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1965 ENVIRONMENTAL MONITORING RADIATION LEVELS AT BROOKHAVEN NATIONAL LABORATORY

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ABSTRACT

Measurements of "natural background" radiation levels and of increments attributable to Laboratory operations obtained on site and in the vicinity of Brookhaven National Laboratory during 1965 are summarized in this report. These increments include contributions from the gaseous and air particulate effluent of the Brookhaven Graphite Research Reactor stack, from multicurie field γ sources, and from the discharge of low-level liquid wastes from the Laboratory's sanitary waste treatment plant into the headwaters of the Peconic River.

The natural background external radiation level declined to an average of 2.26 mR/wk during 1965. A small increment which became perceptible late in May was attributed to fallout from a foreign weapons test. The highest yearly on-site level attributable to Laboratory operations was 9.83 mR/wk (for 168 hr), well below the established radiation protection standards for individuals in controlled areas. The highest yearly average radiation level at the perimeter was 2.50 mR/wk, to which the ecology forest contributed 1.61 mR/wk and the balance was from ^{41}Ar. The total is 25% of the established yearly standard of 500 mR for individuals in uncontrolled areas.

No airborne radioactivity attributable to Laboratory operations, other than ^{131}I, was detectable during routine environmental monitoring. The yearly average gross β concentration of samples counted after a 30-hr delay (to allow for the decay of almost all the natural radioactivity) was 0.25 pCi/m^3, with a 1-day maximum of 1.69 pCi/m^3 on May 26.

Because of the possibility of using the low level of ^{131}I as a meteorological tracer to study stack effluent dispersion, efforts to sample and evaluate very low environmental concentrations of airborne ^{131}I were continued during 1965. The highest yearly average at the perimeter was determined to be 0.0035 pCi/m^3, which may be compared with the radiation protection standard concentration of 100 pCi/m^3 in uncontrolled areas. Fallout ^{131}I from the foreign nuclear weapons test was also present in an average concentration of 0.0083 pCi/m^3 from May 21 to July 16.

The activity in precipation declined to a monthly average of 8.2 nCi/m^2. The monthly average concentration was 123 pCi/liter. The largest daily samples, each 8.0 nCi/m^2, were collected on May 26 and 27.

Liquid wastes discharged to the headwaters of the Peconic River averaged 38 pCi/liter, about 3.5% of a calculated radiation protection standard which assumes that the ^{90}Sr content is 20% and that the balance of the isotopes present are "unknown" β or γ emitters. The average of monthly downstream "grab" samples in the Peconic River ranged from 56 to 4 pCi/liter, while those from off-site control locations averaged 12 pCi/liter. The highest concentrations of individual isotopes in bottom sediments (11.2 pCi/g of ^{60}Co, 6.9 pCi/g of ^{137}Cs, and 1.3 pCi/g of ^{144}Ce) were found between the on-site outfall and a point about a mile downstream from the Laboratory perimeter. A similar distribution was found in underwater vegetation, the highest concentrations being 18.9 pCi/g of ^{60}Co and 28.4 pCi/g of ^{137}Cs. Concentrations in both sediment and vegetation were found to decline to near background levels beyond a distance of three miles downstream.

The concentrations of ^{131}I in routine monthly milk samples obtained from several nearby farms were all <5 pCi/liter, except for a brief time late in May and early in June. The applicable radiation protection guide, assuming an intake of 1 liter/day, is 100 pCi/liter.

The Environmental Monitoring Program has established that during 1965 radiation levels attributable to Laboratory operations were maintained well below the established radiation protection standards of the AEC for external exposures, air particulate concentrations, and liquid effluent concentrations. Radiation levels attributable to fallout were also well below the established limits.

1965 ENVIRONMENTAL MONITORING RADIATION LEVELS AT BROOKHAVEN NATIONAL LABORATORY

INTRODUCTION

Brookhaven National Laboratory is situated on Long Island, about 70 miles east of New York City. Its location with regard to surrounding communities is shown in Figure 1. Except for shoreline communities, most of the land area within ten miles is either forested or under cultivation. Environmental monitoring data have been obtained in the vicinity of the Laboratory since 1949. Annual reports [1-3] of this information were instituted in 1962 to make both the fallout data and the results of the investigations of local effects available to interested parties.

The evaluation of radiation levels in the vicinity of the Brookhaven National Laboratory site is performed by the Environmental Monitoring section of the Health Physics Division. Laboratory operations contribute three principal additions to the local natural background radiation: gaseous and particulate radioactivity contained in the cooling-air effluent of the Brookhaven Graphite Research Reactor (BGRR), the Medical Research Reactor (MRR), and the off-gas of the Hot Laboratory (discharged from the BGRR stack); radiation from two multicurie field γ sources; and low-level 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 1965 are summarized in this report. Although much reduced from the record 1963 levels, some residual fallout from the atmospheric testing of nuclear weapons during 1961 and 1962 was observed during 1965 in many types of environmental samples. Some fresh fission products were also evident for a brief period after the Chinese weapons test[4] in mid-May. While the identification of fallout is done primarily to separate it from the Laboratory's contribution to the environment, such information about fallout radioactivity levels as has been obtained is summarized herein.

Among the data reported are external whole-body exposures, air particulate concentrations, rain and settled dust collections, milk and grass concentrations, liquid effluent concentrations, and water, silt, and vegetation concentrations in off-site streams.

EXTERNAL EXPOSURE MONITORING

Environmental radiation levels, including natural background (as influenced by fallout) and the increments attributable to reactor cooling-air effluent and to the ecology forest sources, were monitored continuously at six fixed monitoring stations and seasonally at two additional stations. As indicated in Figure 2, one of these continuous stations was on site and four were at the perimeter. Off-site station O-6, at 8.7 km and 168° downwind from the BGRR stack, is not shown. The seasonal stations were located on site in a line downwind from the BGRR stack for the prevailing southwesterly wind from May to September. Included in each station's equipment is an ion chamber and dynamic capacitor electrometer assembly which has been described in detail elsewhere.[5] These units are capable of accurately measuring <10 μR/hr and of detecting changes of the order of 1 μR/hr. Although information about the instantaneous dose rates up to about 0.5 mR/hr may be obtained from these units, normally the integrated radiation over 4-hr periods was used to obtain weekly averages, and these in turn were used to compute the monthly data tabulated in this section.

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

Since the established radiation protection standard[6] of 500 mR/yr for individuals living in the vicinity of the Laboratory is in addition to natural background, determinations of the latter are routinely made. Natural background levels, as measured by 6-liter atmospheric-pressure ion chambers which reflect some deposition of fallout radio-

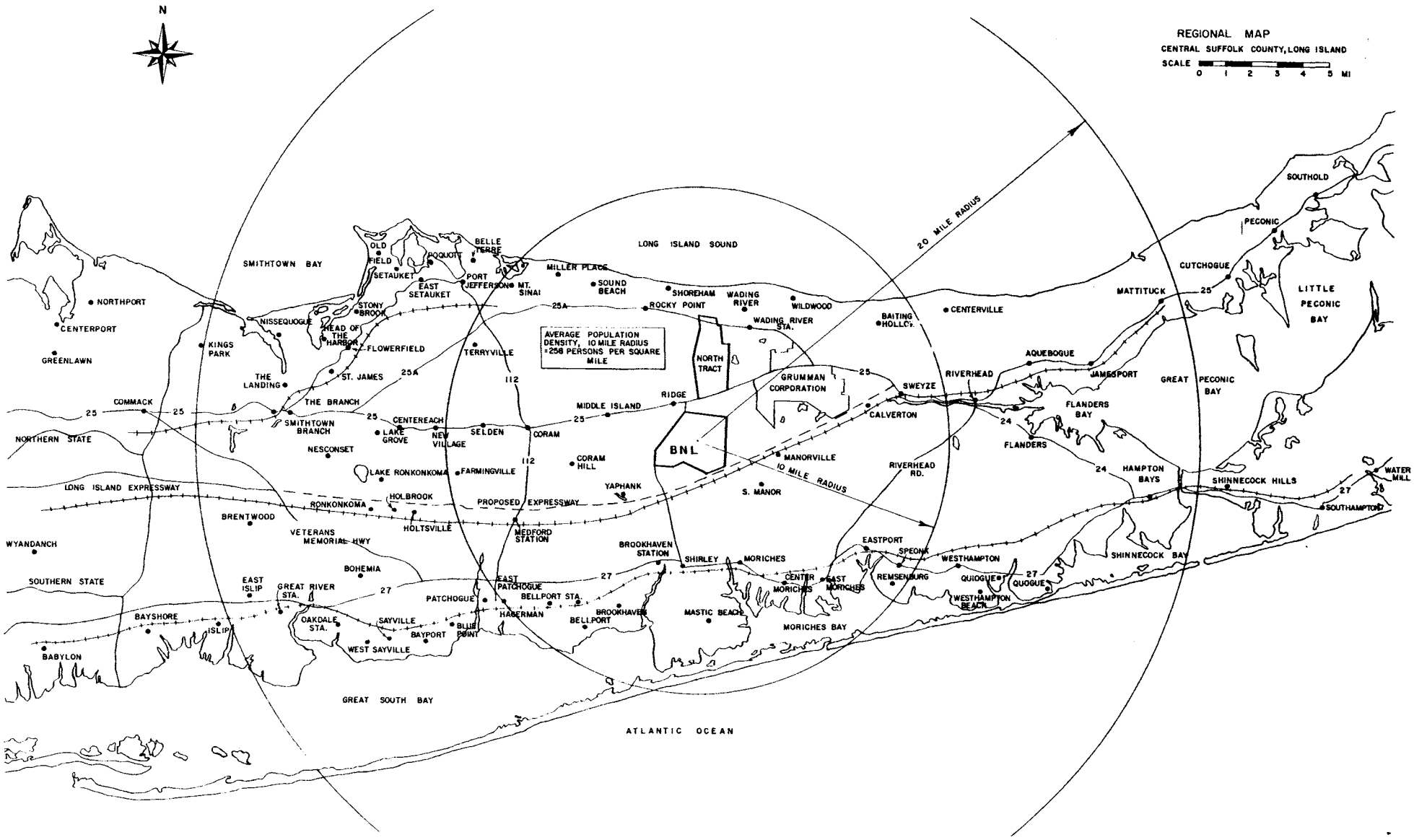

Figure 1. Central Suffolk County, showing the area around Brookhaven National Laboratory.

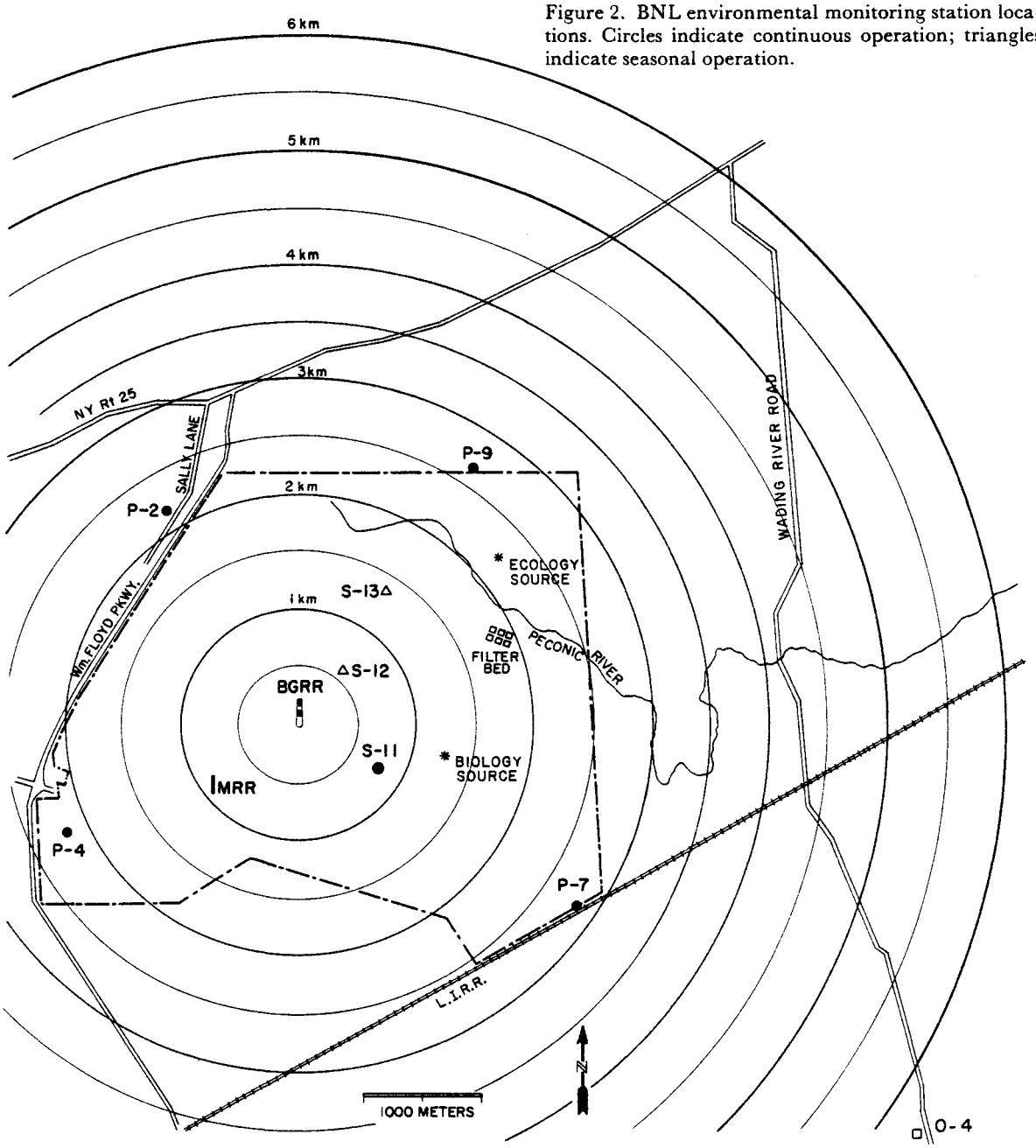

Figure 2. BNL environmental monitoring station locations. Circles indicate continuous operation; triangles indicate seasonal operation.

activity, are reported in Table 2. A comparison with the 1964 data suggests that some, if not all, of the increase during the summer months is a seasonal effect and is not attributable to fallout from the mid-May test. Yearly natural background levels (including fallout) from the time that observations were initiated at this site in 1949 to the present are indicated in Figure 3. The data prior to 1964 have been adjusted to take into account the change in elevation of the ion chambers from 6 in. to 2 ft above the roof of each monitoring station.

Natural background at a given station was determined from the radiation level prevailing when no obvious Laboratory contributions were detectable at a station. The subjective error in making

Table 1

1965 BNL Environmental Monitoring
Monthly Average Gross Radiation Levels, mR/wk

	On site			Perimeter				Off site
Month	S-11	S-12	S-13	P-2	P-4	P-7	P-9	O-6
Jan.	6.08	4.24	—	1.85	2.14	2.98	3.76	1.74
Feb.	5.71	4.21	—	2.32	2.18	2.93	4.10	1.85
Mar.	6.92	3.38	—	2.17	2.32	3.39	3.86	2.05
Apr.	7.06	4.59	—	2.51	2.25	3.40	4.14	2.13
May	6.87	7.18	—	2.78	2.30	2.70	5.68	2.30
June	6.89	7.53	—	2.31	2.28	2.86	6.30	2.30
July	6.63	5.73	4.90	2.43	2.06	2.42	5.50	2.24
Aug.	6.48	7.59	5.86	3.08	2.44	2.50	6.00	2.30
Sept.	6.97	5.90	5.28	2.49	2.68	2.56	6.12	2.24
Oct.	8.02	4.60	4.06	2.59	2.28	3.08	4.36	2.27
Nov.*	12.93	**	—	2.27	2.52	2.60	4.13	1.94
Dec.*	11.29	—	—	2.28	2.22	2.65	3.74	1.99
Av	7.62	5.50	5.02	2.42	2.30	2.84	4.81	2.11

Estimated error (monthly average): ±3%.
*Station relocated closer to ^{60}Co field source.
**Seasonal shutdown.

Table 2

1965 BNL Environmental Monitoring
Monthly Average Background Radiation Levels, mR/wk

	On site			Perimeter				Off site	
Month	S-11	S-12	S-13	P-2	P-4	P-7	P-9	O-6	All stations, av
Jan.	2.44	2.00	**	1.75	1.99	2.24	1.98	1.66	2.01
Feb.	2.35	2.09	—	1.98	2.10	2.38	2.36	1.83	2.16
Mar.	2.34	2.22	—	2.12	2.15	2.37	2.34	2.00	2.22
Apr.	2.16	2.31	—	2.16	2.10	2.54	2.30	2.09	2.24
May	2.50	2.64	—	2.30	2.15	2.56	2.65	2.26	2.44
June	2.64	2.41	—	2.27	2.20	2.60	2.52	2.26	2.41
July	2.29	2.38	2.42	2.39	2.04	2.34	2.42	2.21	2.31
Aug.	2.47	2.54	2.57	2.43	2.18	2.33	2.58	2.20	2.41
Sept.	2.49	2.35	2.38	2.16	2.11	2.27	2.36	2.18	2.29
Oct.	2.42	2.16	2.30	2.10	2.03	2.27	2.27	2.16	2.21
Nov.	—	**	**	2.15	1.97	2.11	2.29	1.93	2.09
Dec.*	2.08	—	—	2.09	1.90	2.16	2.21	1.98	2.07
Av	2.38	2.31	2.42	2.16	2.08	2.35	2.36	2.06	2.26

Estimated error (monthly average) : ±5%.
*Station relocated.
**Seasonal shutdown.

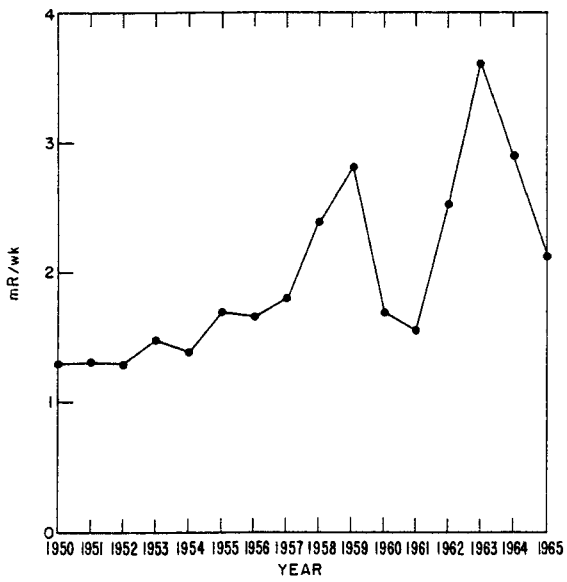

Figure 3. Yearly average background at elevation of 3 ft, 1949-1965.

this determination was minimized by reference to meteorological data (to establish the direction of the reactor plume) and, for one station, to the log indications of down hours of the ecology forest source.

The only measurable increase above natural background attributable to Laboratory operations at most of the monitoring stations was caused by the activated ^{41}Ar component of the BGRR effluent cooling air. As indicated in Table 3, a monthly summary of emissions from the BGRR stack, Kanne chamber measurements showed an average ^{41}Ar stack concentration of 1.85×10^{-3} $\mu Ci/cm^3$ during 1965. The daily discharge of 110-min half-life ^{41}Ar was 19,500 Ci/day when the BGRR was in operation at close to 20 MW. Although the MRR stack concentration of ^{41}Ar is 3×10^{-4} $\mu Ci/cm^3$ and the discharge is 75 Ci/24-hr day at full power (3 MW), during 1965 the MRR was infrequently operated at this power level. About 5 Ci/wk were discharged from its stack and it was insignificant as a source of ^{41}Ar when compared with the BGRR. The yearly average radiation levels, in mR/wk, attributable to ^{41}Ar at each of the monitoring stations are shown in Table 4. Assuming the plume to be of several mean free paths (for the ^{41}Ar 1.29-MeV γ rays) in dimension, an average dilution factor of about 500,000 can be calculated from the observed ^{41}Ar radiation level at station P-9.

The percentage frequencies of wind directions to the nearest 10° during the years 1961-1963 were tabulated by the BNL Meteorology Group and published in the 1964 report.[3] The seasonal patterns apparent from these wind roses can be correlated reasonably well with the monthly variations in the ^{41}Ar reported at the individual monitoring stations.

An unusual persistence of ^{41}Ar ion-chamber readings >0.10 $\mu R/hr$ was noted during the afternoon of August 19 at in-line stations S-12, S-13, and P-9, which are situated at distances of 570, 1330, and 2750 m downwind from the BGRR stack during southwesterly winds. The data for these stations are summarized by 15-min intervals in Table 5. When compared with the monthly August data, corrected for the 25 days that the BGRR operated, they suggest the existence of 4-hr concentrations at ground level that are about 5 times the monthly averages, and 15-min concentrations about 10 times the monthly averages.

Two multicurie field γ sources are routinely exposed 20 hr/day. One, a ^{60}Co source that contained 2700 Ci on January 1, 1965, and was restored to 3400 Ci on April 1, is used primarily for plant irradiations in a cultivated plot. The other, a ^{137}Cs source that contained 8200 Ci as of January 1, 1965, is used to irradiate an otherwise undisturbed wooded area for ecological studies. Located about 800 m equidistant from the north and east boundaries (see Figure 2), the ^{137}Cs source produces a measurable dose rate at these boundaries. Monthly average radiation levels at station P-9 (on the northeast perimeter) attributable to the ^{137}Cs source are given in Table 6. With use of a method suggested by Cowan and Meinhold[7] and the observed monthly mean temperatures, a monthly dose rate has been calculated. Attenuation by the shield plug and by the surrounding woods is suggested as the explanation for the lower radiation levels observed.

Some radiation from the ^{60}Co source also reaches on-site station S-12, but the amount is too small to be measured accurately in the presence of the much higher ^{41}Ar levels usually observed at this location. A calculated correction for the source effect was applied to obtain the natural background measurements at station S-12.

The cylindrical ion chambers used in making the above measurements have a sensitive volume of 6 liters and operate at atmospheric pressure. They have Bakelite side walls $\simeq 400$ mg/cm^2 thick.

Table 3

1965 BNL Environmental Monitoring
BGRR Stack Emission

Month	BGRR MWD	Air volume, cm^3	^{131}I		^{41}Ar		Particulate	
			mCi	$\mu Ci/cm^3$	Ci	$\mu Ci/cm^3$	Ci	$\mu Ci/cm^3$
Jan.	393.3	1.92×10^{14}	132	6.75×10^{-10}	4.2×10^{5}	2.18×10^{-3}	28	1.45×10^{-7}
Feb.	398.6	2.01×10^{14}	140	6.96×10^{-10}	4.2×10^{5}	2.09×10^{-3}	30	1.50×10^{-7}
Mar.	457.5	2.04×10^{14}	257	12.60×10^{-10}	4.3×10^{5}	2.11×10^{-3}	31	1.52×10^{-7}
Apr.	432.3	2.38×10^{14}	171	7.23×10^{-10}	4.6×10^{5}	1.93×10^{-3}	39	1.64×10^{-7}
May	456.1	2.35×10^{14}	175	7.45×10^{-10}	4.4×10^{5}	1.88×10^{-3}	30	1.28×10^{-7}
June	434.7	2.43×10^{14}	192	7.90×10^{-10}	4.3×10^{5}	1.77×10^{-3}	30	1.23×10^{-7}
July	271.8	1.70×10^{14}	128	7.52×10^{-10}	2.5×10^{5}	1.47×10^{-3}	19	1.12×10^{-7}
Aug.	507.0	2.87×10^{14}	202	7.15×10^{-10}	4.5×10^{5}	1.57×10^{-3}	34	1.18×10^{-7}
Sept.	425.0	2.43×10^{14}	183	7.53×10^{-10}	4.2×10^{5}	1.73×10^{-3}	28	1.15×10^{-7}
Oct.	389.4	1.84×10^{14}	180	9.78×10^{-10}	3.4×10^{5}	1.85×10^{-3}	26	1.41×10^{-7}
Nov.	327.4	1.78×10^{14}	223	12.53×10^{-10}	3.1×10^{5}	1.74×10^{-3}	24	1.35×10^{-7}
Dec.	408.2	2.24×10^{14}	183	8.14×10^{-10}	4.2×10^{5}	1.86×10^{-3}	29	1.29×10^{-7}
Annual total	4901.3	25.99×10^{14}	2166		47.9×10^{5}		348	
Av				8.48×10^{-10}		1.85×10^{-3}		1.38×10^{-7}

Table 4
1965 BNL Environmental Monitoring
Monthly Average ^{41}Ar Radiation Levels, mR/wk

Month	On site			Perimeter				Off site
	S-11	S-12	S-13	P-2	P-4	P-7	P-9	O-6
Jan.	2.03	2.05	—	0.10	0.15	0.74	0.55	0.08
Feb.	1.94	1.94	—	0.34	0.08	0.55	0.49	0.02
Mar.	3.30	0.97	—	0.05	0.17	1.02	0.27	0.05
Apr.	2.89	2.04	—	0.35	0.15	0.86	0.46	0.04
May	1.84	4.26	—	0.48	0.15	0.13	1.34	0.04
June	1.28	4.84	—	0.04	0.08	0.25	1.84	0.04
July	1.14	3.06	1.48	0.03	0.02	0.08	1.54	0.02
Aug.	0.82	4.77	2.23	0.65	0.26	0.17	1.26	0.10
Sept.	1.35	3.26	1.89	0.33	0.57	0.29	1.79	0.06
Oct.	2.72	2.08	0.90	0.49	0.25	0.81	0.56	0.11
Nov.	1.94	*	*	0.12	0.55	0.48	0.34	—
Dec.	2.31	—	—	0.19	0.32	0.49	0.25	0.01
Yearly av	1.96	2.93	1.62	0.26	0.23	0.49	0.89	0.05

Estimated Monthly Average Error

mR/wk	Error
<0.02	$\pm100\%$
0.02–0.05	$\pm$ 50%
0.05–0.25	$\pm$ 25%
<0.25	$\pm$ 10%

*Seasonal shutdown.

Table 5

1965 BNL Environmental Monitoring
Net ^{41}Ar Radiation Levels, August 19, μR/hr

15-Min period ending	Station S-12	S-13	P-9
1215*	42	10	0
1230	49	13	0
1245	53	17	2
1300	60	34	23
1315	79	49	12
1330	61	27	5
1345	64	32	12
1400	120	110	48
1415	110	96	84
1430	89	76	91
1445	92	91	71
1500	99	71	43
1515	97	83	61
1530	113	91	38
1545	102	81	68
1600	102	118	78
1615	89	71	71
1630	78	88	91
1645	88	63	33
1700	85	49	15
1715	75	46	10
1730	94	81	61
1745	102	86	86
1800	99	88	99
1815	89	51	71
1830	43	7	0
1845	59	7	2
1900	56	7	3
1915	52	2	0
1930	15	1	2
1945	3	1	0
2000	2	2	0
Av	74	52	37

Estimated Error	
μR/hr	Error
< 3	±100%
3–10	±50%
10–30	±25%
>30	±10%

*Eastern standard time.

Table 6

1965 BNL Environmental Monitoring
Monthly Average Radiation Levels,
Ecology Forest Source (Station P-9)

Month	Mean T, °F	°C	mR/wk Observed	Calculated	Obs./Calc.
Jan.	25.5	−3.6	1.24	2.14	0.58
Feb.	29.1	−1.6	1.26	2.17	0.58
Mar.	35.7	2.1	1.26	2.28	0.55
April	43.8	6.6	1.38	2.58	0.54
May	59.6	15.4	1.68	2.90	0.58
June	64.8	18.2	1.24	3.15	0.62
July	68.5	20.3	2.15	3.47	0.62
Aug.	68.0	20.0	2.16	3.32	0.65
Sept.	63.0	17.3	1.97	3.07	0.64
Oct.	51.0	10.6	1.53	2.80	0.55
Nov.	40.0	4.5	1.50	2.42	0.62
Dec.	34.2	1.2	1.28	2.14	0.60
Av	48.6	9.2	1.61	2.70	0.59

Estimated error, ±5%.

Table 7

1965 BNL Environmental Monitoring
Ion Chamber Comparison

Chamber type	Wall, mg/cm²	Background, μR/hr
BNL, Bakelite wall	400	12.4
BNL, Bakelite wall and steel shell	2825	9.6
NYS Dept. of Health, steel wall	≈2500	8.4

The ends are much thicker and may be considered essentially β-opaque. On November 18 a comparison was made between the response of one of these BNL chambers and that of an 8-liter, high-pressure, Ar-filled chamber with a 2500-mg/cm² steel wall. The latter belongs to the New York State Department of Health and is identical to the high-pressure chambers used by the Health and Safety Laboratory.[8] The data (see Table 7) indicate that about 30% of the background dose rate measured by the BNL chamber was attributable to β or soft-γ radioactivity not detectable by the high-pressure chamber.

AIR PARTICULATE MONITORING

During 1965, "high-volume" (20 ft³/min) air samplers were operated at all monitoring stations. Particulate filters (MSA No. C-17651) 4 in. in diameter were usually installed for a 2-wk sampling interval.

Gross β counts were made with an end-window GM tube at about 30 hr postcollection on a section from the particulate filters. This delay minimized the contribution from the naturally oc-

curring ^{212}Pb (10.6-hr half-life) thoron daughter. A γ analysis was routinely made of a composite of the filter samples from the seasonally downwind stations, and another of those from the remaining stations.

A moving-tape air-particulate sampler was counted after a 20-min delay to determine the gross β concentration of the stack effluent. As shown in Table 3, during 1965 the average gross β concentration of the stack effluent was 1.38×10^{-7} $\mu Ci/cm^3$. Although routine analyses for specific radionuclides other than ^{131}I were not made, a detailed study[3] indicates that the air particulate concentration of individual isotopes in the stack effluent was $< 1 \times 10^{-9}$ $\mu Ci/cm^3$. No activity uniquely attributable to these stack effluent isotopes was detectable on the routine 2-wk air particulate samples at the seasonally downwind monitoring stations. No significant differences in gross β or individual isotope concentrations were apparent between the samples from stations in the prevailing downwind direction and those seldom downwind. This is not surprising, since calculated ground-level concentrations of the particulate stack effluent isotopes are too small for detection in the presence of the prevailing background of natural and fallout activity.

Monthly average 30-hr-delay gross β concentrations and the average concentrations of all identifiable (concentration $> 10^{-2}$ pCi/m^3) γ-emitting isotopes are given in Table 8 and plotted in Figure 4. Initial calculations of short-lived isotopes have been adjusted for the presence of longer-lived isotopes with overlapping photopeaks in the same spectrum.

These longer-lived isotopes were evaluated by a recount of composite monthly samples after a 1-yr delay. The number of photopeak transactions attributable to the amount of longer-lived isotopes, such as those from 1-yr ^{106}Ru at 0.51 MeV and 285-day ^{144}Ce at 0.13 MeV, that should have been present in the initial count were then calculated and subtracted from the total initial photopeak count of the same energy (within the resolution of the 4×2-in. NaI detector). The concentrations of 39-day ^{103}Ru at 0.50 MeV and 33-day ^{141}Ce at 0.15 MeV were determined from the net initial photopeak count. When ^{140}Ba-^{140}La appeared to be present, a "stripping" procedure (using a magnetic tape of a ^{140}Ba-^{140}La standard) was employed to remove the several interfering photopeaks of this isotope prior to evaluation of the amounts of other isotopes present in air particulate samples.

Table 8

1965 BNL Environmental Monitoring, Monthly Average Gross β and γ-Emitting Isotope Concentrations, Air Particulate Filters, pCi/m^3*

Month	Gross β	^{144}Ce	^{106}Ru	^{137}Cs	^{54}Mn	^{125}Sb	^{7}Be	^{131}I	^{140}Ba	^{95}Zr-^{95}Nb	^{141}Ce	^{103}Ru
Jan.	0.243	0.043	0.023	0.028	0.008	0.015	0.136	—	—	—	—	—
Feb.	0.365	0.042	0.026	0.047	0.013	0.019	0.217	—	—	—	—	—
Mar.	0.244	0.041	0.028	0.031	0.009	0.017	0.220	—	—	—	—	—
Apr.	0.323	0.052	0.061	0.045	0.012	0.024	0.234	—	—	—	—	—
May	0.295	0.049	0.041	0.042	0.010	0.019	0.226	—	—	—	—	—
5/21-6/18	0.427	0.040	0.030	0.037	0.010	0.019	0.225	0.013**	0.045	0.042	0.018	0.014
6/18-7/16	0.512	0.028	0.040	0.036	0.008	0.017	0.225	0.002**	0.021	0.068	0.034	0.042
7/16-8/6	0.582	0.023	0.029	0.030	0.007	0.014	0.195	<0.001	<0.002	0.005	0.004	0.005
Aug.	0.126	0.017	0.016	0.021	0.004	0.009	0.205	—	—	<0.001	<0.001	<0.001
Sept.	0.080	0.009	0.009	0.010	0.002	0.005	0.168	—	—	—	—	—
Oct.	0.065	0.007	0.008	0.008	0.001	0.004	0.145	—	—	—	—	—
Nov.	0.052	0.005	0.007	0.008	0.001	0.004	0.131	—	—	—	—	—
Dec.	0.053	0.007	0.008	0.010	0.002	0.003	0.172	—	—	—	—	—
Av	0.254	0.028	0.025	0.027	0.007	0.013	0.192					
Estimated error (%)	±10	±25	±25	±25	±50	±50	±10	±50	±25	±10	±25	±25

*Monthly average of composite 2-wk samples, terminated on last full period in the month except between May 21 and August 6, when fresh fission products from the May 14 Chinese weapons test were evident.

**Estimated.

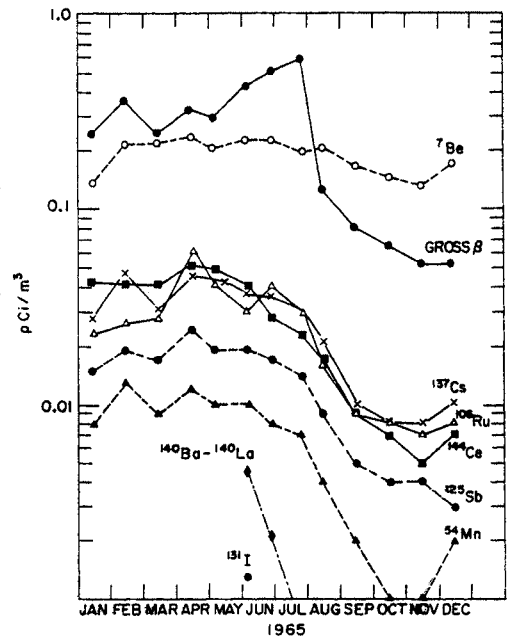

Figure 4. Monthly average air particulate concentrations.

A "spring maximum" related to the exchange to the troposphere from the stratospheric reservoir of "aged" nuclear debris, mostly from the high-yield weapons test of 1961-1962, is apparent. A small peak in the gross β concentration caused by the presence in the troposphere of fresh nuclear debris from the low-yield Chinese nuclear test[4] of May 14, 1965, is also apparent.

The arrival, about ten days later, of this debris at ground level in the Brookhaven area was apparent in the increase in gross β concentrations of daily air particulate samples, as shown in Table 9. Comparable arrival times at New York City were reported by the Public Health Service,[9] as also indicated in Table 9, and by the U.S. Atomic Energy Commission's Health and Safety Laboratory (HASL).[10] The latter measured a ^{140}Ba-^{140}La concentration of 0.0059 pCi/m^3 for the period May 22–June 1, as compared with a BNL measured concentration of 0.0053 pCi/m^3 for the period May 22–June 4. A secondary peak in daily gross β concentrations was observed on June 18-23, which suggested that the debris had traveled around the world in about one month.

A γ analysis of a composite of daily air particulate samples for the week of May 21–27 was made to determine the concentrations of recent fission products. The ^{103}Ru and ^{141}Ce data were corrected, where ^{106}Ru and ^{144}Ce photopeak interferences were present, by assuming that the previous two weeks' concentrations of the longer-lived isotopes prevailed. The identified γ-emitting "fresh" fission products and their concentrations are shown in Table 10. The agreement with theo-

Table 9

1965 BNL Environmental Monitoring
Air Particulate Gross β Concentrations, May 15–31

Date	Concentration, pCi/m³ BNL (30-hr delay count)	New York City** (4-day delay count)
May 15	0.47*	0.38
16	0.47*	0.29
17	0.24	0.17
18	0.18	<0.10
19	0.16	<0.10
20	0.13	No sample
21	0.36*	No sample
22	0.36*	0.13
23	0.36*	0.26
24	0.55	0.21
25	0.76	0.30
26	1.69	0.41
27	1.08	1.25
28	0.45*	0.62
29	0.45*	0.39
30	0.45*	0.25
31	0.45*	0.20
Estimated error	±10%	—

*Week-end sample.
**U.S. Public Health Service, Radiation Surveillance Network.

Table 10

1965 BNL Environmental Monitoring
Air Particulate γ Emitter Concentrations, May 21–27

Isotope	Concentration, pCi/m³	Observed % of total	Theoretical % of total
^{95}Zr-^{95}Nb	0.033 ±25%	4.4±1.1	5.4
^{103}Ru	0.034 ±25%	4.5±1.1	3.5
^{131}I	0.056*±25%	7.5±1.9	6.8
^{132}Te	0.044 ±25%	5.8±1.4	3.0
^{140}Ba-^{140}La	0.121 ±25%	16 ±4	24
^{141}Ce	0.048 ±25%	6.4±1.6	6.8
Gross β	0.750 ±10%	100	—

*^{131}I particulate and charcoal collection.

Table 11

1965 BNL Environmental Monitoring
Air Particulate Fresh Fission Product Concentrations, pCi/m³
May 21–July 16

Sampling period	^{95}Zr-^{95}Nb	^{131}I			^{140}Ba-^{140}La
		Particulate	Charcoal	Total	
5/21–6/4	0.020	0.011	0.010	0.021	0.054
6/4 –6/10	0.066	0.003	0.003	0.006	0.039
6/10–7/2	0.102	<0.003	0.002	0.004*	0.094
7/2 –7/16	0.032	<0.003	0.001	0.002*	0.024
Estimated error	±25%	±25%	±25%	±35%	±25%

*Air particulate ^{131}I concentration assumed to be equal to charcoal.

retical ratios[11] is satisfactory except in the case of ^{140}Ba-^{140}La.

The concentrations of ^{95}Zr-^{95}Nb, ^{131}I, and ^{140}Ba-^{140}La over 2-wk periods from May 21 to July 16 (during which ^{131}I was detectable) are shown in Table 11. The particulate fraction of the total ^{131}I appears to have been close to 50% during the two 2-wk periods in which it could be quantitated.

A charcoal cannister for ^{131}I sampling was operated in sequence after the particulate filter in each of the continuous high-volume samplers for the same 2-wk sampling period as the particulate filter. After a delay of two or three days immediately following the sampling period (to allow for the decay of radon and thoron progeny), a complete γ spectrum (from 0.1 to 3.0 MeV) was made for both filters. At the BGRR stack, about 1% of the emitted radioiodine is filterable on a 2-day particulate sample.[12]

Stack-emitted ^{131}I has not been found on routine field air particulate filters. The interference from other nuclides normally present on air particulate samples imposed a lower limit of detection of particulate ^{131}I of about 0.003 pCi/m³, but it had been assumed on the basis of the stack sampling that all the stack-emitted ^{131}I passed through the particulate filter and was collected on the charcoal cannister. During the June 2-18 sampling period nearly uniform particulate and charcoal "fallout" ^{131}I concentrations of about 0.003 pCi/m³ were observed. A comparison was made between the four stations downwind from the stack during this period and three control stations not downwind. Their respective average charcoal concentrations were 0.0080 and 0.0029 pCi/m³, whereas their respective particulate concentrations were 0.0032 and 0.0031 pCi/m³. From this comparison, it appears that a negligible ($\leqslant 2\%$) error is introduced by neglecting the particulate collection of stack effluent ^{131}I.

Interference from photopeaks of ^{214}Bi (RaC) originating from radium in the filter medium imposes a lower limit of sensitivity on γ analysis for ^{131}I. During 1965 this was reduced by substituting petroleum-based charcoal (Columbia Grade LC 12/28 × Mesh), loaded into locally fabricated cannisters, for the coconut charcoal preloaded cannister previously employed. In the routine analysis procedure, an initial 5-hr spectrum of the charcoal sample was obtained. The sample was set aside for about a month and then recounted. The net difference in the 0.36-MeV photopeak region was interpreted as the amount of filtered ^{131}I that had decayed during the 1-month interval. The average ^{214}Bi residual background in the 0.36 photopeak region was reduced from 5±1 counts/min (equivalent to about 0.003 pCi/m³ of ^{131}I) to 2±1 counts/min by the change in type of charcoal used.

As shown in Table 3, sampling devices operated by the BNL Health Physics Division indicated that a total of 2.17 Ci of ^{131}I were emitted from the BGRR stack during 1965 in an average concentration of 8.5×10^{-10} μCi/cm³. Ground-level isoconcentration lines calculated by the BNL Meteorology Group based on an emission rate of 0.1 μCi/sec from the BGRR stack, for each of four prevailing meteorological seasons within which the prevailing local wind directions and stability

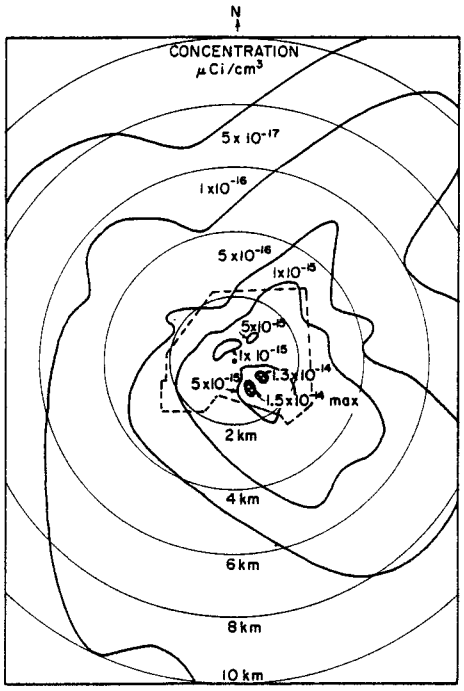

Figure 5. Average ground-level concentrations, Season I (Jan.-Mar.).

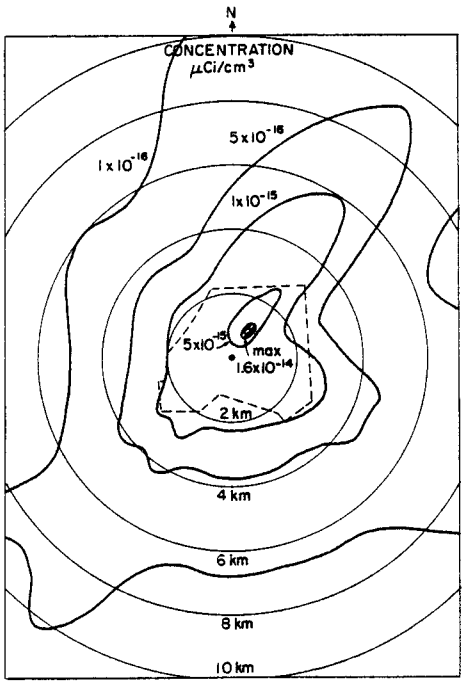

Figure 6. Average ground-level concentrations, Season II (May-Sept.).

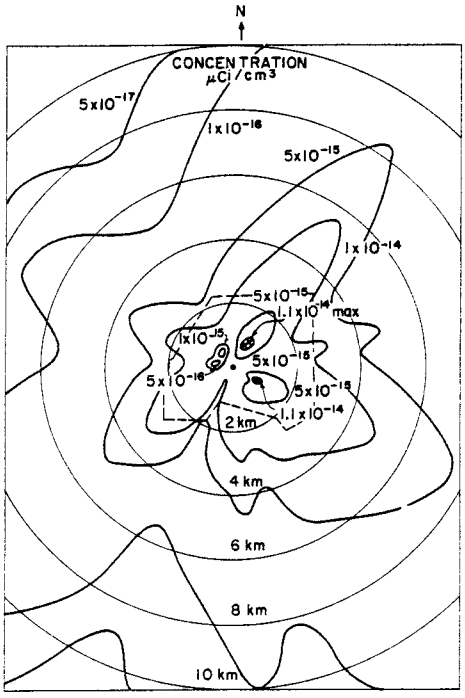

Figure 7. Average ground-level concentrations, Season III (Apr. + Oct.).

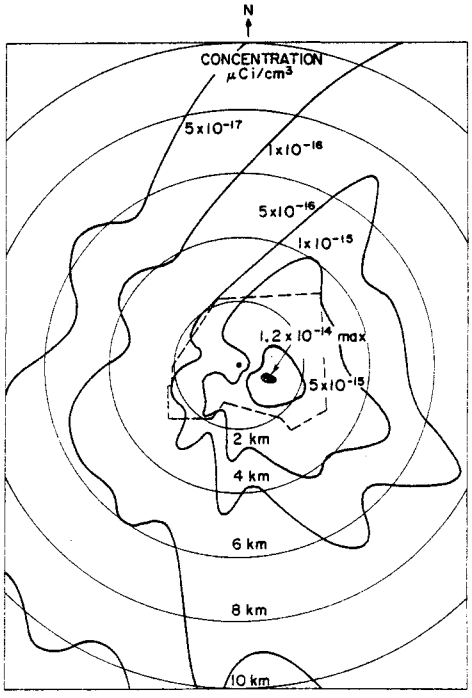

Figure 8. Average ground-level concentrations, Season IV (Nov.-Dec.).

Table 12

1965 BNL Environmental Monitoring
Seasonal Emission of ^{131}I from BGRR Station

Season	Amount, mCi*	Av concentration, nCi/cm^3	Av release rate, pCi/sec
I (Jan.–Mar.)	530	0.90	0.075
II (May–Sept.)	870	0.75	0.066
III (Apr.+Oct.)	351	0.83	0.067
IV (Nov.–Dec.)	406	1.01	0.075
Yearly total	2157		
Yearly av		0.85	0.069

*Sum of BGRR and Hot Laboratory releases.

conditions are relatively uniform, are shown in Figures 5 to 8. The BGRR ^{131}I stack emission data for each of these seasons are shown in Table 12. Measured and anticipated ground-level concentrations of stack effluent ^{131}I for each season are given in Table 13. The latter are calculated from Figures 5 to 8 and the reported average stack emission rate for each 2-week sampling period. Although the stack emission of ^{131}I generally increased from about 0.5 μCi/sec at the beginning of each 3-wk BGRR operating cycle (after a 1-wk shutdown) to about 0.8 μCi/sec at the end of the cycle, the measurement error of both the field and stack samples was believed to be such that corrections for this systematic variation in stack emission were not justified.

As previously reported,[13] the method of predicting the long-term ground-level concentration leads to an underestimate, on the average, of the observed ^{131}I ground-level concentrations. Since the data do not reveal a significant directional or seasonal effect, the measurements (of rate of discharge and field concentration) are being analyzed for systematic errors, and the model itself is being studied to determine its appropriateness.

On March 1, 1965, an irradiated 1.0-g sample of ^{235}U overheated. Although it was removed from the flux within an hour of the first indications of unusual stack effluent concentrations, it resulted in the emission of about 100 mCi of ^{131}I and 1.0 Ci of ^{133}I from the BGRR stack during the next few days. As can be seen from Figure 9, the release rate of both isotopes began at a fairly high level (34.4 mCi/hr of ^{131}I and 365 mCi/hr of ^{133}I), diminished by an order of magnitude within a

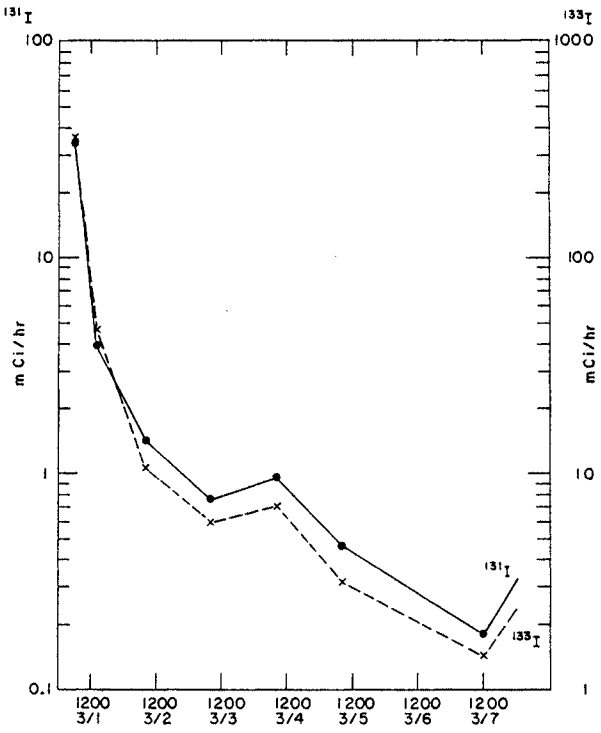

Figure 9. Stack release rate of ^{131}I and ^{133}I, Mar. 1-7.

few hours, and then slowly returned to the prevailing release rate (0.25 mCi/hr of ^{131}I) over the next few days.

Ground-level concentrations of ^{131}I and ^{133}I at the BNL monitoring stations (and at one special sampling location) are given in Table 14. As can be seen, 21-hr ^{133}I was detectable in the field for only a few days, but 8-day ^{131}I was found in concentrations above those normally encountered for a full two weeks. The stack sample data did not indicate an unusually large particulate fraction of the radioiodines. This fraction in field samples during the first day after the initial release was close to 50%, a day later it was 40%, from the second to the fifth day 30%, and from the fifth to fifteenth day $<20\%$ of the total field collections. The general consistency between ^{133}I and ^{131}I concentrations and between field and stack-release $^{133}I/^{131}I$ ratios supports the reliability of the field measurements.

From the highest integrated concentration at the Laboratory's perimeter (about 2.25×10^{-8} μCi/sec-cm^3 of ^{131}I and 1.75×10^{-7} μCi/sec-cm^3 of ^{133}I), an adult inhalation dose of 0.036 mR can be calculated. Under the same meteorological

Table 13

1965 BNL Environmental Monitoring
Ground-Level Concentrations of Stack-Effluent ^{131}I, pCi/m^3

Station	Downwind from stack: Direction	Distance, m	Season I (Jan.–Mar.): Calc.	Obs.	%	Season II (May–Sept.): Calc.	Obs.	%	Season III (April + Oct.): Calc.	Obs.	%	Season IV (Nov.–Dec.): Calc.	Obs.	%	Annual: Calc.	Obs.	%
P-2	140°	1850	0.0004	0.0015	0.27	0.0011	0.0012	0.92	0.0005	0.0012	0.42	0.0004	Na[a]	—	0.0007	0.0013	0.54
P-4	63°	2200	0.0007	0.0011	0.64	0.0007	0.0005	1.40	0.0008	0.0005	1.60	0.0004	Na[a]	—	0.0007	0.0006	1.17
S-11	319°	680	0.0065	0.0041	1.59	0.0023	0.0025	0.92	0.0034	0.0017	2.00	—	—	—	0.0035[b]	0.0033[b]	1.06
S-11	300°	580	—	—	—	—	—	—	—	—	—	0.0053	0.0064	0.82	—	—	—
S-6	300°	1490	—	—	—	—	—	—	—	—	—	0.0060	0.0084	0.72	—	—	—
P-7	321°	2550	0.0030	0.0072	0.42	—	—	—	—	—	—	—	—	—	—	—	—
P-7	300°	2860	—	—	—	0.0007	0.0008	0.87	0.0020	0.0029	0.69	0.0026	0.0037	0.70	0.0016	0.0031	0.52
S-12	218°	570	—	—	—	0.0048	0.0027	1.78	0.0057	0.0035	1.63	—	—	—	—	—	—
S-13	217°	1330	—	—	—	0.0053	0.0054	0.98	0.0054	0.0065	0.83	—	—	—	—	—	—
P-9	217°	2750	0.0011	0.0033	0.35	0.0032	0.0041	0.78	0.0023	0.0023	1.00	0.0017	0.0034	0.50	0.0024	0.0035	0.68
Av					0.45			1.09			1.17			0.69			0.77

[a]Not available because of the presence of a prevailing background of ^{131}I of unknown off-site origin.
[b]Includes Nov.–Dec. data.

Table 14

1965 BNL Environmental Monitoring
Ground-Level Concentrations of ^{131}I and ^{133}I, March 1–15

Station	Downwind: Direction,	Distance, m	Sampling period	^{131}I, μCi/cm^3	^{133}I, μCi/cm^3	$^{133}I/^{131}I$
S-11	320°	700	3/1			
			0840–1010	1.22×10^{-12}	1.36×10^{-11}	11.1
			1010–1330	5.80×10^{-13}	5.19×10^{-12}	8.8
			3/1–3/2			
			1330–1450	6.20×10^{-14}	2.66×10^{-13}	4.3
			3/2–3/5			
			1450–1450	7.50×10^{-15}	3.14×10^{-14}	4.2
			3/5–3/15			
			1450–1600	2.74×10^{-15}	—	—
Igloo	311°	1750	3/1			
			0910–1350	8.07×10^{-13}	5.65×10^{-12}	7.0
P-7	321°	2550	3/1			
			0830–0930	2.10×10^{-12}	2.25×10^{-11}	10.7
			0930–1340	5.81×10^{-13}	5.78×10^{-12}	10.0
			3/1–3/5			
			1430–0935	1.66×10^{-14}	1.72×10^{-13}	10.4
			3/5–3/15			
			0935–1600	2.74×10^{-15}	—	—
P-9	217°	2750	3/1–3/5			
			0955–0955	3.14×10^{-15}	6.18×10^{-15}	1.9
			3/5–3/15			
			0955–1000	1.50×10^{-15}	—	—
P-4	63°	2200	3/1–3/5			
			0950–0920	$<5.0\times10^{-16}$	—	—
			3/5–3/15			
			0920–0845	6.9×10^{-16}	—	—

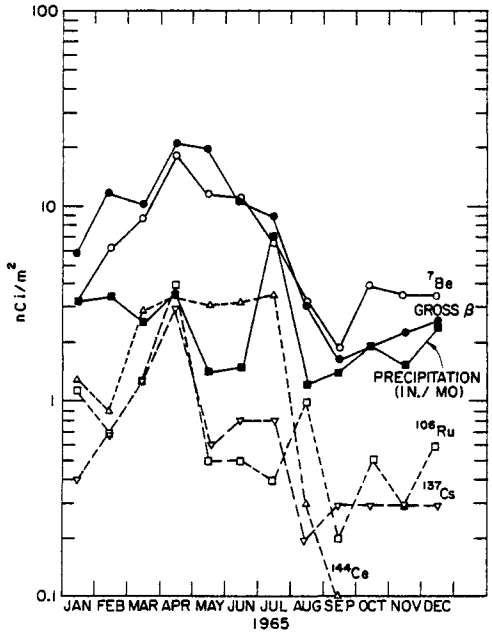

Figure 10. Monthly precipitation collection, gross β activity, and ^{7}Be, ^{106}Ru, ^{137}Cs, and ^{144}Ce activities.

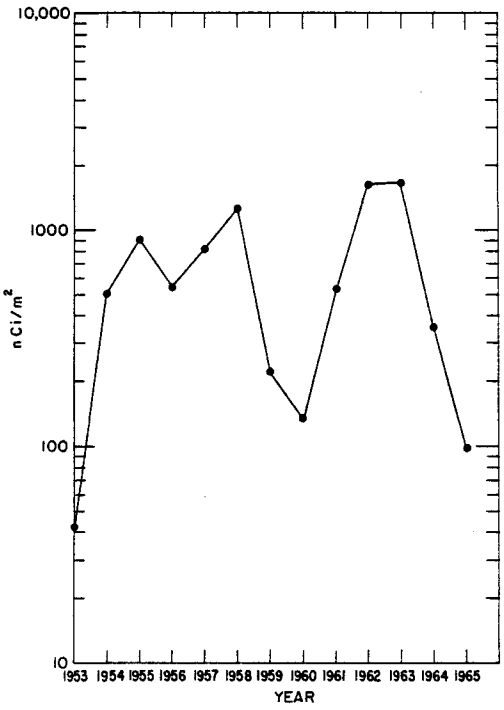

Figure 11. Yearly total gross β activity in precipitation, 1953-1965.

Table 15

1965 BNL Environmental Monitoring
Monthly Average Gross β Concentration, Total Gross β Activity, and Principal Isotope Activities in Precipitation

Month	Amount, in.	Conc., pCi/liter	Gross β activity, nCi/m²	^{7}Be	^{54}Mn	^{89}Sr	^{90}Sr	^{95}Zr-^{95}Nb	^{106}Ru	^{131}I	^{137}Cs	^{140}Ba-^{140}La	^{144}Ce
Jan.	3.32	68	5.74	3.2	0.1	<0.1	0.2	<0.1	1.2	0.3	0.4	<0.1	1.3
Feb.	3.42	154	11.55	6.2	0.2	<0.1	0.5	<0.1	0.7	<0.1	0.7	<0.1	0.9
Mar.	2.57	153	10.06	8.6	0.7	<0.1	0.7	<0.1	2.6	<0.1	1.3	<0.1	2.9
Apr.	3.53	231	20.70	18.3	0.7	<0.1	1.0	<0.1	4.0	<0.1	3.1	<0.1	3.4
May	1.42	349	19.40	11.6	0.6	0.5	0.3	0.8	0.5	0.8	0.6	1.7	3.1
June	1.50	337	10.68	11.1	0.3	0.9	0.3	0.6	0.5	0.6	0.8	1.0	3.2
July	7.11	70	8.70	6.7	0.2	0.5	0.5	0.1	0.4	<0.1	0.8	<0.1	3.6
Aug.	1.23	63	3.07	3.3	<0.1	<0.1	<0.1	<0.1	1.0	<0.1	0.2	<0.1	0.3
Sept.	1.41	46	1.60	1.9	<0.1	<0.1	0.1	<0.1	0.2	<0.1	0.3	<0.1	0.1
Oct.	1.93	43	1.93	3.9	<0.1	<0.1	<0.1	<0.1	0.5	<0.1	0.3	<0.1	<0.1
Nov.	1.54	55	2.27	3.6	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.3	<0.1	<0.1
Dec.	2.44	38	2.58	3.5	<0.1	<0.1	<0.1	<0.1	0.6	<0.1	0.3	<0.1	<0.1
Total	31.42	1607	98.28	81.9	2.6	1.4	3.4	1.1	12.5	1.2	9.1	2.2	18.6
Av	2.62	123	8.19	6.8	0.2	0.1	0.3	0.1	1.0	0.1	0.8	0.2	1.6
Estimated error	±0.10	±25	±0.25	±1.0	±0.1	±0.05	±0.1	±0.05	±0.1	±0.05	±0.2	±0.1	±0.4

conditions (those generally prevailing at this site) a release of some 15,000 Ci of the 10:1 $^{133}I/^{131}I$ mixture or a release of some 20,000 Ci of a 10-min postrelease equilibrium fission product mixture (^{131}I, ^{132}I, ^{133}I, ^{134}I, and ^{135}I) would have been required to produce a calculated 500-mrad inhalation thyroid dose at the S-7 perimeter location.

PRECIPITATION COLLECTION

Two pot-type rain collectors, each with a surface area of 0.33 m^2, are situated adjacent to the Meteorology Building in a prevailing upwind direction from the BGRR stack. Two collections were made. One was picked up at 0900 only if precipitation had been observed during the previous 24 hr (or weekend); the other was made each Monday morning, whether or not precipitation had occurred. A standard amount of distilled water was used to wash down the collector if no precipitation was falling at the time each sample was terminated.

Part of each collection was evaporated for gross β counting. The largest single rainout, 15.9 mCi/m^2 at a concentration of 2050 pCi/liter, occurred on May 26-27. Weekly samples were analyzed for identifiable γ-emitting isotopes, and monthly composite samples for ^{89}Sr and ^{90}Sr. Monthly average gross β concentrations and monthly amounts of gross β activity and of individual isotopes in precipitation are given in Table 15. The monthly amounts of gross β activity and of the more prevalent isotopes, ^{144}Ce, ^{106}Ru, ^{137}Cs, and ^{95}Zr-^{95}Nb, are plotted in Figure 10. Although a spring peak of fallout activity is evident, the presence of recent fission isotopes in the May-July samples reflects the input from the Chinese test in mid-May. The amounts of longer-lived fallout isotopes are in general agreement with those reported by the Health and Safety Laboratory[14] for New York City.

Rain and settled dust collections have been made by the Environmental Monitoring Group at Brookhaven National Laboratory continuously since the latter part of 1953. Total yearly activity is shown in Figure 11. The amount for 1953 is estimated from the Sept.-Dec. average.

LIQUID EFFLUENT MONITORING

Low-level radioactive liquid effluents were rountinely disposed of by release into the Laboratory's sanitary waste system, where they were diluted by a large volume of uncontaminated water. This liquid waste effluent passed through an Imhoff tank which removed most of the solids and then flowed onto sand filter beds, from which most of it was collected by an underlying tile field. The liquid effluent was then chlorinated and discharged into a small stream that forms one of the headwaters of the Peconic River.

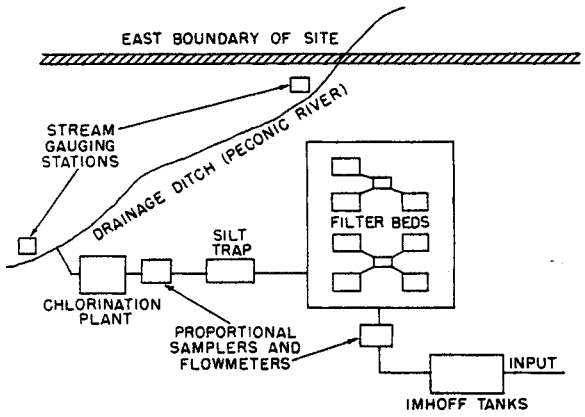

Figure 12. BNL sewage processing and monitoring system

The monitoring arrangements for the central sewage system are indicated in Figure 12. Values of the monthly average gross β concentration and total gross β activity for the input to the filter bed, discharge to the river, and at the site boundary (computed on the basis of stream flow) are given in Table 16. A calculated radiation protection standard concentration of 1070 pCi/liter that assumes a 20% ^{90}Sr content is applied at the boundary.

A γ spectrum and a ^{90}Sr analysis were performed on a monthly composite of the filter bed input samples and of the effluent from the beds. The amounts and average concentrations of identifiable isotopes entering and leaving the beds are shown in Table 17.

The amounts of radioactivity released as liquid waste by the Laboratory have decreased annually during recent years. Information extracted from internal BNL reports concerning the gross β liquid effluent activity going into and discharged from the sand filter beds since 1951 is presented in Figure 13. A shock absorber effect is apparent in the 2-yr delay between the 1959 peak input to the beds from the Imhoff tank and the 1961 peak

Table 16

1965 BNL Environmental Monitoring
Monthly Average Liquid Effluent Flow, Concentration, and Total Gross β Activity

Month	Imhoff tank			Chlorine house			Perimeter		
	Flow, gal/day	Conc., pCi/liter	Activity, mCi	Flow, gal/day	Conc., pCi/liter	Activity, mCi	Flow, gal/day	Conc., pCi/liter	Activity, mCi
Jan.	630,000	58	4.3	516,000	47	2.8	645,000	37	2.8
Feb.	659,000	63	4.8	571,000	68	4.6	846,000	46	4.6
Mar.	643,000	67	4.6	516,000	85	4.6	704,000	62	4.6
Apr.	960,000	33	2.6	568,000	52	3.4	703,000	41	3.4
May	834,000	74	7.0	666,000	43	3.3	832,000	35	3.3
June	1,001,000	37	4.3	790,000	41	3.8	1,046,000	31	3.8
July	1,102,000	58	7.2	833,000	34	3.3	844,000	34	3.2
Aug.	1,232,000	42	5.9	939,000	30	3.3	963,000	29	3.3
Sept.	995,000	28	3.2	751,000	29	2.6	765,000	28	2.6
Oct.	991,000	120	13.6	743,000	36	3.0	780,000	34	3.0
Nov.	812,000	31	2.9	647,000	33	2.5	694,000	31	2.5
Dec.	810,000	70	6.4	603,000	70	4.8	653,000	65	4.8
Total	—	—	66.8	—	—	42.0	—	—	41.9
Av	865,000	56	—	704,000	45	—	789,000	38	—
Estimated error		±10%	±10%		±10%	±10%		±10%	±10%

Table 17
1965 BNL Environmental Monitoring
Total Activities and Average Concentrations of Identifiable Isotopes

Month	^{24}Na	^{32}P	^{54}Mn	^{60}Co	^{90}Sr	^{95}Zr-^{95}Nb	^{106}Ru	^{131}I	^{137}Cs	^{144}Ce
					Imhoff Tank					
Jan.	<0.05	<0.25	<0.05	<0.10	0.41	<0.05	<0.05	<0.05	0.64	<0.05
Feb.	<0.05	<0.25	<0.05	3.13	0.38	<0.05	<0.05	0.62	<0.05	<0.05
Mar.	<0.05	<0.25	<0.05	0.47	0.33	<0.05	<0.05	0.11	0.18	<0.05
Apr.	1.82	<0.25	<0.05	0.64	0.31	<0.05	<0.05	1.37	0.41	<0.05
May	1.00	<0.25	<0.05	0.33	0.28	2.46	1.16	<0.05	0.16	0.70
June	<0.05	<0.25	<0.05	<0.10	0.26	<0.05	<0.05	1.24	0.48	<0.05
July	<0.05	<0.25	<0.05	0.92	0.27	<0.05	<0.05	7.89	1.65	<0.05
Aug.	<0.05	<0.25	0.18	0.36	0.36	<0.05	1.17	0.41	1.34	1.15
Sept.	<0.05	<0.25	<0.05	<0.10	0.15	<0.05	<0.05	0.08	0.37	<0.05
Oct.	<0.05	15.75	0.07	0.31	0.26	<0.05	0.15	0.16	0.82	0.72
Nov.	<0.05	<0.25	<0.05	0.16	0.22	<0.05	<0.05	<0.05	0.26	<0.05
Dec.	<0.05	<0.25	<0.05	0.68	0.13	<0.05	<0.05	0.04	0.34	<0.05
Total mCi*	3.1	17.1	0.5	7.1	3.3	2.7	2.7	12.0	6.6	2.8
Av. conc., pCi/liter	3	14	<1	6	3	2	2	10	6	2
					Chlorine House					
Jan.	<0.05	<0.25	<0.05	<0.10	0.47	<0.05	<0.05	<0.05	1.64	<0.05
Feb.	<0.05	<0.25	<0.05	0.35	0.32	<0.05	<0.05	<0.05	2.51	<0.05
Mar.	0.11	<0.25	<0.05	0.11	0.59	<0.05	<0.05	0.08	0.26	<0.05
Apr.	<0.05	<0.25	<0.05	<0.10	0.57	<0.05	<0.05	0.21	1.38	<0.05
May	1.35	<0.25	<0.05	<0.10	0.48	0.05	0.28	<0.05	1.22	0.27
June	<0.05	<0.25	<0.05	<0.10	0.38	<0.05	<0.05	<0.05	1.95	<0.05
July	<0.05	<0.05	<0.05	0.92	0.23	<0.05	0.14	1.05	2.05	0.08
Aug.	<0.05	<0.25	0.05	<0.10	0.31	<0.05	<0.05	<0.05	1.79	<0.05
Sept.	<0.05	<0.05	<0.05	<0.10	0.19	<0.05	<0.05	<0.05	1.21	0.57
Oct.	<0.05	0.90	<0.05	0.31	0.20	<0.05	<0.05	<0.05	1.59	0.14
Nov.	<0.05	<0.25	<0.05	0.11	0.25	<0.05	<0.05	<0.05	1.14	<0.05
Dec.	<0.05	<0.25	<0.05	0.52	0.18	<0.05	<0.05	<0.05	1.63	<0.05
Total mCi*	1.7	<2.2	<0.3	2.6	4.2	<0.3	<0.7	1.6	18.4	1.3
Av. conc., pCi/liter	2	<2	<1	3	4	<1	1	2	20	1

* "Less than" amounts summed as half the indicated amount.

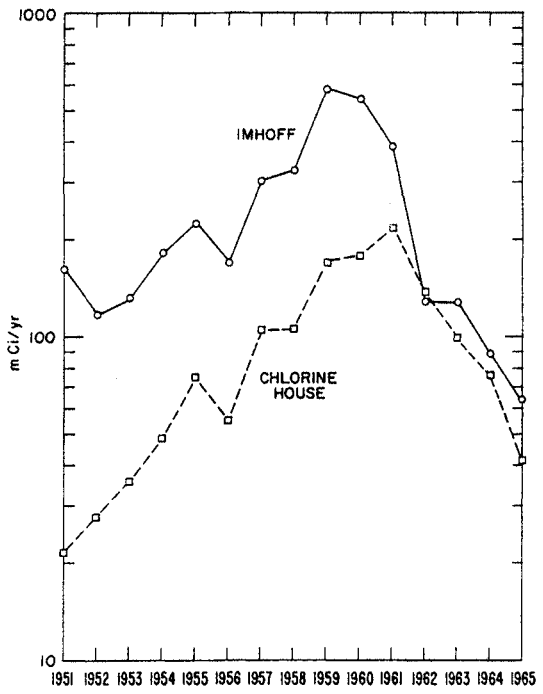

Figure 13. Liquid effluent yearly gross β activity, 1951-1965.

of discharged activity as measured at the chlorine house, and also in the excess-over-input amounts of ^{90}Sr and ^{137}Cs leaving the filter beds during 1965.

Although sludge was pumped from the Imhoff tank to the drying beds, none was disposed of on the BNL dump during 1965.

The sand filter beds have been reported to be about 90% efficient for most isotopes.[15] A recapitulation of three unusual releases that occurred during the year is presented in Table 18. It appears that on a short-term basis all the isotopes involved except ^{24}Na were substantially retained on the filter beds. The excess of ^{90}Sr and ^{137}Cs in the filter bed effluent during recent years, again apparent during 1965, indicates that these isotopes are not permanently retained in the filter beds; rather, a delay mechanism with a long time constant is operative.

Table 18

1965 BNL Environmental Monitoring
Retention Efficiency of Sand Filter Beds

Isotope	Imhoff tank, mCi	Chlorine house, mCi	Retention, %
	May (release of Apr. 28–29)		
^{24}Na	2.82±10%	1.35±10%	52± 8
^{95}Zr-^{95}Nb	2.46±10%	0.05±25%	98± 2
^{106}Ru	1.16±10%	0.28±25%	77± 9
^{144}Ce	0.70±25%	0.27±25%	60±21
	July (release of July 16–18)		
^{131}I	7.89±10%	1.05±10%	87± 5
	Oct. (release of Oct. 1–3)		
^{32}P	6.5 ±10%	0.5 ±25%	92± 3

STREAM SAMPLING

Monthly "grab" water samples were obtained at on- and off-site locations along the upper tributary of the Peconic River, into which the Laboratory routinely discharges low-level liquid wastes. Reference grab samples were also obtained from other nearby streams and bodies of water outside the Laboratory's drainage area. The sampling locations (Figure 14) were as follows:

A. Peconic River at Schultz Rd., 15,900 ft downstream from chlorine house.
B. Peconic River at Wading River–Manorville Rd., 23,100 ft downstream from chlorine house.
C. Peconic River at Manorville, ≈35,500 ft downstream from chlorine house.
D. Peconic River at Calverton, ≈46,700 ft downstream from chlorine house.
E. Peconic River, upstream from BNL effluent outfall.
F. Peconic River at north tributary (independent of BNL drainage).
G. Carman's River at Middle Island.
H. Carman's River at outflow of Yaphank Lake.
I. Artist Lake (maintained by water table, no surface outflow.)
J. Lake Panamoka (maintained by water table, no surface outflow).
K. Peconic River, just below BNL effluent outfall.
L. Peconic River, 1300 ft below BNL effluent outfall.
M. Peconic River, 2600 ft below BNL effluent outfall (at BNL boundary).
Q. Peconic River, 6900 ft downstream from BNL boundary.

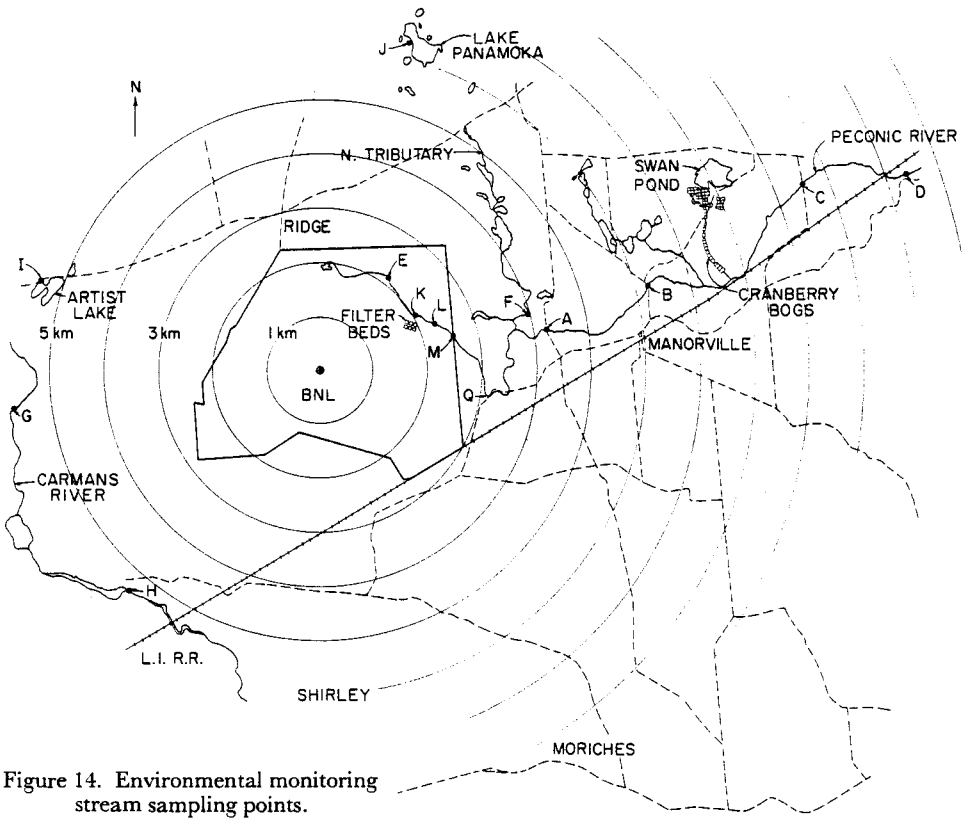

Figure 14. Environmental monitoring stream sampling points.

Table 19

1965 BNL Environmental Monitoring
Monthly Stream Water Samples and Yearly Averages for 1960–1965,
Gross β Concentrations in pCi/liter

	Peconic River locations, proceeding downstream from chlorine house								Control locations					
Month, 1965	K	L	M	Q	A	B	C	D	E	F	G	H	I	J
Jan.	40	56	75	137	24	8	11	9	16	—	—	—	—	23
Feb.	95	90	78	84	22	16	12	11	16	11	14	10	29	29
Mar.	41	45	47	—	18	13	9	8	7	17	8	3	13	44
Apr.	24	24	27	57	13	11	11	13	15	14	7	4	21	<10
May	19	19	21	29	18	11	12	17	6	8	6	2	14	11
June	32	31	26	43	27	9	9	4	17	8	13	27	15	16
July	19	23	26	34	22	7	7	4	5	3	Dry	<1	16	8
Aug.	33	34	10	24	22	15	9	7	28	19	Dry	18	17	8
Sept.	42	43	39	55	7	5	8	5	13	12	—	<1	15	8
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	41	42	40	44	12	6	15	4	—	<2	—	<2	15	6
Yearly av														
1965	39	41	39	56	18	10	10	8	14	10	10	7	17	15
1964	115	83	49	52	30	25	19	14	15	19	13	10	25	18
1963	61	74	39	—	46	42	59	40	36	37	13	25	50	35
1962	—	—	—	—	47	31	39	33	38	35	23	36	44	38
1961	—	—	—	—	34	19	—	17	17	10	6	9	14	16
1960	—	—	—	—	20	13	—	11	8	5	7	9	13	6

Estimated error: <25 pCi/liter, ±3; >25 pCi/liter, ±10%.

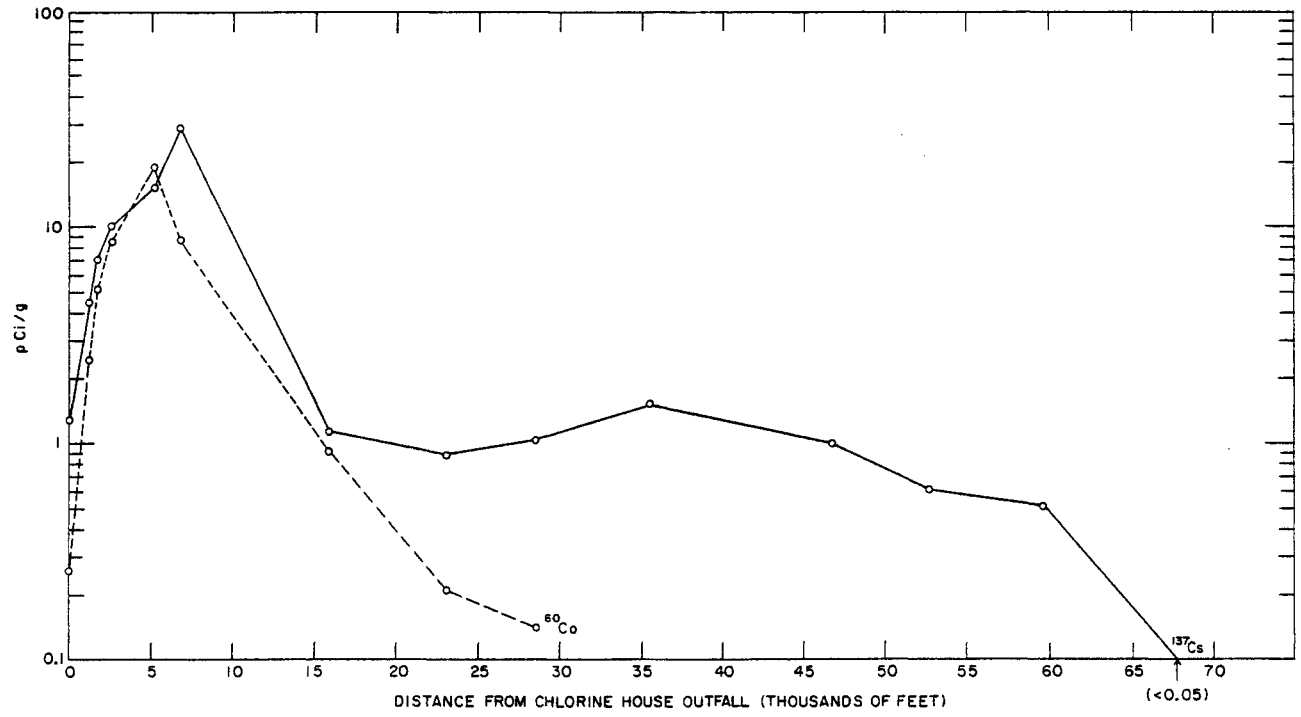

Figure 15. Peconic River bottom sediment samples.

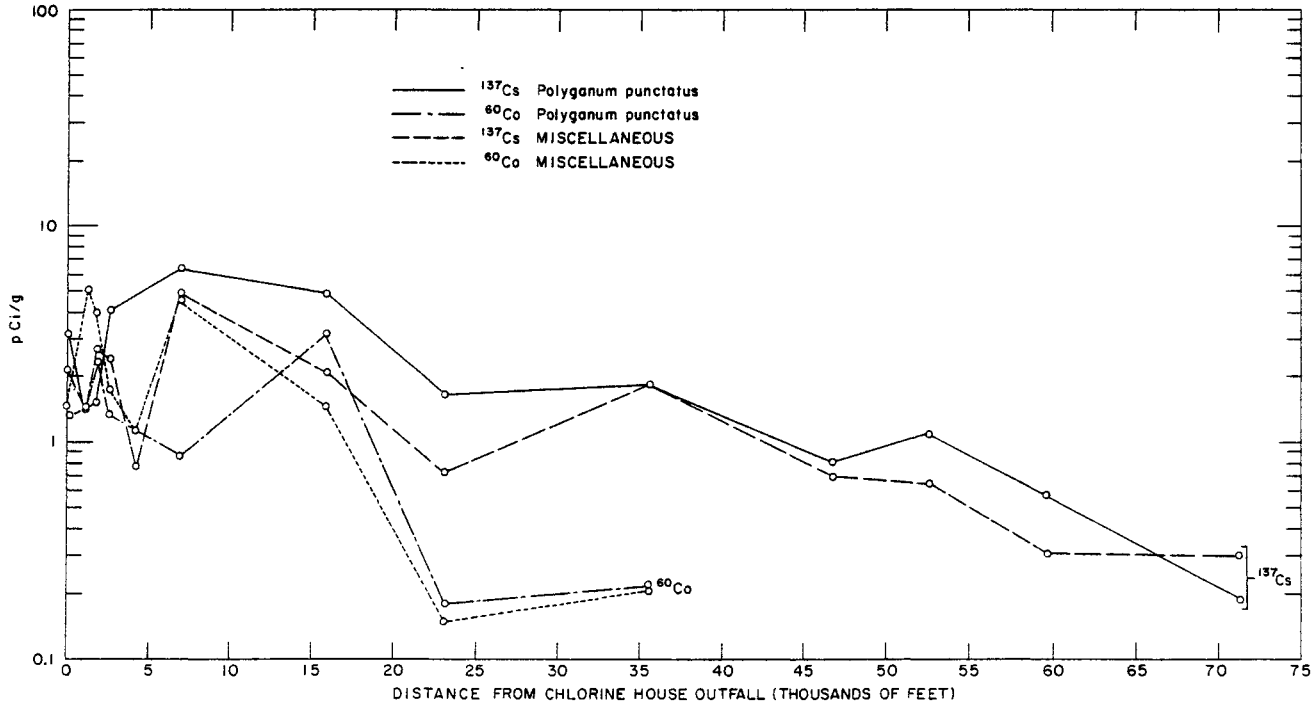

Figure 16. Peconic River vegetation samples.

Stream-water-sample gross β concentrations found during 1965 are summarized in Table 19. To facilitate comparisons, the samples are divided into two groups, one comprising locations in sequence from upstream to downstream on the Peconic River, and the other, control locations. Off-site stream sampling was initiated in 1960. Yearly averages since that time are also given in Table 19. There appears to be relatively little dilution by tributaries in the upper reaches of the stream. Three separate measurements made by the Water Resources Division of the U.S. Geological Survey[16] during 1965 indicated that the average daily flow of the Peconic River at Schultz Rd. (sampling location A) was about 150% of that at the perimeter (sampling location M), while continuous flow measurements made at the Riverhead Gauging Station, near the mouth of the river, averaged 1.7×10^7 gal/day, about 21 times that at the perimeter. However, the fraction of the gross β concentration in downstream water samples attributable to BNL effluent appears to fall off quite rapidly in the river's upper reaches; it was not perceptible at or beyond sampling location B, about four miles downstream. A summer program of stream bottom sampling in the Peconic River was initiated in 1963 to obtain a profile of the distribution of radioactivity along the river downstream from the chlorine house outfall. Sediment samples were again obtained in 1965. Most of the remaining effort was directed toward the collection of identifiable species of bottom-growing plants and of turtles. A few frogs and fish were also obtained. No processing was performed on these samples beyond packaging for analysis for γ-emitting isotopes. The turtles were also identified (by numbers engraved into their shells) and returned to the stream so that they would be available for future sampling. The only nuclides detectable in most samples were ^{60}Co and ^{137}Cs.

The bottom sediment profile appears in Figure 15. Profiles for one species of underwater vegetation *(Polyganum punctatus)* which was found throughout the stream and for the average of all vegetation samples at each sampling location appear in Figure 16.

The data are generally consistent with those previously obtained and confirm that most of the radioactvity contained in the Laboratory liquid effluent released to the Peconic is retained within a distance of a few miles downstream from the point of release.

A general increase throughout the stream in ^{137}Cs concentrations (by somewhat more than a factor of two compared with those encountered in 1964) was evident in the bottom sediment samples. Although not apparent from the reported 1964 data (in which the ^{60}Co bottom sediment concentrations given were almost the same as those reported here), a similar increase occurred in ^{60}Co concentrations. The reported 1964 bottom sediment ^{60}Co concentrations contain a uniform fac-

Table 20

1965 BNL Environmental Monitoring
Concentrations of ^{137}Cs and ^{60}Co in Peconic River Turtles, pCi/g

Trap location (ft downstream)	Stream station	Aquatic species						Terrestrial species	
		Eastern painted		Musk		Snapping		Box	
		^{137}Cs	^{60}Co	^{137}Cs	^{60}Co	^{137}Cs	^{60}Co	^{137}Cs	^{60}Co
1,800	—	3.1	0.5	—	—	—	—	—	—
2,700	M	6.4	<0.1	—	—	—	—	—	—
35,500	C	—	—	5.2	<0.1	5.2	<0.1	11.3	<0.1
52,600	—	1.2	<0.1	3.3	<0.1	—	—	—	—
59,600	—	1.3	<0.1	—	—	—	—	—	—
71,300	—	0.5	<0.1	0.6	<0.1	—	—	—	—
Lake Panamoka	—	0.1	<0.1	—	—	—	—	—	—

Estimated error: ^{60}Co, $\leqslant 1$ pCi/g, ± 0.1 pCi/g.
^{137}Cs, $\leqslant 1$ pCi/g, ± 0.1 pCi/g; >1, $\pm 10\%$.

Table 21

1965 BNL Environmental Monitoring
Concentrations of ^{60}Co and ^{137}Cs in Peconic River Frogs, Fish, and Snakes, pCi/g

Trap location (ft downstream)	Sampling station	Frogs		Pickerel		Bluegill		Snakes	
		^{137}Cs	^{60}Co	^{137}Cs	^{60}Co	^{137}Cs	^{60}Co	^{137}Cs	^{60}Co
150	K	—	—	—	—	—	—	—	—
1,300	L	—	—	—	—	—	—	—	—
1,800	—	1.6	<0.1	—	—	—	—	—	—
2,600	M	1.5	<0.1	5.8	<0.1	3.6	<0.1	8.1	0.4
6,900	Q	4.3	0.5	—	—	—	—	—	—
15,900	A	—	—	—	—	—	—	—	—
23,100	B	—	—	—	—	—	—	—	—
35,500	C	—	—	—	—	—	—	—	—
46,700	D	1.0	<0.1	—	—	—	—	—	—
52,600	11	—	—	—	—	—	—	—	—
59,600	12	—	—	—	—	—	—	—	—
71,300	13	—	—	—	—	—	—	—	—

Estimated error: ^{60}Co, $\leqslant 1$ pCi/g, ± 0.1 pCi/g; ^{137}Cs, $\pm 10\%$.

tor-of-two error of analysis which became apparent only recently. The highest concentration of ^{60}Co (18.9 pCi/g) was found 5200 ft downstream from the outfall (at the chlorine house), and that of ^{137}Cs (28.4 pCi/g), at 6500 ft downstream. The highest concentrations of each isotope were found in bottom sediments at the same locations in 1964.

Since the vegetation samples collected in 1964 were not identified by species, direct comparisons cannot be made. The greatest single concentration of ^{60}Co in a sample (8.4 pCi/g) was found at 1800 ft downstream from the outfall, and that of ^{137}Cs (6.4 pCi/g) at 6900 ft downstream.

The data on turtles are summarized in Table 20, since turtles could not be found at enough locations to provide a representative profile. The highest concentration of ^{137}Cs, 6.4 pCi/g, was found in an aquatic species taken 2700 ft downstream; but a still higher concentration, 11.3 pCi/g, was found in a terrestrial species obtained close to the 35,500-ft downstream sampling site. Similar data for frogs, fish, and a snake are summarized in Table 21. A sample of clams and one of scallops were obtained during February from the Peconic Bay, near the mouth of the river. No activity attributable to the Laboratory's effluent could be detected. The analytical results are given in Table 22.

Since there is an abundant underground supply of water on Long Island, the Peconic River is not used to supply drinking water or for irrigation. Its waters are occasionally used to flood the lower bogs of a commercial cranberry operation eight miles downstream. Although they were not so used during 1965, one sample of berries from lower bogs of this farm was obtained. The identifiable γ-emitting isotopes in it were ^{137}Cs (1.2 pCi/g) and ^{54}Mn (<0.1 pCi/g).

WELL SAMPLING

The Laboratory's potable water wells and cooling water supply wells are about 100 ft deep or 50 ft below the water table in the Long Island surface layer of glacial till. They are also generally west to northwest and upstream from most of the facilities of the Laboratory. The exceptions are principal potable water wells Nos. 1 and 3, the smaller well No. 5 at the sewage plant, and the one at the waste and reclamation area (see Figure 17). Monthly gross β results are summarized in Table 23. Less than background values have been assumed to be 50% of the detection limit in calculating yearly averages. No significant differences from previous sampling were apparent.

VEGETATION AND SOIL SAMPLING

In addition to routine sampling early and late in the summer, early in June a number of grass

Table 22

1965 BNL Environmental Monitoring
γ-Emitting Radioactivity in Peconic Bay Shellfish

Type	Isotope		
	^{54}Mn, pCi/kg	^{137}Cs, pCi/kg	K, g/kg
Clams, meat	20±20	<20	1.3±0.2
shells	<20	"	—
Scallops, meat	390±39	"	2.3±0.2
shells	480±48	"	—

samples were secured from nearby farms (at most of which milk and soil samples were also obtained) to ascertain the levels of fallout isotopes from the May Chinese weapons test. The several periods of light to moderate precipitation late in May and early in June apparently deposited most of the fallout activity observed in these samples. About 50% of the available ^{131}I (per unit area) was retained on the grass. One grass sample was obtained on March 1st at the Igloo area in connection with the ^{131}I release described earlier. The deposited ^{131}I was <50 pCi/kg, which indicated that its deposition velocity was <0.5 cm/sec.

Concentrations of identifiable γ-emitting isotopes in these pasture samples are summarized in Table 24. About one-third as much ^{137}Cs as was observed during 1964 was deposited by precipitation this year. The decline in the average concentration of ^{137}Cs in pasture grass was in close agreement. Corrected for half-life, similar decreases of ^{106}Ru and ^{144}Ce were observed in both precipitation and pasture vegetation.

Grass plots were established during mid-summer at the prevailing downwind stations S-12, S-13, and P-9 (see Figure 2) at which the highest ^{131}I concentrations were observed. Samples were obtained at 2-wk intervals between August 6 and October 8. About half the samples were double-counted (in a manner analogous to that for the charcoal-filter samples), and for the balance an average background in the control-sample photopeak region (equivalent to 25 pCi/kg) was subtracted from the gross count in the 0.36-MeV photopeak region. The average ^{131}I concentrations were S-12, 13 pCi/kg; S-13, 18 pCi/kg; and P-9, 10 pCi/kg, with an estimated error of ±10 pCi/kg. The apparent ^{131}I deposition velocity was 0.5±0.3 cm/sec.

Samples of the top 6 in. of soil were obtained in June and September from most of the farms in the vicinity of the Laboratory from which vegetation samples were secured. The concentrations of identifiable γ-emitting isotopes present appear in Table 25. The concentrations of natural uranium and thorium were determined by comparison with the γ spectrum of calibrated ore samples.

MILK SAMPLING

Meteorological predictions of average ground concentrations of ^{131}I emitted from the BGRR, reasonable assumptions about its deposition and about the relationship between grass and milk concentrations, lead to the conclusion that ^{131}I in the milk from cows pastured in the vicinity of the Laboratory would generally be <1 pCi/liter, or well below the lower limit of detection.

The concentrations of ^{137}Cs and the amounts of potassium in routine monthly samples are shown in Table 26. Some locations were sampled more

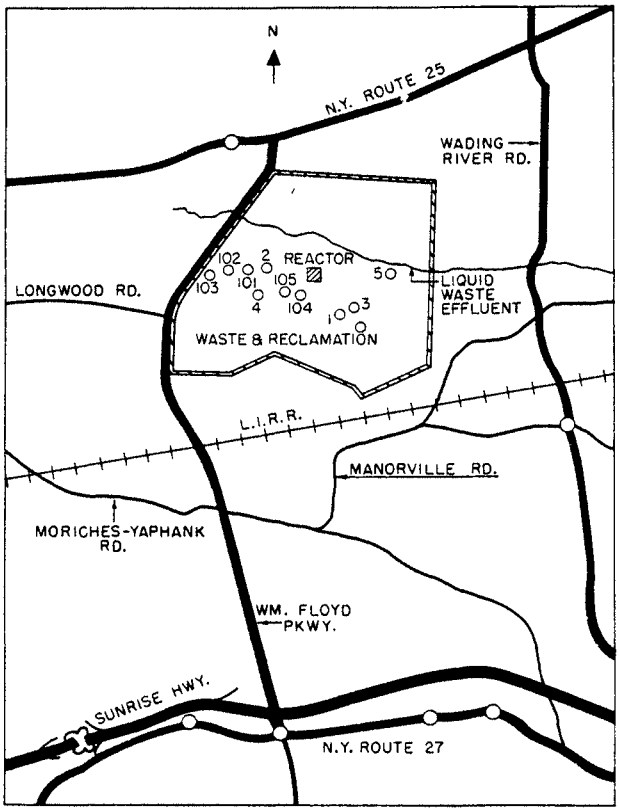

Figure 17. Location of BNL water supply wells.

Table 23

1965 BNL Environmental Monitoring
Gross β Concentrations in Deep Well Samples, pCi/liter

	Potable water well no.							
Month	1	2	3	4	5	6	7	W&R*
Jan.	3.8	2.0	<1.2	2.0	11.3	—	—	4.6
Feb.	3.1	<1.3	2.3	<1.3	1.6	—	—	3.9
Mar.	2.1	<1.0	1.8	9.8	1.5	—	—	10.8
Apr.	1.7	<1.0	<1.0	1.7	11.2	—	—	3.2
May	<1.0	2.6	1.4	1.3	10.8	3.6	<1.0	1.8
June	2.1	1.7	1.7	1.4	10.7	2.9	1.7	2.3
July	3.9	<1.0	2.3	3.3	2.5	2.2	<1.0	—
Aug.	1.7	2.0	<1.1	1.9	2.3	<1.1	<1.1	<2.6
Sept.	5.4	<1.2	2.0	<1.3	10.0	<1.3	<1.2	—
Oct.	3.1	2.0	<1.2	2.0	<1.2	1.3	<1.2	—
Nov.	2.1	3.0	—	2.2	2.8	2.3	2.3	<1.6
Dec.	<1.8	—	—	3.9	<1.7	<1.7	<1.7	—
Av	2.3	1.0	0.9	2.4	5.3	1.3	0.1	3.1

	Cooling supply well no.				
Month	101	102	103	104	105
Jan.	1.7	<1.2	<1.2	—	2.4
Feb.	—	1.6	<1.3	—	1.9
Mar.	<1.0	2.0	2.2	4.9	1.7
Apr.	<1.0	<1.0	<1.0	<1.0	1.3
May	1.6	1.6	<1.0	2.1	<1.0
June	—	<1.0	1.3	2.1	2.1
July	2.9	1.6	2.6	2.0	2.0
Aug.	1.6	1.6	<1.1	<1.1	1.6
Sept.	<1.3	<1.2	<1.2	2.7	7.5
Oct.	—	—	—	1.7	<1.2
Nov.	<1.2	2.0	1.9	—	—
Dec.	4.7	2.0	<1.7	2.2	2.0
Av	1.1	0.9	0.3	1.8	1.9

Estimated error: $\pm$1.0 pCi/liter.
*Waste disposal and reclamation well.

than once, in which case the number of samples is shown in parentheses and the ^{137}Cs and K values are averages. Samples with a concentration $\geqslant$2 pCi/liter of ^{131}I are also listed by date and location. The applicable radiation protection guide for ^{131}I, assuming an intake of 1 liter/day, is 100 pCi/liter.

Nominal concentrations of ^{131}I were generally evident late in May and early in June, shortly after the arrival of debris from the mid-May Chinese weapons test. The June 1-7 average milk-to-vegetation ratio of 1 pCi/liter:13 pCi/kg is in general agreement with previous observations[17] of fallout ^{131}I.

ON-SITE SUMPS

Monitoring for the possible entry of radioactivity into the ground water included three recharge basins, one north of the Alternating Gradient Synchrotron, one east of the BGRR, and one south of the Medical complex, into which second-

Table 24

1965 BNL Environmental Monitoring
Concentrations of γ-Emitting Isotopes in Pasture Grass
(Values for K in g/kg; all others in pCi/g.)

Location	Month	No. of samples	^{7}Be	^{54}Mn	^{95}Zr-^{95}Nb	^{106}Ru	^{131}I	^{137}Cs	^{140}Ba-^{140}La	^{144}Ce	K
Farm A,	May	1	<100	<100	<100	152	<100	124	<100	486	6.00
3 km NW	June	2	<100	<100	1223	<100	262	136	801	<100	5.24
	Sept.	2	<100	486	<100	805	<100	1776	<100	1526	2.64
	Oct.	1	3030	204	<100	351	<100	289	<100	459	4.10
	Av		548	221	—	369	—	705	—	683	4.31
Farm B,	May	1	226	<100	<100	127	<100	<100	<100	149	5.22
6 km SW	June	3	350	<100	<100	107	<100	<100	466	186	7.68
	Sept.	2	146	<100	<100	244	<100	<100	<100	155	5.59
	Oct.	1	2120	220	<100	146	<100	236	<100	195	5.80
	Av		527	<100	—	155	—	<100	—	173	5.28
Farm C,	June	2	150	<100	<100	149	<100	268	669	333	7.52
10 km SE	Sept.	1	<100	<100	<100	125	<100	112	<100	105	5.66
	Av		117	<100	—	212	—	216	—	257	6.57
Farm D,	June	2	<100	<100	<100	<100	117	<100	466	<100	6.23
15 km NW	Sept.	1	1210	103	<100	409	<100	258	<100	700	8.82
	Av		420	<100	—	170	—	119	—	267	7.09
Farm E, 8 km E	June	2	899	166	143	<100	124	176	836	<100	2.83
Farm F,	June	1	214	174	407	<100	252	<100	831	<100	4.90
30 km E	Sept.	1	<100	<100	<100	121	<100	111	<100	309	5.75
	Av		132	112	—	<100	—	<100	—	180	5.33
Farm H,	June	1	<100	603	225	<100	470	956	1265	<100	5.53
6 km NE	Sept.	1	<100	406	<100	2340	<100	2270	<100	3080	4.88
	Av		<100	510	—	1195	—	1613	—	1065	5.21
Monthly av											
	May		138	<100	<100	140	<100	<100	<100	318	5.61
	June		278	120	285	<100	152	186	740	117	5.94
	Sept. + Oct.		690	206	<100	569	<100	793	<100	851	5.15
Yearly av			429	142	—	276	—	378	—	378	5.60
Estimated error of individual sample			25% or ±100*	10% or ±50	10% or ±50	25% or ±100	10% or ±50	10% or ±50	25% or ±100	25% or ±100	±0.50

*Whichever is greater.

Table 25

1965 BNL Environmental Monitoring
Concentrations of γ-Emitting Isotopes in Soil, pCi/kg

Location	Month	^{7}Be	^{54}Mn	^{106}Ru	^{137}Cs	^{144}Ce	U_{nat}	Th_{nat}	K
Farm A	June	0.8	<0.2	1.2	1.5	3.6	0.8	1.6	4.1
	Sept.	0.7	<0.2	0.4	0.3	1.3	1.2	0.9	8.3
Farm B	June	1.5	0.3	1.4	2.0	3.2	1.5	1.5	5.2
	Sept.	0.6	<0.2	0.5	0.7	1.7	1.0	0.1	6.8
Farm C	June	2.2	0.4	1.3	2.5	3.8	0.7	1.2	2.7
	Sept.	0.6	<0.2	0.9	0.6	1.2	1.6	1.0	9.0
Farm D	June	1.6	0.2	1.0	2.0	3.7	1.0	1.5	5.9
	Sept.	1.5	0.6	1.3	2.4	3.4	1.7	1.6	11.3
Farm H	June	0.4	<0.2	0.3	0.2	1.0	1.0	1.0	3.8
	Sept.	0.7	<0.2	1.0	0.4	1.9	1.1	1.0	6.9
Farm I,	June	1.8	0.2	1.4	1.8	2.6	1.6	2.2	9.4
30 km ENE	Sept.	1.0	<0.2	0.7	0.4	3.2	2.2	1.8	15.2
Yearly av		1.1	0.2	1.0	1.2	2.6	1.3	1.3	7.4
Estimated error (individual sample)		±0.5	±0.2	±0.2	±0.2	±0.5	±0.5	±0.5	±1.0

Table 26

1965 BNL Environmental Monitoring
Concentrations of ^{131}I, ^{137}Cs, and K in Milk Samples
(Values for K in g/liter; all others in pCi/liter.)

	Farm A, 3 km NW		Farm B, 6 km SW		Farm C, 10 km SE		Farm D, 15 km NW		Farm E, 8 km E	
	^{137}Cs	K	^{137}Cs	K	^{137}Cs	K	^{137}Cs	K	^{137}Cs	K
1/65	—	—	72	1.3	126	1.3	82	1.1	—	—
2/65	—	—	81	1.2	151	1.3	100	1.2	—	—
3/65	—	—	76	1.4	130	1.4	93	1.4	—	—
4/65	—	—	87	1.3	101	1.1	78	1.3	—	—
5/65	—	—	48	1.3	77	1.1	83	1.1	119	1.4
6/65	60	1.2	(2)64	1.3	(2)112	1.1	63	1.1	(3)81	1.4
7/65	—	—	44	1.5	56	1.4	70	1.4	94	1.4
8/65	—	—	57	1.2	—	—	105	1.3	—	—
9/65	38	1.3	59	1.4	76	1.5	34	1.3	—	—
10/65	61	1.3	40	1.7	58	1.3	116	1.3	—	—
11/65	56	1.2	34	1.1	51	1.1	46	1.1	—	—
12/65	65	1.5	68	1.3	50	1.3	79	1.4	—	—
Av			61	1.3	90	1.3	79	1.2		

^{131}I

Farm:	A	B	C	D	E	G, 5 km ESE
5/18	3	—	—	—	—	—
5/27	—	—	—	—	—	5
6/1	—	—	6	18	—	—
6/4	—	—	—	—	22	—
6/7	6	8	4	7	—	—
6/10	—	—	—	—	3	—
6/25	—	—	—	—	3	—
7/8	—	—	—	4	<2	—
10/19	2	—	—	—	—	—
12/7	4	—	—	—	—	—

Estimated error: ±25% if >2 pCi/liter.

Table 27

1965 BNL Environmental Monitoring
Gross β Concentrations in Recharge Basins, pCi/liter

Month	Location		
	North of AGS	East of BGRR	Medical complex
Jan.	8	6	—
Feb.	7	15	—
Mar.	4	2	3
Apr.	10	2	3
May	3	2	<2
June	<2	—	4
July	2	2	<2
Aug.	<2	<2	<2
Sept.	2	<2	<2
Oct.	—	—	—
Nov.	—	—	—
Dec.	<2	3	<2
Av	4	4	2

Estimated error: $\pm 10\%$ if $> \pm 1$ pCi/liter.

ary cooling water from these facilities is discharged. These sumps are also open to surface runoff and, as shown in Table 27, appear to follow the concentration trends reported in the section on stream sampling.

THYROID SAMPLING

Three deer thyroids from animals accidentally killed on the public highways in the vicinity of the Laboratory or on site were obtained through the cooperation of the New York State Department of Conservation. The amounts of ^{131}I and ^{137}Cs found are shown in Table 28.

MISCELLANEOUS

During mid-1964, a program in cooperation with the Medical Department was initiated to gather data for a comparison of whole-body burdens and 24-hr urine sample levels of ^{137}Cs. A summary of the quarterly average body burdens, urine concentrations, and daily excretion is presented in Table 29. Quarterly average concentrations of ^{137}Cs in milk and in air samples and the ^{137}Cs deposited in precipitation are also shown. The data obtained thus far indicate that during 1965 an increasing fraction of the total ^{137}Cs intake came from sources other than milk and that this fraction was not directly responsive to seasonal variations in ^{137}Cs deposition.

Samples of underground water were obtained from a well in the Igloo (waste and reclamation) area which was accidentally contaminated in the summer of 1960 and from a well 60 ft downstream. As indicated in a report[18] on this incident, most of the activity was found at a depth of 21 ft. The gross β concentrations in water samples obtained between 1961 and 1965 at this depth in the contaminated well and in the one 60 ft downstream in the apparent direction of groundwater flow are shown in Table 30.

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Table 28

1965 BNL Environmental Monitoring
^{131}I and ^{137}Cs in Deer Thyroids

Location	Date	Thyroid weight, g	^{131}I, pCi	^{137}Cs, pCi
BNL perimeter	4/19	6.0	<2	5± 5
South Haven (10 km SW)	8/10	4.6	6±5	19± 5
On site	10/13	3.0	<2	61±10

Table 29

1965 BNL Environmental Monitoring
Comparison of ^{137}Cs in Humans and in Environmental Media

				Urine		Milk	Air	Precipitation
Year	Qtr.	No. of persons	Av body burden, pCi	Av conc., pCi/l	Av daily excretion, pCi	Av conc., pCi/l	Av conc., pCi/m³	Activity, nCi/m²
1964	1st					194	0.070	12.3
	2nd					148	0.150	12.3
	3rd	18	16,300	134	187	128	0.057	4.3
	4th	8	18,000	126	139	112	0.030	2.7
1965	1st	13	13,300	100	98	101	0.035	2.4
	2nd	7	18,900	107	89	76	0.041	4.5
	3rd	6	27,100	96	120	64	0.020	1.3
	4th	25	11,500	106	101	58	0.009	0.9
Estimated error				±10%	±25%	±10%	±10%	±10%

Table 30

1965 BNL Environmental Monitoring
Gross β Concentrations in Igloo Area Wells, pCi/liter

Well No.	Distance, ft	Feb. 1961*	Nov. 1961*	Aug. 1962	July 1963	May 1965
1	0	2.2×10^6	3.3×10^5	3.6×10^5	3.2×10^5	**
12	60	10×10^4	530	980	318	193

Estimated error, ±10%.
*Wells were pumped through ion exchange column between Feb. and Nov. 1961.
**Not sampled in 1965.

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