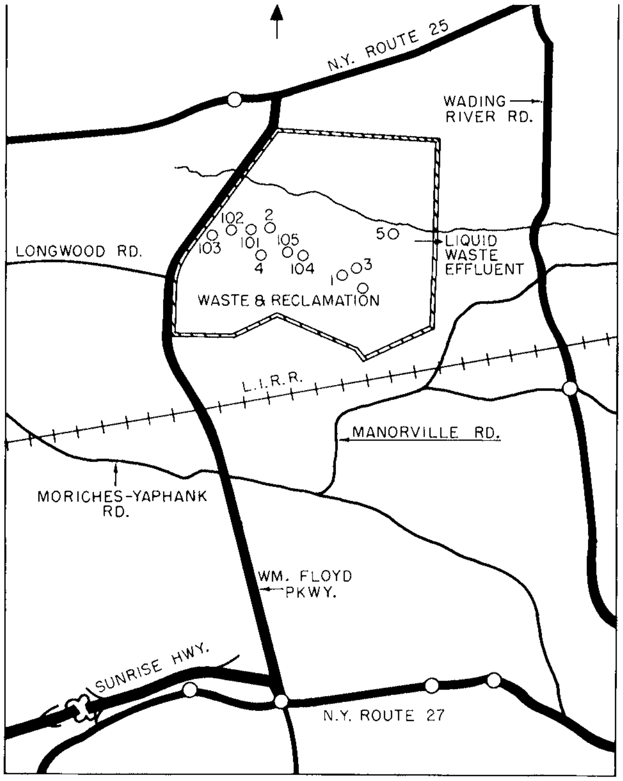

Figure 10. Location of BNL water supply wells.

Quarter	Curies
First	0.79
Second	0.83
Third	1.95
Fourth	0.65

Table 13

1962 BNL Area Survey
I^{131} Levels in Milk

Month	No. of samples	Within 5 miles, $\mu\mu$C/l	No. of samples	15 to 30 miles, $\mu\mu$C/l
Mar.	2	<10	3	<10
Apr.	2	<10	3	<10
May	4	13	6	14
June	3	45	4	49
July	2	17	2	<10
Aug.	2	17	3	10
Sept.*	8	85	2	38
Oct.*	7	153	5	30
Nov.*	6	141	6	81
Dec.	2	12	2	22

Estimated error, at 90% confidence level: <50 $\mu\mu$C/l, ±20; 50 to 100 $\mu\mu$C/l, ±35; >100 $\mu\mu$C/l, ±50.

*During these months more frequent "local" sampling was made on dates that often did not correspond to the "control" sampling dates. Because of rapidly changing I^{131} levels, comparisons between local and control samples for this period may not be very meaningful.

Table 11

1962 BNL Area Survey
Deep Well Samples, $\mu\mu$C/l

Month	Well No. 1	2	3	4	5	101	102	103	104	105	Waste and reclamation
Jan.	—	2.4	5.8	3.3	7.1	—	5.2	2.3	1.8	2.0	—
Feb.	—	<4.7	4.3	6.0	<4.7	10.9	<4.7	—	<4.7	<4.7	—
Mar.	—	10.8	<4.7	10.4	<4.6	7.7	8.9	<4.8	—	<4.6	—
Apr.	3.6	9.6	2.8	6.3	<2.8	15.5	4.3	3.4	—	—	—
May	<2.3	—	<2.3	<2.3	<2.3	2.3	14.2	<2.3	<2.3	—	—
June	<2.4	<2.4	<2.4	<2.4	5.7	<2.4	3.5	<2.4	3.1	1.0	—
July	<2.4	<2.4	4.5	3.6	2.8	<2.4	6.2	3.7	3.9	<2.4	—
Aug.	<1.7	1.8	2.1	7.6	2.8	8.1	<1.7	<1.7	<1.7	<1.7	—
Sept.	<2.5	—	8.2	2.4	9.5	<2.5	5.4	11.9	3.4	<2.5	—
Oct.	<2.5	<2.5	<2.5	<2.5	<2.5	9.5	3.1	<2.5	5.4	5.6	8.6
Nov.	7.0	<2.5	<2.5	4.1	2.6	<2.5	3.7	<2.5	—	<2.5	<2.5
Dec.	<2.3	—	<2.3	3.0	4.3	—	5.3	—	—	<2.3	<2.3
Av*	2.3	3.5	3.0	4.2	3.6	5.9	5.3	2.9	2.7	2.1	3.7

Estimated error, ±5 $\mu\mu$C/l, at 90% confidence level.
*In averaging, samples measuring less than background were considered to be half of background.

are indicated in Figure 10. Monthly gross beta counting results are summarized in Table 11.

MILK SAMPLING

Monitoring devices operated by Health Physics Division personnel indicated that 4.23 curies of I^{131} were emitted from the BGRR stack during 1962, distributed as shown in Table 12.

Except for a brief period during the third quarter, when slightly more than one curie was discharged in a week, the routine stack I^{131} concentration was $\approx 8 \times 10^{-10}$ μC/cc. Meteorological analysis indicated that this should have led to average I^{131} concentrations at the Laboratory perimeter of the order of 1×10^{-16} μC/cc. This latter value is too low to be directly measurable and also is believed to be too low to be detectable by indirect means. A limited milk sampling program to document these tentative conclusions was initiated in the spring of 1962 with the cooperation of the Suffolk County Health Department. The I^{131} levels in milk produced by 2 herds within 5 miles of the Laboratory were compared with the levels in milk produced by other herds 15 to 30 miles distant. The averaged results are given in Table 13. The correlation of I^{131} levels in milk with the pattern of fallout-produced isotopes, including I^{131}, in air and rain samples suggests that the I^{131} observed in milk samples can be attributed to fallout from atmospheric testing of nuclear devices during 1962.

LIQUID WASTE MONITORING

Low-level radioactive liquid wastes are routinely disposed of by discharge into the Laboratory's sanitary waste sewerage system. The liquid waste effluent passes through an Imhoff tank which removes most of the solids and then passes through sand filter beds from which it is collected by an underlying tile field. The liquid effluent is then chlorinated and discharged to a small stream that forms one of the headwaters of the Peconic River.

The monitoring arrangements for the central sewage system, indicated in Figure 11, include continuous proportional samplers at the input to the sand filter beds and at the point where the liquid effluent is discharged to the stream. Values of concentration and activity for the input to the filter bed, discharge to the river, and at the site

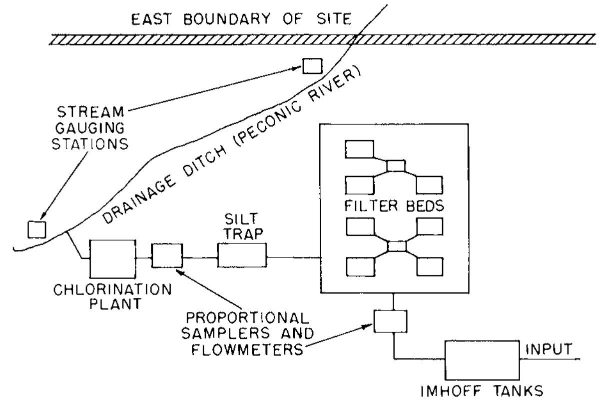

Figure 11. BNL sewage processing and monitoring system.

boundary (computed on the basis of stream flow) are indicated in Table 14.

A gamma-spectrometer scan and a Sr^{90} analysis is performed on a monthly composite of the filter bed input samples and on a composite of the effluent samples. The concentrations of the two principal isotopes usually detected, Cs^{137} and Sr^{90}, are indicated in Table 15. Co^{60}, Zr^{95}-Nb^{95} and Ce^{144} were also seen, generally in amounts too small for satisfactory quantitative determinations.

SUMMARY

Measurements have been made of "natural background" radiation levels (including fallout contributions) during 1962 in the environment of Brookhaven National Laboratory and vicinity. Perturbations in this natural background attributable to Laboratory operations, i.e., radiation from the Ar^{41} content of the BGRR cooling-air effluent, from an ecology field gamma source, and from the discharge of low-level liquid wastes, have also been measured.

The natural background increased from an average of 2.84 mr/wk during January 1962 to 3.96 mr/wk during December. This is attributed to fallout from atmospheric weapons testing. The highest yearly average on-site radiation level from Ar^{41} was 3.1 mr/wk (for 168 hr), well below the established maximum permissible exposure (MPE) level of 100 mr/wk (for 40 hr).[3] The highest yearly average level at the perimeter from Ar^{41} was 1.08 mr/wk. The contribution from the ecology forest at this location was 1.53 mr/wk. The resultant total, 2.61 mr/wk, is 26% of the established MPE

Table 14

1962 BNL Area Survey
Monthly Average Liquid Effluent

Month	Imhoff tank Flow, gal/day	Imhoff tank Conc., μμC/l	Imhoff tank Activity, mC	Chlorine house Flow, gal/day	Chlorine house Conc., μμC/l	Chlorine house Activity, mC	Site boundary Flow, gal/day	Site boundary Conc., μμC/l	Site boundary Activity, mC
Jan.	529,000	238	14.8	468,000	234	12.8	1,095,000	100	12.8
Feb.	493,000	165	9.6	509,000	264	15.8	1,111,000	121	15.8
Mar.	512,000	195	11.4	510,000	285	15.8	1,781,000	83	15.8
Apr.	537,000	144	9.1	511,000	169	10.2	1,485,000	58	10.2
May	611,000	146	10.1	514,000	107	9.9	1,175,000	75	9.9
June	726,000	114	9.8	635,000	198	14.3	863,000	145	14.3
July	842,000	138	13.2	652,000	118	8.9	690,000	108	8.6
Aug.	817,000	123	11.8	673,000	155	12.2	660,000	147	11.4
Sept.	713,000	185	15.4	622,000	152	11.1	640,000	152	10.5
Oct.	750,000	109	9.3	610,000	105	7.3	665,000	96	7.3
Nov.	629,000	91	6.7	527,000	155	9.6	670,000	122	9.6
Dec.	604,000	112	7.7	513,000	135	7.9	642,000	108	7.9
Av	648,000	143	10.7	562,000	169	11.3	956,000	102	11.2
Total	237,000,000		128.9	205,000,000		135.8	349,000,000		134.1
Estimated error		±15	± 1.0		± 15	± 1.0		±15	± 1.0

level of 10 mr/wk (for a 168-hr week) for nonoccupational exposure.[3]

No activity attributable to Laboratory operations was detected in air particulate monitoring samples. The yearly average gross beta concentration of a 30-hr delay count, which allows for the decay of almost all of the natural progeny, was 6.4 $\mu\mu C/m^3$. This may be compared to an established maximum permissible concentration (MPC) non-occupational level[4] of 100 $\mu\mu C/m^3$. The principal constituent of the air particulate collection, Zr^{95}-Nb^{95}, averaged 2.4 $\mu\mu C/m^3$ or 37% of the total. I^{131} was measurable from August through December in concentrations ranging from 0.03 to 1.15 $\mu\mu C/m^3$.

The activity in a rain and settled dust collection averaged 325.2 $\mu\mu C/m^2$/month. The average concentration in measurable precipitation was 1340 $\mu\mu C$/liter.

Liquid wastes discharged to the headwaters of the Peconic River averaged 102 $\mu\mu C$/liter, about 20% of the established off-site drinking-water concentration (based on 20% Sr^{90}). Monthly off-site stream sample collections ranged from 23 to 47 $\mu\mu C$/liter. On-site potable water supply deep wells averaged 3.4 $\mu\mu C$/liter.

Table 15

1962 BNL Area Survey
Sr^{90} and Cs^{137} Concentrations in Liquid Waste, $\mu\mu C/l$

Month	Imhoff tank Cs^{137}	Imhoff tank Sr^{90}	Chlorine house Cs^{137}	Chlorine house Sr^{90}
Jan.	54	48	81	30
Feb.	17	12	53	27
Mar.	12	34	52	41
Apr.	48	20	86	26
May	24	20	84	35
June	9	13	93	45
July	14	12	47	16
Aug.	20	11	54	15
Sept.	51	26	69	21
Oct.	8	11	47	10
Nov.	6	10	80	13
Dec.	19	13	95	18
Av*	23	18	70	23
% of Total activity	18	14	52	17
Estimated error	±10	±5	±10	±5

*Weighted for monthly flow.

Except for periods when recently produced fallout isotopes were prevalent, the results of a monthly milk sampling program were generally below 10 $\mu\mu$C/liter for I^{131}. This is within Range I of the applicable Radiation Protection Guide (RPG) levels,[5] assuming an intake of 1 liter/day. The highest yearly average recommended RPG level is the upper limit of Range II, 100 $\mu\mu$C/day intake.

From the foregoing, it is apparent that during 1962 radiation levels attributable to Laboratory operations were well below the established MPE, MPC, and RPG levels for whole-body exposures, air particulate concentrations, and liquid effluent concentrations. Radiation levels attributable to fallout were also below these established levels.

ACKNOWLEDGMENTS

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