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1981 ENVIRONMENTAL MONITORING REPORT

J.R. Naidu and L.L. Olmer, Editors

April 1982

SAFETY AND ENVIRONMENTAL PROTECTION DIVISION

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, LONG ISLAND, NEW YORK 11973

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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL MONITORING REPORT

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1.0 INTRODUCTION

1.1 Background:

The primary purpose of a routine environmental monitoring program, according to Department of Energy (DOE) DOE Order 5484.1 [1], is to determine whether:

1) facility operations, waste treatment, and control systems have functioned as designed and planned from the standpoint of containment of radioactivity, and

2) the applicable environmental radiation and radioactivity standards and effluent control requirements have been met.

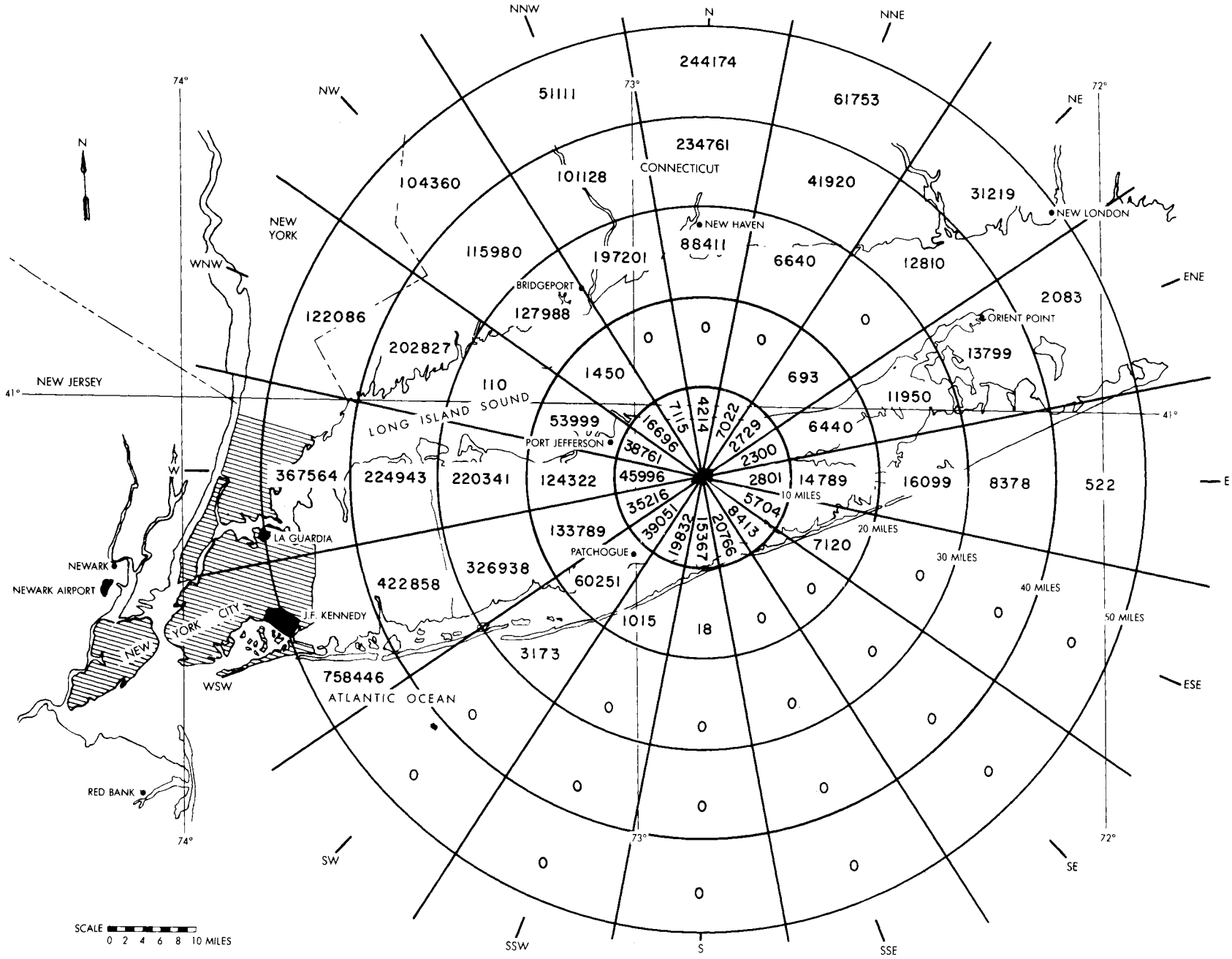
Brookhaven National Laboratory's (BNL) environmental monitoring program is designed and developed to accomplish these two primary objectives. While this annual report follows the recommendations given in DOE/EP-0023, "A Guide for Environmental Radiological Surveillance at U.S. DOE Installations" [2], considerable latitude has been exercised in tailoring the scope and methodology to meet the site's specific environmental monitoring needs. In addition, the Laboratory has extended its environmental surveillance program to include the sampling and analysis of nonradiological pollutants, such as heavy metals and organics. This latter program reflects the growing concern about nonradiological pollutants, particularly with regard to the preservation of the quality of the aquifer underlying Long Island [3].

1.2 Site Characteristics:

Brookhaven National Laboratory is a multidisciplinary scientific research center situated in the geographical center of Suffolk County on Long Island, about 97 km east of New York City. Its location with regard to surrounding communities is shown in Figure 1. About 1.29 million people live in Suffolk County [4,5] and about 0.37 million people in Brookhaven Township, within which the Laboratory is situated. The principal nearby population centers are located in shore line communities. Table 1 gives the resident population distribution within 80 km of the BNL site. Though much of the land area within a 16 km radius is either forested or under cultivation, there has been some development of suburban housing in proximity to the Laboratory during the last decade.

The Laboratory site is shown in Figure 2. It consists of some 2130 hectares (ha), most of which is wooded, except for a developed area of about 655 ha. The site terrain is gently rolling, with elevations varying between 36.6 and 13.3 m above sea level. The land lies on the western rim of the shallow Peconic River watershed, with a principal tributary of the river rising in marshy areas in the northern and eastern sections of the site.

In terms of meteorology, the Laboratory can be characterized as a well-ventilated site. In common with most of the eastern seaboard, its prevailing ground level winds are from the southwest during the summer, from the northwest



RESIDENT POPULATION (1981) WITHIN A 50 MILE RADIUS OF BNL

TABLE 1

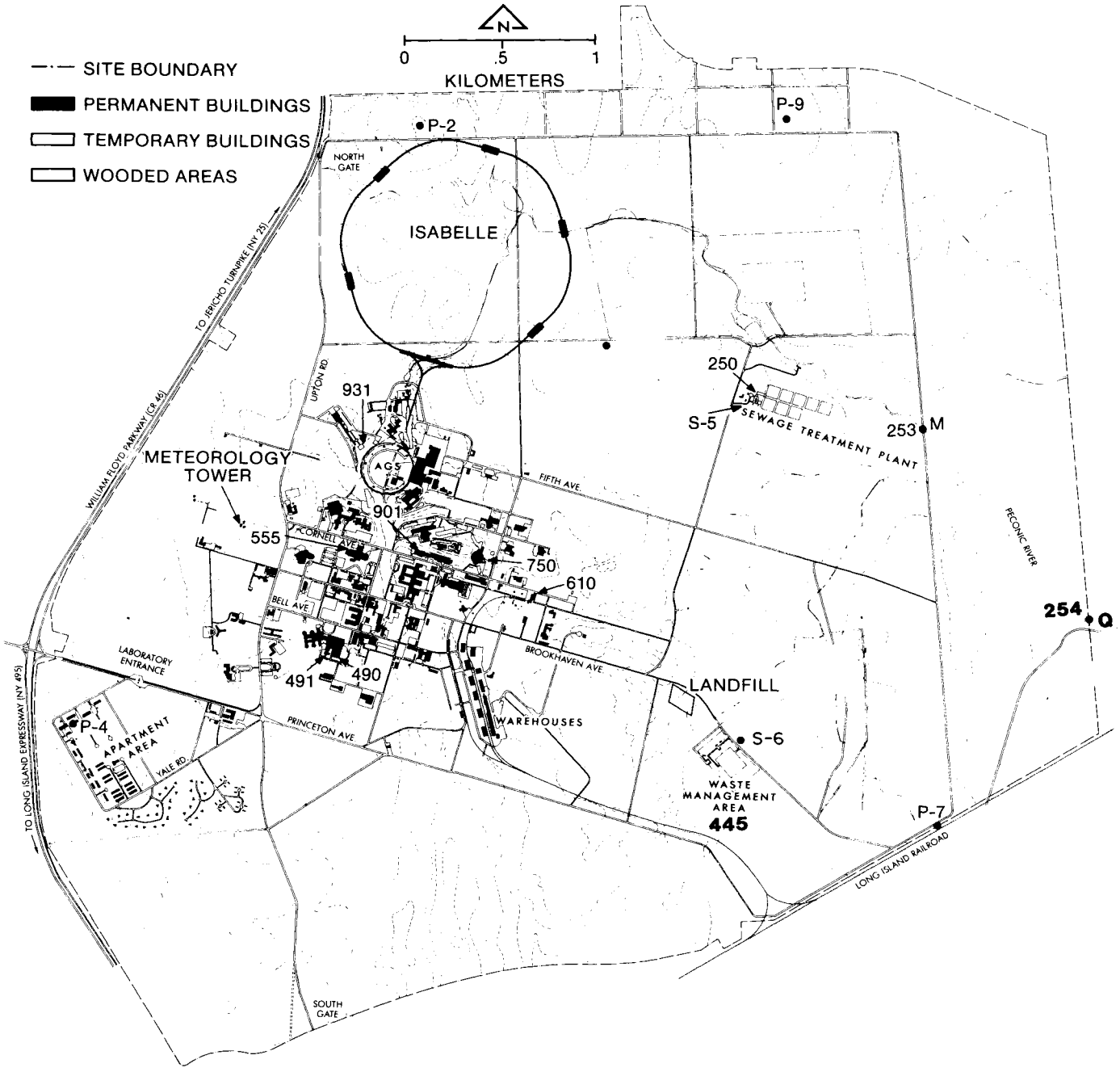
1981 BNL Environmental Monitoring

Resident Population (1981)[a] Distribution Within 80 Km Radius of BNL

Sector	0-16 Km (10 mi)	16-32 Km (20 mi)	32-48 Km (30 mi)	48-64 Km (40 mi)	64-80 Km (50 mi)	Total	Remarks
SSW	19,832	1,015	0	0	0	20,847	Beyond 32 Km - Atlantic Ocean
SW	39,051	60,251	3,173	0	0	102,475	Beyond 48 Km - Atlantic Ocean
WSW	35,216	133,789	326,938	422,858	758,446	1,677,247	Beyond 80 Km - Part of New York City
W	45,996	124,322	220,341	224,943	367,564	983,166	Beyond 80 Km - New York City
WNW	38,761	53,999	110	202,827	122,086	417,783	Between 32 Km and 48 Km - Long Island Sound, beyond 48 Km - Connecticut and New York
NW	16,696	1,450	127,988	115,980	104,360	366,474	Same as WNW
NNW	7,115	0	197,201	101,128	51,111	356,555	Between 16 Km and 32 Km - Long Island Sound, beyond 20 Km - Connecticut
N	4,214	0	88,411	234,761	244,174	571,560	Same as NNW
NNE	7,022	0	6,640	41,920	61,753	117,335	Same as NNW
NE	2,729	693	0	12,810	31,219	47,451	Between 32 Km and 48 Km - Long Island Sound, beyond 48 Km - Connecticut
ENE	2,300	6,440	11,950	13,799	2,083	36,572	North Fork of Long Island
E	2,801	14,789	16,099	8,378	522	42,589	South Fork of Long Island and Atlantic Ocean
ESE	5,704	7,120	0	0	0	12,824	Long Island and beyond 32 Km - Atlantic Ocean
SE	8,413	0	0	0	0	8,413	Beyond 18 Km - Atlantic Ocean
SSE	20,766	0	0	0	0	20,766	Same as SE
S	15,367	18	0	0	0	15,385	Beyond 32 Km - Atlantic Ocean
Total	271,983	403,886	998,851	1,379,404	1,743,318	4,797,442	

[a] Population data estimated from information supplied by the Long Island Regional Planning Board {4,5}.

BROOKHAVEN NATIONAL LABORATORY SITE



ENVIRONMENTAL MONITORING STATIONS		DESIGNATION	EFFLUENT RELEASE POINT
AIR		250	SAND FILTER BEDS
P-2	NORTHWEST PERIMETER	253	PECONIC R. STREAM BED
P-4	SOUTHWEST PERIMETER	254	SITE BOUNDARY
P-7	SOUTHEAST PERIMETER	490	MRC STACK
P-9	NORTHEAST PERIMETER	491	MRR STACK
S-5	SEWAGE TREATMENT AREA	555	CHEMISTRY STACK
S-6	WASTE MANAGEMENT AREA	750	HFBR STACK
		901	VAN DE GRAAFF STACK
WATER		931	BLIF STACK
250	SEWAGE TREATMENT PLANT		
M	PECONIC RIVER, 0.5 MI. DOWNSTREAM		
Q	SITE BOUNDARY		

FIGURE 2

during the winter, and about equally from these two directions during the spring and fall [6].

Studies of Long Island hydrology and geology [7-9] in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits, which are between 31-61 m thick, are generally sandy and highly permeable. Water penetrates them readily and there is little direct run-off into surface streams, except during periods of intense precipitation. The average annual precipitation is 122 cm. However, the annual total for 1981 was only 101.7 cm. About half of this precipitation is lost to the atmosphere through evapotranspiration and the other half percolates to recharge groundwater. The groundwater in the vicinity of the Laboratory moves predominantly in a horizontal direction to the Great South Bay [7]. This is modified toward a more easterly direction in the Peconic River watershed portions of the site. The estimated rate of movement at the groundwater surface is about 16.2 cm d^{-1} [7].

1.3 Existing Facilities:

A wide variety of scientific programs are conducted at Brookhaven, including research and development in the following areas:

1) the fundamental structure and properties of matter,

2) the interactions of radiation, particles and atoms with other atoms and molecules,

3) the physical, chemical and biological effects of radiation, and of other energy-related environmental pollutants,

4) the production of special radionuclides and their medical applications,

5) energy and nuclear related technology,

6) the assessment of energy sources, transmission and uses, including their environmental and health effects.

Among the major scientific facilities operated at the Laboratory to carry out the above programs are:

1) the High Flux Beam Reactor (HFBR) which is fueled with enriched uranium, moderated and cooled by heavy water, and which operates at a routine power level of 40 MW(th). Modifications to the primary water cooling system have been made to allow the power level to be raised to 60 MW(th), and operation at this level is anticipated during 1982,

2) the Medical Research Reactor (MRR), an integral part of the Medical Research Center (MRC), is fueled with enriched uranium, moderated and cooled by natural water, and is operated intermittently at power levels up to 3 MW(th),

3) the Alternating Gradient Synchrotron (AGS), a proton accelerator which operates at energies up to 33 GeV, is used for high energy research,

4) the 200 MeV Proton Linac, which serves as an injector for the AGS, also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven Linac Isotopes Production Facility (BLIP) and in the Chemistry Linac Irradiation Facility (CLIF),

5) the Tandem Van de Graaff, Vertical Accelerator and Chemistry Van de Graaff, which are used in medium energy physics investigations, as well as for special nuclide production,

6) the National Synchrotron Light Source which utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings operating at energies of 700 MeV vacuum ultraviolet (VUV) and 2.5 GeV (x-ray) commenced operation during 1981 and will be used for spectroscopy in the VUV ring and for diffraction studies in the x-ray ring,

7) an intersecting storage ring accelerator, "ISABELLE" currently under construction, will be a colliding-beam machine, within which the collision of two proton beams of 400 GeV will make available effective energies up to 800 GeV to facilitate advanced studies in high energy physics. It is anticipated that it will be operational sometime in the 1980's.

Additional programs involving irradiations and/or the use of radionuclides for scientific investigations are carried on at other Laboratory facilities including the Medical Research Center, the Biology Department, the Chemistry Department, and the Department of Energy and Environment (DEE). At the Hot Laboratory, special purpose radionuclides are developed and processed for on- and off-site use under the joint auspices of the DEE and the Medical Department. This facility also contains a radioactive waste treatment center, which includes an evaporator for volume reduction of liquid wastes.

Most of the airborne radioactive effluents at Brookhaven originate from the HFBR, BLIP and the research Van de Graaff, with lesser contributions from the Chemistry and Medical Research Centers. The first two also produce significant fractions of the Laboratory's liquid radioactive wastes, with additional smaller contributions originating from the Medical Research Center, the Hot Laboratory complex, as well as from decontamination and laundry operations. Current environmental monitoring programs are being enhanced so as to permit the evaluation and impact of non-radiological pollutants being released to the environment.

2.0 SUMMARY

The environmental levels of radioactivity and other pollutants found in the vicinity of BNL during 1981 are summarized in this report. As an aid in

the interpretation of the data, the amounts of radioactivity and other pollutants released in airborne and liquid effluents from Laboratory facilities to the environment are also indicated. The environmental data includes external radiation levels; radioactive air particulates; tritium and iodine concentrations; the amounts and concentrations of radioactivity in and the water quality of the stream into which liquid effluents are released; the concentrations of radioactivity in sediments and biota from the stream; the concentrations of radioactivity in and the water quality of ground waters underlying the Laboratory; and concentrations of radioactivity in milk samples obtained in the vicinity of the Laboratory.

External Radiation:

At the boundary of the Laboratory, about 1.0 km northwest of the Alternating Gradient Synchrotron (AGS), the calculated dose due to skyshine (scattered neutron radiation) was about 0.6 mrem a^{-1}, or 0.1% of the Standard. This was too small to be measured. Due to their limited range, the external radiation from the AGS did not produce a measurable additive effect at off-site locations.

Air and Rainfall - Radioactivity:

Other than tritium, there was no indication of BNL radioactive effluents in environmental air and precipitation samples. The largest concentration of tritium in air at the site boundary, 1.3×10^{4} pCi m^{-3} (1.3×10^{-8} µCi ml^{-1}) was 6.5% of the Radiation Concentration Guide (RCG). However, this concentration, which is the average for the quarter, appears to have been contaminated by some non-environmental source of tritium. The largest average concentration of tritium in precipitation was at or below the Minimum Detection Limit (MDL) which was 200 pCi l^{-1} (2×10^{-7} µCi ml^{-1}). The MDL represents about 1% of the standard for drinking water.

Air - Nonradioactive:

At the Central Steam Plant, the most recent measurement of the stack emission of air particulates indicated that the average rate was 0.078 $lb/10^{6}$ Btu. A calculation based on meteorological parameters indicates that at the site boundary, their concentration was 0.28 µg m^{-3}, 0.4% of the yearly average ambient Air Quality Standard. At the site boundary the calculated concentrations of SO_2 and NO_x, resulting from the steam plant operations, were 0.76×10^{-3} ppm, and 5.1×10^{-4} ppm, respectively, which were about 3 and 1% of their respective ambient air quality standards.

Liquid Effluent - Sewage Treatment Plant:

Of the sewage effluent released onto the sand filter beds of the Laboratory sewage treatment plant 80% flowed directly into the Peconic River. The balance was assumed to have percolated into the ground water underlying the beds. The gross beta concentration of the output from them was 26.9 pCi l^{-1} (2.69×10^{-8} µCi ml^{-1}), or < 1% of the Radiation Concentration Guide (RCG). The tritium concentration was 6.0 nCi l^{-1} (6.0×10^{-6} µCi ml^{-1}), or 0.2% of the RCG. The same concentration was assumed for the infiltration into groundwater.

Liquid Effluents - National Pollutant Discharge Elimination System Permit:

Except for 59 daily pH levels which were "out of limit" and a single instance of BOD_5 percent removal, all reportable non-radiological parameters of the Laboratory sewage effluent were within the limits set forth in the Laboratory's permit, issued by EPA under the National Pollution Discharge Elimination System. The average water quality of the sewage treatment plant effluent at the point of discharge was at or within water quality standards for the receiving body of water.

Peconic River - On-Site:

Downstream, about 54% of the combined flow from the sand filter beds and from upstream of the Peconic River also percolated into the groundwater. This occurred between the sewage treatment plant outfall and the Laboratory perimeter, mostly during the latter half of the year. At the former site boundary (Station M), the gross beta concentration was 21.4 pCi l^{-1} (2.14×10^{-8} µCi ml^{-1}), or 0.4% of the RCG, and the tritium concentration was 5.5 nCi l^{-1} (5.5×10^{-6} µCi ml^{-1}), or 0.2% of the RCG. At the site boundary, the gross beta concentration was 23.6 pCi l^{-1} (2.36×10^{-8} µCi ml^{-1}), or 0.8% of the RCG, and the tritium concentration was 5.3 nCi l^{-1} (5.3×10^{-6} µCi ml^{-1}), or 0.2% of the RCG.

Peconic River - Off-Site:

Bimonthly sampling of the Peconic River water downstream of the sewage treatment plant outfall has indicated a decrease of concentrations of radioactivity. At a location 4.8 km downstream, the average gross beta concentration as established by bimonthly "grab" sampling was 4.2 pCi l^{-1} (4.2×10^{-9} µCi ml^{-1}), or 0.1% of the RCG and the tritium concentration was 1.9 nCi l^{-1} (1.9×10^{-6} µCi ml^{-1}), or 0.06% of the RCG. About 24 km downstream, at the river's mouth, the average concentration of gross beta activity being 6.7 pCi l^{-1} (6.7×10^{-9} µCi ml^{-1}) and that of tritium being 2.2 nCi l^{-1} (2.2×10^{-6} µCi ml^{-1}). Based on total flow and activity per unit volume, the total gross beta activity in the river at that location exceeded that at the Laboratory's site boundary. This difference is attributed to the fact that the total flow at the river's mouth is increased due to tributary additions which, in turn, have added fallout radionuclides that were present in the drainage area of the tributaries.

Peconic River - Aquatic Biological Studies:

Seasonal sampling of Peconic River bottom sediments, stream vegetation and fish were conducted at the site boundary. The data on fish obtained from the river at the site boundary suggested the presence of small amounts of radioactivity attributable to the Laboratory's past releases. The maximum concentration of ^{137}Cs in fish was about 930 pCi kg^{-1}. This concentration would result in a dose commitment that was about 1% of the RCG, based on an assumed ingestion of 50 g of fish per day.

Groundwater - Supply and Process Wells and Recharge Basins:

About 22 million liters of water per day obtained from on-site supply wells were used for "once through" cooling and returned to groundwater in on-site recharge basins. The concentration of gross beta activity at point of recharge was, on the average, two times greater than that of the supply wells, and was less than 8% of the EPA Drinking Water Standard. The tritium concentrations were less than the MDL, which is about 1% of the EPA Drinking Water Standard.

Groundwater - Surveillance Wells:

Groundwater surveillance was conducted in a network of some 100 sampling wells installed adjacent to and downstream from identified areas where there is a potential for the percolation and migration of radioactivity and other contaminants in groundwater. With the aquifer underlying Long Island being classified as a "sole source" it was necessary to apply EPA Drinking Water Standards to all activities concerning groundwater use or recharge.

a. On-Site Wells:

Immediately adjacent to the sand filter beds and to the Peconic River on-site and at the site boundary, gross beta, tritium and ^{90}Sr concentrations have been decreasing, when compared to those observed during previous years. This reflects the decrease in the concentrations due to decay and dilution. They were not more than a few percent of the EPA Drinking Water Standards. The largest average gross alpha concentration, 1.12 pCi l^{-1} (1.12×10^{-9} µCi ml^{-1}) was 7.5% of the EPA Drinking Water Standard for unidentified mixtures containing alpha activity other than ^{226}Ra. It was not directly relatable to any known Laboratory effluent releases. The largest average gross beta concentration was 19.8 pCi l^{-1} (19.8×10^{-9} µCi ml^{-1}). The largest average tritium concentration, 6.3 nCi l^{-1} (6.3×10^{-6} µCi ml^{-1}) was 32% of the EPA Drinking Water Standard.

On-site, adjacent to the Solid Waste Management area, the landfill, the former open dump, and the decontamination facility storm sewer sump, above ambient background concentrations of gross beta activity, ^{90}Sr, and tritium were found in a number of nearby groundwater surveillance wells. Much of the gross beta activity appeared to be related to ^{90}Sr.

At the Waste Management area, the largest ^{90}Sr concentration, 31.5 pCi l^{-1} (31.5×10^{-9} µCi ml^{-1}), or 4 times the EPA Drinking Water Standard, was found in a well 175 m southeast of the area. This level reflects the effects of a known inadvertent injection into groundwater which occurred in 1960.

At the landfill, a gross alpha concentration of 7.3 pCi l^{-1} (7.3×10^{-9} µCi ml^{-1}), or 0.5 times of the EPA Drinking Water Standard, a gross beta concentration of 120 pCi l^{-1} (120×10^{-9} µCi ml^{-1}), or 2.5 times the compliance level based on the EPA Drinking Water Standard, and a tritium concentration of 29 nCi l^{-1} (29×10^{-6} µCi ml^{-1}) or 1.5 times the EPA Drinking Water Standard, were the largest found. They were found in wells between the landfill and locations 80 m south of the perimeter of the working area.

At the decontamination facility storm sewer sump, a ^{90}Sr concentration of 82 pCi l^{-1} (82 x 10^{-9} μCi ml^{-1}), 10 times the EPA Drinking Water Standard, was found in a surveillance well within a few meters of the sewer outfall into the sump.

Iron and zinc were found in excess of their respective standards (0.6 and 0.3 ppm for surface waters) in numerous sampling wells on-site. However, this appears to be related to corrosion from the well casings and not to Laboratory effluents, except for a few wells adjacent to the Landfill. There, the largest concentration of iron was 65 ppm and of zinc, 0.5 ppm.

In all cases, the on-site levels of radioactivity or of other agents which were found in above ambient background in ground water appeared to be confined to within a hundred meters of their origin. They would require decades of travel before reaching the site boundary. Concentrations of radioactivity, and water quality parameters, in ground water from perimeter surveillance wells (other than those adjacent to the Peconic River) were at or near background and only a few percent of the EPA Drinking Water Standards.

b. Off-Site Wells:

Concentrations of gross alpha, gross beta, and ^{90}Sr radioactivity were found to be slightly higher in a sampling well about 0.35 km east of the site boundary than in wells at the boundary itself. The gross alpha concentration, 1.25 pCi l^{-1} (1.25 x 10^{-9} μCi ml^{-1}) was 8% of the EPA Drinking Water Standard. However, this was not directly relatable to any known Laboratory effluent. The gross beta concentration was 7.1 pCi l^{-1} (7.1 x 10^{-9} μCi ml^{-1}), and the ^{90}Sr concentration was 1.9 pCi l^{-1} (1.9 x 10^{-9} μCi ml^{-1}). The latter was 24% of the EPA Drinking Water Standard.

Except for pH levels slightly lower than the Water Quality Standard, but within the local natural variation, most other indices of water quality in these surveillance wells were within the standards.

Total Population Dose Resulting from Laboratory Sources:

The collective average dose-equivalent rate (total population dose) attributable to Laboratory sources, for the population up to a distance of 80 km, was calculated to be 1.42 rem a^{-1} (person-rem a^{-1}), as compared to a natural background dose-equivalent rate to the same population of about 313,273 rem a^{-1} (person-rem a^{-1}).

3.0 MONITORING DATA COLLECTION, ANALYSIS AND EVALUATION

3.1 External Radiation Monitoring:

Dose-equivalent rates at the site boundary, including natural background (as influenced by fallout) and the increments attributable to Laboratory activity, were routinely measured by the use of CaF_2:Dy thermoluminescent dosimeters (TLD) [10] exposed for monthly periods at each of the four perimeter monitoring stations P-2, P-4, P-7, and P-9, the locations of which are shown in Figure 2.

The observed dose-equivalent rates from external gamma radiation, as measured by TLDs, are given in Table 2. There was no measurable addition to the natural background attributable to Laboratory activities. The dose-equivalent rate from naturally occurring external background radiation at the site perimeter averaged 65.3 mrem a^{-1}. Fluctuations noted over the years [11] are within the realm of local variations of natural background levels and are regulated to a significant extent by climatic variations [12].

During 1981, 21 additional TLDs have been placed at off-site locations for monitoring around the facility. Figure 3 shows the locations of the TLDs with respect to the Laboratory (HFBR Stack, #750 as the center; Figure 2). The standard 16 sectors with sector #1 centering on magnetic North has been used to locate the TLDs [13]. The dose-equivalent rates observed are given in Table 3 and are comparable with the average background given in Table 2. Variations observed could be attributed to climatic changes [12]. Additional TLDs will be incorporated in the near future, especially in sectors 3, 4 and 5 (Figure 3). An additional function of those TLDs will be to serve as a benchmark reflecting conditions prior to the start-up of the Shoreham Nuclear Power Station.

3.2 Airborne Effluents and Groundlevel Air Particulates, Tritium and Radioiodine Monitoring:

3.2.1 Facilities and Effluents:

The principal Laboratory facilities from which radioactive or nonradioactive effluents are released to the atmosphere are listed in Table 4. Their locations on the Laboratory site are shown in Figure 2. The installed on-line effluent monitors, sampling devices, and the types and amounts of effluents released during 1981 are indicated in Table 4.

Considerable dilution with ambient air occurs between the release points to the atmosphere and the site boundary. Additionally, radioactive decay decreases the concentrations of shorter lived radionuclides during the transit time between the point of release and the site boundary. Consequently, the concentrations of airborne radioactivity at the site boundary were reduced to levels where no detectable increase in dose-equivalent rate was apparent during 1981.

Oxygen-15 (^{15}O), Argon-41 (^{41}Ar) and Xenon-127 (^{127}Xe) are radioactive gases with relatively short half-lives. Thus, they have the potential of being environmentally significant as sources of increased external radiation only in proximity to the point of release. Oxygen-15, which has a two minute half-life is produced by the interaction of protons and water in the BLIP facility and generated at an estimated rate per unit beam current of 0.21 Ci μA^{-1} h^{-1}. When this facility is operated at the full beam current of 180 μA, the ^{15}O equilibrium activity at the point of generation is 1.8 Ci. Argon-41, which has a 110-minute half-life, is produced by the interaction of neutrons and ventilating air in the shield of the Medical Research Reactor and released from its stack at an estimated per unit power level rate of 1 Ci $MW(th)^{-1}h^{-1}$ when the reactor is operated at full power of 3 MW(th). Xenon-127, which has a 36.4-day half-life, is produced at the BLIP facility and is processed at the Hot Laboratory for

TABLE 2

1981 BNL Environmental Monitoring
External Dose-Equivalent Rates from Background and BNL Operations

	Location				
	P-2	P-4	P-7	Northeast Perimeter P-9	Average Background[a]
	mrem				
Minimum (Monthly)	4.5	4.5	4.6	4.9	4.6
Maximum (Monthly)	6.0	6.1	6.1	6.7	6.1
Average (Monthly)	5.5	5.5	5.4	5.9	5.4
Total (Annual)	65.7	65.5	64.9	70.5	65.3

Locations of monitoring stations indicated in Figure 2.

[a] Average of P-2, P-4 and P-7. These monitoring stations are assumed to be unaffected by BNL on-site radiations or effluents.
Station P-9 was excluded from the average because the station lies on a bed of coal cinders. These cinders contain radium and thorium at concentrations larger than the foundation material used at other perimeter stations thus resulting in a background which is slightly different than the other perimeter stations.

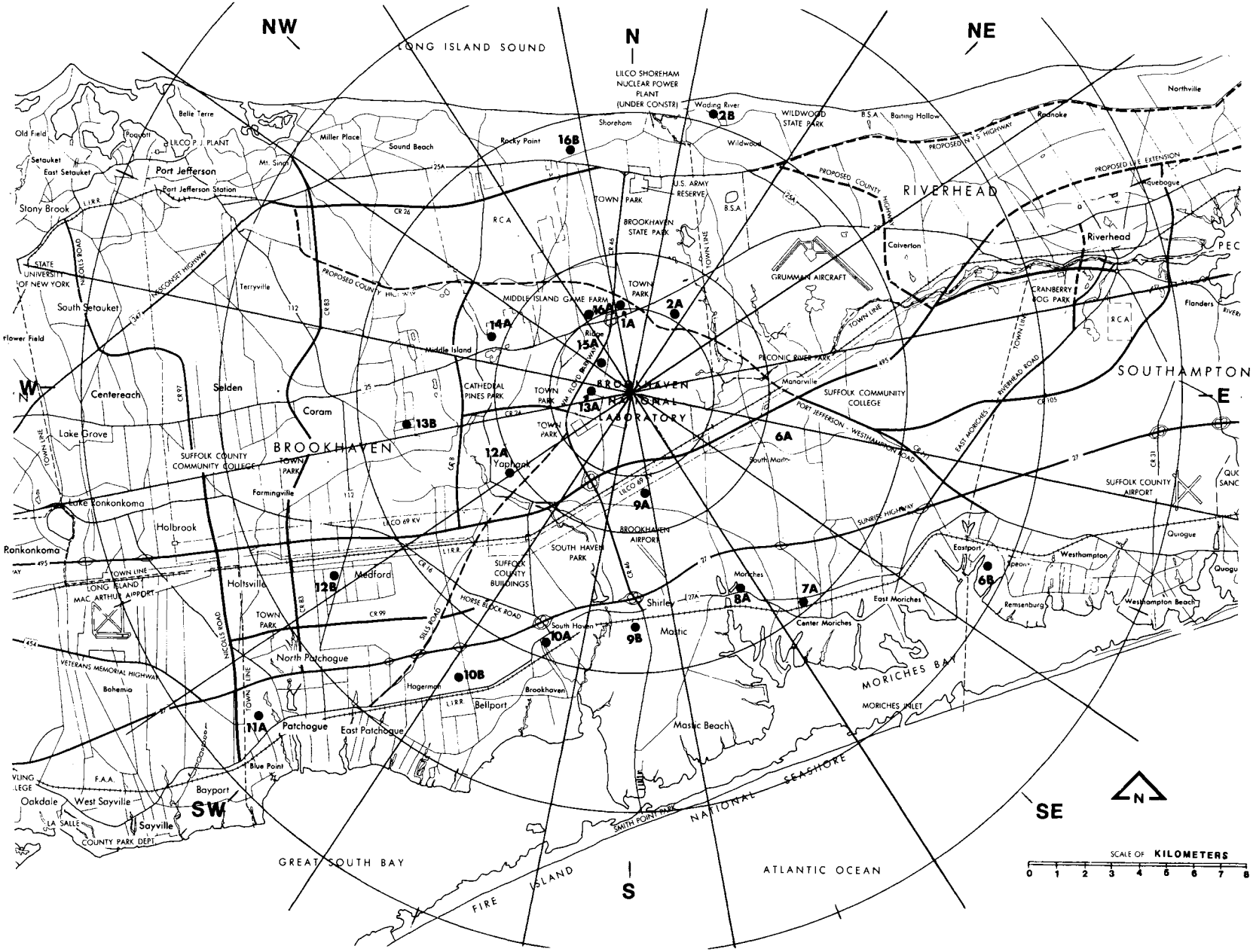


FIGURE 3: LOCATION OF OFF-SITE THERMOLUMINESCENT DOSIMETERS

BROOKHAVEN NATIONAL LABORATORY

TABLE 3

1981 BNL Environmental Monitoring
Off-Site External Dose-Equivalent Rates

TLD # [1]	Compass Heading (degrees)	Distance from Stack [2] (km)	Minimum	Maximum	Average [3]	Annual Total
			mrem/month			mrem
1a	350	3.1	4.89	6.58	5.67	68.12
2a	31	3.2	4.16	5.50	4.89	58.76
2b	15	10.8	5.11	5.85	5.54	66.56
4a(S-5) [4]	65	2.6	4.98	5.41	5.20	62.40
6a	107	5.6	4.50	5.37	4.76	57.20
6b	115	14.2	4.07	4.94	4.46	53.56
7a	140	9.7	4.72	5.28	5.02	60.32
8a	151	8.0	4.85	6.62	5.89	70.72
9a	173	3.4	4.68	5.59	5.07	60.84
9b	178	8.3	4.94	6.02	5.37	64.48
10a	199	9.3	3.90	4.85	4.33	52.00
10b	211	12.0	5.11	5.89	5.67	68.12
11a	229	17.8	4.33	5.11	4.72	56.68
12a	238	5.0	4.29	5.46	4.81	57.72
12b	238	12.5	5.24	5.80	5.50	66.04
13a	273	1.4	4.24	5.41	4.72	56.68
13b	262	8.2	5.85	6.80	6.28	75.40
14a	290	5.6	5.11	6.67	5.72	68.64
15a	306	1.4	5.98	6.32	6.15	73.84
16a	327	3.0	4.42	5.11	4.68	56.16
16b	346	8.8	4.37	5.11	4.59	55.12
Gun Barrel - Counting Bldg. 535A [5]					1.56	-

1. See Figure 3 for TLD location.
2. See Figure 2 for Stack (#750) location.
3. Based on four measurements with each representing a period of 14 weeks.
4. Location of S-5 given in Figure 2.
5. Represents background value for TLD and is based on eight measurements.

TABLE 4

1981 BNL Environmental Monitoring
Gaseous Effluent Release Locations and Data on Effluent Pollutant
(Radionuclides, Particulate, SO_2 and NO_x) Concentrations

Building[a]	Facility and Release Point	Release[b] Height (m)	Principal Pollutant	On-Line Monitoring	Fixed Sampling Devices	Amount Released During 1981
490	Medical Research Center Roof Stack	13.7	Tritium (^3H)-	None	Dessicant for tritium vapor	1.1×10^0 Ci (vapor)
491	Medical Research Reactor - Stack	45.7	Argon-41 (^{41}Ar)	Moving tape for radio-particulates	Charcoal for radioiodines	1.7×10^2 Ci[c]
555	Chemistry - Roof Stack	16.8	Tritium (^3H)	None	Dessicant for tritium vapor	4.3×10^0 Ci (vapor)
750	High Flux Beam Reactor	Stack 97.5	Tritium (^3H)	Kanne Chamber for Tritium (gas + vapor)	Dessicant for tritium vapor	2.4×10^2 Ci (vapor)
801	Hot Laboratory		^{127}Xe	None		2.3×10^0 Ci
			Gross Beta particulate	Beta scintillator for radioactive gases	Particulate filter for gross beta charcoal cartridge for radioiodines	1.8×10^{-4} Ci
901	Van de Graaff Accelerator	18.3	Tritium (^3H) (gas + vapor)	Kanne Chamber for tritium (gas + vapor)	Dessicant for tritium vapor	3.0×10^2 Ci (gas) 1.1×10^2 Ci (vapor)
931	Linac Isotope Facility	18.3	Tritium (^3H) vapor	G-M Detector for radiogases	Dessicant for tritium vapor	6.6×10^{-2} Ci (vapor)
			Oxygen-15 (^{15}O)			3.6×10^4 Ci[d]
610	Central Steam Plant - Stack	19.8	Particulates	None	None	2.5×10^4 Kg[e]
			SO_2			2.6×10^5 Kg[e]
			NO_x			1.2×10^5 Kg[e]

[a] Locations given in Figure 2.

[b] Above ground level.

[c] Calculated from reported operating time and "one-time" measured emission rate at 3 MW power level.

[d] Calculated from reported operating time and estimated production rate at 180 μamp full beam current.

[e] Estimated - based on amount of fuel consumed (See Table 6).

commercial uses. It is occasionally released unintentionally due to escape from the transfer system at the latter facility. As indicated in the previous environmental monitoring reports [11] the radioactive gases released, except for ^{127}Xe, are a function of operational time and facility power level.

Tritium (^{3}H) has a 12.3-year half-life, and is a very low energy beta emitter ($T\beta_{(max)}$ = 18.6 KeV). It is of principal environmental significance when in the form of tritiated water vapor (HTO), which is taken up and utilized by living systems as is ordinary water. Of the 655 Ci of tritium released from the Laboratory facilities during 1981 (Table 4), 300 Ci (46%) were in gaseous form, and 355 Ci (54%) were released as HTO.

A significant increase in amount of tritium released at the Van de Graaff facility was observed during 1981. This was attributed to a decontamination activity conducted at the facility. The slight increase in tritium (as vapor) released from the HFBR resulted principally from purging of the heat exchanger system during facility modifications to increase the power level from 40 MW(th) to 60 MW(th).

As of March 1981 the Laboratory was granted a permit to incinerate certain categories of waste in the Waste Management Incinerator by the New York State Department of Environmental Conservation. The individual radionuclides, their half-lives and total quantities in the incinerated waste material are shown in Table 5. ^{3}H formed the largest in quantity - 0.18 Ci. Other radionuclides ranged from 148 μCi to 0.006 Ci. Limits on the amount incinerated and meterological dispersion are utilized to assure that airborne concentrations at the site boundary were small fractions of the RCGs.

Most heating requirements for the principal buildings at the Laboratory are supplied by a central steam plant (Figure 2). The estimated amounts of conventional pollutants released from its stack are shown in Table 6. Those for sulfur dioxide (SO_2) and nitrogen oxides (NO_x) were estimated from reported emission factors for comparable plants [14], supplemented by analyses of the fuel oil for its sulfur content as utilized at the plant. The amount of particulates produced was based on the average concentration determined from stack sampling of the steam boiler units in a series of tests conducted during 1977. At that time the average particulate emission rate was 0.078 lb $MBTU^{-1}$. This was below the emission limit of 0.1 lb $MBTU^{-1}$ for particulates as set forth by the New York State Department of Environmental Conservation (Part 227, Stationary Combustion Installations).

The emissions of SO_2, NO_x and particulates have decreased markedly since 1976 when the Laboratory initiated the utilization of alternate liquid fuels (ALF), such as mineral spirits, alcohol, jet fuel and reconstituted fuels. In 1981, the fraction of ALF relative to total fuel consumption, was 38%. These alternate fuels typically have a weighted average sulfur content of 0.5% or less as compared to the typical 1% sulfur content of #6 oil and therefore contribute to the reduction of pollutants discharged to the atmosphere through the stack. Samples of ALF have been analyzed for cadmium (Cd), lead (Pb) and chlorinated hydrocarbons. The results indicated that the burning of ALF does not constitute a potential environmental problem [11,15].

TABLE 5

1981 BNL Environmental Monitoring
Estimated Radionuclide Content of Materials Incinerated[a]

Radionuclide	Half-life	Quantity[b] (μCi)
^{3}H	12.2 y	180112
^{7}Be	53.6 d	2550
^{14}C	5730 y	814
^{32}P	14.3 d	148
^{35}S	87.9 d	5673
^{59}Fe	45.6 d	249
^{113}Sn	115 d	263
^{125}I	60.2 d	990

y = year

d = day

[a] Incinerated in the Waste Management Incinerator.

[b] Activity less than 100 μCi have not been reported.

TABLE 6

1981 BNL Environmental Monitoring
Estimated Concentrations of SO_2, NO_x and Particulates at the Central Steam Plant Stack (Bldg. #610) and at the Site Boundary

Effluent	Total kg	Calculated Stack Concentration	Average Boundary Concentration[a]	EPA Primary Air Quality Standard {15}
SO_2	2.59×10^5[b]	216 ppm	0.76×10^{-3} ppm	0.03 ppm
NO_x	1.15×10^5	125 ppm	5.06×10^{-4} ppm	0.05 ppm
Particulates	2.46×10^4[c]	0.07 g m^{-3}	0.28 µg m^{-3}	75 µg m^{-3}

[a] Based on average X/Q of 2.4×10^{-7} sec m^{-3} calculated by BNL Meteorolgy Group (1981).

[b] Based on average 1.0% sulfur content.

[c] Based on measured average value during February 1977 stack sampling conducted on main steam boiler unit (New York Testing Laboratories, Inc., Westbury, N.Y., 11590).

3.2.2 Sampling and Analysis:

The Brookhaven environmental air monitoring program is designed to identify and quantify airborne radioactivity attributable to natural sources, to activities remote from the Laboratory (e.g. above ground nuclear weapon tests) and to Laboratory activities. Most of the air concentrations of radioactivity detected during 1981 could be attributable to the first and to a decreasing extent to the second.

3.2.3 Air Samples:

During 1981, positive displacement air pumps (Gast) were operated at a flow rate of 15 $\ell\,min^{-1}$ at the monitoring station adjacent to the solid waste management area (S-6), and at the site boundary stations P-2, P-4, P-7 and P-9 (see Figure 2 for locations). The air sampling media consisted of a 5 cm diameter air particulate filter (Gelman type) followed by a 5 cm x 2.5 cm bed of TEDA impregnated charcoal for collection of radiohalogens. A parallel low volume filter system sampler was operated at a flow rate of 56 $\ell\ min^{-1}$. It consisted of a 7.6 cm diameter air particulate filter (Gelman type G), followed by a 250 cm^3 TEDA impregnated charcoal filter. The rationale for the latter sampling system is to assure collection of all radioiodine species at a suitable flow rate.

The air particulate samples were counted for gross beta activity using an anti-coincidence proportional counter. The data are shown in Table 7. A seasonal trend was observed for gross beta activity in 1981. The gross beta activity was at a maximum at all monitoring stations during the second quarter. This is attributed to the spring exchange between stratosphere and troposphere, which results in an increase in particulate concentrations at this time.

In addition to counting for gross beta activity, analyses for gamma emitting nuclides were performed on a composite of all air particulate samples shortly after the end of each month. The charcoal samples were also composited and were analyzed at one month post-collection to determine ^{131}I by decay. These data are also reported in Table 7. Only ^{137}Cs was detectable. Other fission product nuclides were below MDL for the counting system used (see Table 20). No ^{131}I was detected during 1981, which is consistent with absence of any reported atmospheric nuclear tests during the year.

Sampling for tritium vapor was performed at each of the air sampling stations by drawing a small side stream of air ($\sim$100 $cm^3\ min^{-1}$) through silica gel cartridges. These were generally changed on a biweekly basis. Collected vapor was subsequently removed from the gel by heating, then condensed, collected and assayed by liquid scintillation counting. Tritium vapor concentration data obtained during 1981 is shown in Table 8. The measured yearly average concentration (including background) at the site boundary was 6.2 pCi m^{-3} (6.2×10^{-12} $\mu Ci\ cm^{-3}$) or 0.003% of the applicable RCG (16).

This reported average concentration does not reflect the anamolous results indicated by the silica gel cartridges operated at the southeast perimeter (P-7) and at the southwest perimeter (P-4) locations during the third and fourth quarters of 1981. Although no plausible mechanism has yet been identified, most of the individual bi-weekly to monthly samples collected from these two locations during this time period appear to have been contaminated by some non-environmental source of tritium. This judgment is based on meteorological analysis, which

TABLE 7

1981 BNL Environmental Monitoring
Gross Beta Concentrations in Air Particulate Filters
and Gamma Emitting Nuclides in Charcoal Filters
(pCi/m^3)

Period	Location	Number of Samples	Gross Beta			^{137}Cs (a)
			Average	Maximum	Minimum	
January	N.W. Perimeter (P-2)	5	0.20	0.56	0.03	ND
to	S.W. Perimeter (P-4)	15	0.19	0.60	0.03	0.004
March	S.E. Perimeter (P-7)	1	0.06	0.06	0.06	-
	N.E. Perimeter (P-9)	14	0.23	0.59	0.06	0.008
April	N.W. Perimeter	11	0.35	0.58	0.13	0.004
to	S.W. Perimeter	12	0.38	0.63	0.13	0.009
June	S.E. Perimeter	9	0.24	0.41	0.001	0.003
	N.E. Perimeter	11	0.29	0.61	0.006	0.002
July	N.W. Perimeter	12	0.10	0.25	0.02	0.005
to	S.W. Perimeter	13	0.12	0.26	0.02	0.007
September	S.E. Perimeter	13	0.09	0.28	0.03	0.005
	N.E. Perimeter	13	0.12	0.31	0.04	0.003
October	N.W. Perimeter	12	0.03	0.06	0.02	0.004
to	S.W. Perimeter	12	0.03	0.04	0.01	0.002
December	S.E. Perimeter	12	0.03	0.07	0.01	0.003
	N.E. Perimeter	12	0.03	0.07	0.004	0.004
Annual	N.W. Perimeter	40	0.17	0.58	0.02	0.004
Total	S.W. Perimeter	52	0.18	0.63	0.01	0.006
	S.E. Perimeter	35	0.11	0.41	0.001	0.004
	N.E. Perimeter	50	0.18	0.61	0.004	0.004

Locations given in Figure 2.

ND: Not detectable

(a) Sample - Composite of charcoal filters from all stations.

Applicable Standards - Table 20

TABLE 8

1981 Environmental Monitoring

Tritium Vapor Concentration (Average) in Air

(pCi/m^3)

Quarterly Period	Northeast Perimeter (P-9)	Southeast Perimeter (P-7)	Southwest Perimeter (P-4)	Northwest Perimeter[a] (P-2)	Minimum Detection Limit[b]
First	3.1×10^0	$<0.9 \times 10^0$	1.5×10^0	-	
Second	$<3.5 \times 10^0$	1.3×10^1	7.4×10^0	-	
Third	2.7×10^1	(1.3×10^4)*	(2.5×10^3)*	5.8×10^0	$0.9\text{-}3.5 \times 10^0$
Fourth	2.3×10^0	(2.8×10^2)*	(5.6×10^1)*	6.3×10^0	
Average (Annual)	9.0×10^0	7.0×10^0**	4.5×10^0**	6.1×10^0	
Radiation Concentration Guide (16)	- - - - - - - - - - - - - - - - 2×10^5 - - - - - - - - - - - - - - - -				

[a] Tritium monitoring at Station P-2 began on July 31, 1981.

[b] Range is based on the MDL for this particular tritium determination procedure, which is a function of counting efficiency, counting time, sample volume, and relative humidity.

* Samples apparently contaminated by unidentified non-environmental source of tritium.

** Excluding third and fourth quarter indications.

shows that even using conservative (poorer than average) dispersion factors, improbable quanties of tritium as liquid or vapor would have had to have been released from on-site facilities in order to have produced the indicated concentrations. Not only would the necessary releases have had to have been far in excess of the measured quantities, as indicated in Table 4, but for some of the indicated sampling periods they would have to have exceeded the total inventory of tritium at the Laboratory. In addition, the indicated concentrations at the southeast and southwest stations during most of the individual sampling periods far exceed those at the northeast perimeter. This is contrary to the expected pattern for sustained releases from the central laboratory site, where the principal facilities with a significant inventory of tritium are located, since the northeast station was in the prepondant downwind direction during most of the sampling intervals in which the anomalous results were obtained.

The current Laboratory environmental monitoring program does not include air sampling for nonradioactive substances. The calculated annual average concentrations at the site boundary of the conventional pollutants released from the central steam plant are listed in Table 6. All were less than 3% of the EPA Primary Air Quality Standard for the reported constituents (15).

About 235 kg of various pesticides, chiefly organo-phosphates, Thiodan, Diazinon, Carbaryl and Parathion, were applied on site during 1981, principally to protect crops which were grown for biological research purposes. All of these pesticides are considered biodegradable, with persistence times in the order of a week. Furthermore, they were applied with a "sticker" additive to minimize their subsequently becoming airborne.

3.2.4 Precipitation:

Two pot-type rain collectors, each with a surface area of 0.33 m^2, are situated adjacent to the sewage treatment plant (see Fig. 2). A routine collection was made from these whenever precipitation was observed during a previous 24 hour (or weekend) period. Part of each collection was evaporated for gross beta counting, a small fraction was composited for monthly tritium analysis, and the balance was put through ion exchange columns for subsequent quarterly ^{90}Sr and gamma analyses. The data for 1981 are reported in Table 9. Besides tritium (as vapor) there was no detectable indication of Laboratory released airborne radioactivity in precipitation collected on site. The gross beta activity reflects rainfall scavenging of radioactive fallout which is most pronounced during March through July. Variation in the deposition of ^{7}Be is dependent upon the interaction of cosmic rays with atmospheric nucleii along with trophospheric/stratospheric mixing and would not parallel radioactive fallout. The trend of ^{137}Cs and ^{90}Sr is similar to gross beta activity although the few data points do not clearly demonstrate this.

To obtain an indication of the washout of tritium from local airborne releases, small precipitation collectors were installed at the perimeter stations (P-2, P-4, P-7, P-9), and at Blue Point, some 20 km southwest of the Laboratory site. The average tritium concentrations were all reduced significantly when compared to previous years (11) and were at or below the MDL (Table 20). At the MDL, the average concentration (on site) would have been less than 1% of the EPA Drinking Water Standard (17).

TABLE 9

1981 BNL Environmental Monitoring
Monthly Average Gross Beta Concentration
Total Gross Beta, Tritium and Radionuclide Activity in Precipitation

Month	Rainfall (cm)	Average Gβ Concentration (10^{-9} μCi/mℓ)	Gβ	^{90}Sr	^{3}H	^{7}Be	^{54}Mn	^{95}Zr-Nb	^{106}Ru-Rh	^{103}Ru	^{137}Cs	^{141}Ce
			(10^{-3} μCi/m^2)									
January	2.92	31.16	0.91		16.23							
February	13.11	32.36	1.66	0.067	17.40	44.2	b	b	b	b	0.86	b
March	4.57	54.49	2.49		15.66							
April	11.66	70.33	8.28		113.50							
May	5.51	47.55	2.62	0.154	23.23	11.3	0.07	1.81	1.51	0.98	0.28	0.28
June	7.98	85.71	6.84		100.70							
July	6.83	105.27	7.19		42.11							
August	2.44	6.56	0.16	0.033	4.02	15.9	b	2.13	b	b	0.90	b
September	13.13	19.65	2.58		114.70							
October	11.40	7.19	0.82		76.60							
November	8.03	2.24	0.18	0.018	38.17	40.2	0.04	b	b	b	0.10	b
December	14.10	3.33	0.47		91.72							
Total	101.68	-	34.20	0.272	654.04 [a]	111.6	0.11	3.94	1.51	0.98	2.14	0.28
Average	8.47	38.82	2.85	0.023	54.50	9.3	0.01	0.33	0.13	0.08	0.18	0.02
Radiation Concentration Guide [16]	-	3×10^3	8×10^2	8×10^1	8×10^5	5×10^5					5×10^3	

(a) Site wide deposition of 13.93 Ci of ^{3}H.

(b) Below the Minimum Detection Limit (MDL) of the system used in analyzing the same (See Table 20).

3.3 Liquid Effluent Monitoring:

The basic principle of liquid waste management at the Laboratory is confinement and concentration to minimize the volumes of liquids requiring decontamination prior to on-site release or processing into solid form for off-site burial. Accordingly, liquid wastes are segregated at the point of origin on the basis of their anticipated concentrations of radioactivity or other potentially harmful agents.

Small volumes (up to a few liters) of concentrated liquid wastes containing radioactivity or other hazardous agents are withheld from the Laboratory waste systems. They are stored at their sources of generation in small containers, collected by the Laboratory waste management group, and subsequently packaged for off-site disposal (in the case of hazardous agents, by an EPA licensed contractor).

Facilities which may routinely produce larger volumes (up to several hundred liters) of radioactive or otherwise contaminated waste liquids are provided with dual waste handling systems, one for "active" (D-probably contaminated) and one for "inactive" (F-probably uncontaminated) wastes. As shown in Figure 4, wastes placed into the "active" or D system are collected in holdup tanks. After sampling and analysis, they are either transferred by installed pipelines or by tank truck to storage tanks adjacent to the Laboratory liquid waste evaporator. At this facility, liquids are concentrated about a hundred fold and ultimately disposed of as solid wastes. If found to be of sufficiently low concentration [18], D wastes may be routed directly from holdup tanks to the Laboratory sanitary waste system.

Subject to the results of analysis, "inactive" wastes are routed directly to the Laboratory sanitary waste system, where they are mixed with large quantities (approaching 4,000,000 l d^{-1}) of cooling and other uncontaminated water routinely produced by diverse Laboratory operations. Sampling and analysis of the waste in facility holdup tanks is done to facilitate waste management; while effluent sampling is performed at the sewage treatment plant to establish the concentration and amounts of environmental releases.

The small amounts of low level radioactive waste effluents that may be routinely disposed of by release into the Laboratory sanitary waste system are established by administrative limits [18]. Within these limits, individual releases are kept as low as practicable.

3.3.1 National Pollutant Discharge Elimination System (NPDES) Permit:

As of January 31, 1975, the effluent from the Laboratory sewage treatment plant was subject to the conditions of the National Pollutant Discharge Elimina-

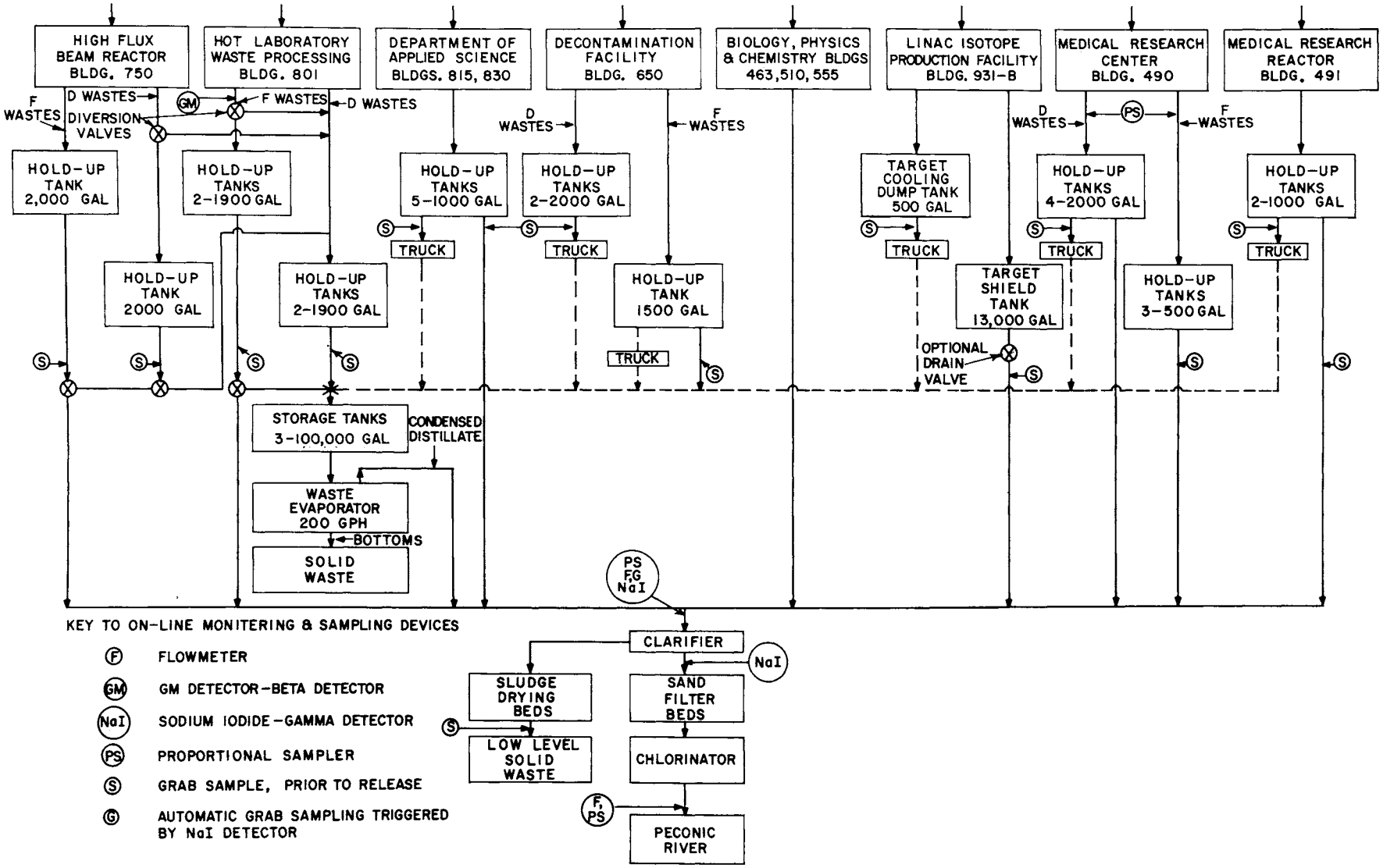


FIGURE 4: LIQUID EFFLUENT SYSTEMS

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tion System (NPDES) Permit No. NY 000 5835. Quarterly reports have been prepared in accordance with this permit, using data obtained by the sewage treatment plant operators. A yearly summary of these data is shown in Table 10, which includes permit conditions. The Laboratory effluent was within all of these conditions, with the exception of some daily pH levels and a single instance of BOD_5 percent removal.

The effluent pH levels were below the lower limit of 5.8 on 59 occasions. They were not related to the influent pH, which averaged 6.7. However, the effluent pH variations were within the local natural range of ground water (pH 5.5-6.0). A Laboratory study has indicated that the low pH of rainfall (pH 2.5-4.9) on Long Island is a significant factor in lowering the pH of the Laboratory effluent as it passes through the sand filter beds.

3.3.2 Peconic River:

Primary treatment of the liquid stream collected by the sanitary waste system to remove suspended solids is provided by a 950,000 liter clarifier. The liquid effluent from it flows onto sand filter beds, from which about 75-80% of the water has typically been recovered by an underlying tile field. This recovered water is chlorinated and then released into a small stream that forms one of the headwaters of the Peconic River.

A schematic of the sewage treatment plant and its related sampling arrangements are illustrated in Figure 5. In addition to the inplant flow measurement and sampling instrumentation, totalizing flowmeters (Leopold and Stevens TP 61-2), with provision for taking a sample for each 7576 liters of flow are installed in combination with positive action battery operated samplers (Brailsford DU-1), at the chlorine house, at the former site boundary which is 0.8 km downstream on the Peconic River, and at the site boundary, 2.6 km downstream.

An aliquot of each daily (or weekend) sample of the input to the sand filter beds and of their output to the chlorine house outfall was evaporated for the analysis of gross alpha and gross beta activity. Another aliquot was counted directly for tritium. Samples from the two downstream locations were obtained three times a week. Aliquots of each were analyzed for gross beta, gross alpha, and tritium. Another aliquot, proportional to the measured flow during the sampling period, was passed through ion exchange columns for subsequent analysis as an integrated sample. Unless the gross beta count at a given location indicated the need for immediate radionuclide identification, one set of these columns was analyzed directly on a monthly or quarterly basis for gamma emitting nuclides and the other was eluted for radiochemical processing for ^{90}Sr analysis. The monthly minimum, maximum and average flow, the gross beta activity and that of the principal individual nuclides at the clarifier (input to the filter beds), the chlorine house (output from the beds), the former perimeter and the site perimeter are shown in Table 11. Yearly totals and average concentrations are also indicated. During 1981, about 80% of the total flow into the clarifier appeared in the output at the chlorine house after passing through the sand filter beds. The balance was assumed to have percolated to the ground water flow under the beds. Estimates of the amount of radioactivity released to

TABLE 10
1981 BNL Environmental Monitoring
National Pollution Discharge Elimination System
Summary of Data

Parameter	Status	Quantity					Concentration					Frequency of Analysis	Sample Type
		Minimum	Average	Maximum	Units	Number[(a)] of Exceptions	Minimum	Average	Maximum	Units	Number[(a)] of Exceptions		
Flow	Sample measurement	0.5	0.8	1.3	MGD	0	-	-	-	-	-	Continuous	NA
	Permit requirement	-	2.3	-			-	-	-			Continuous	NA
pH Influent	Sample measurement	5.3	6.7	8.3	STD.	-	-	-	-	-	-	Daily	GRAB
	Permit requirement	-	-	-	Units		-	-	-			Daily	GRAB
pH Effluent	Sample measurement	5.2	5.9	6.6	STD.	59	-	-	-	-	-	Daily	GRAB
	Permit requirement	5.8	-	9.0	Units		-	-	-			Daily	GRAB
BOD_5 Influent	Sample measurement	85.2	107.1	155.1	kg/day	-	19.5	30.3	41.3	mg/ℓ	-	Weekly	8 hr.
	Permit requirement	-	-	-			-	-	-			Monthly	8 hr.
BOD_5 Effluent	Sample measurement	4.3	10.9	26.4	kg/day	0	1.7	3.6	8.3	mg/ℓ	0	Weekly	8 hr.
	Permit requirement	-	262.0	391.0			-	30.0	45.0			Monthly	8 hr.
Percent removal BOD_5	Sample measurement	-	-	-	-	-	83.0	90.1	95.9	%	1	Weekly	-
	Permit requirement	-	-	-			85.0	-	-			Monthly	-
Suspended solids, Influent	Sample measurement	54.9	123.7	198.3	kg/day	-	12.0	35.3	55.5	mg/ℓ	-	Biweekly	8 hr.
	Permit requirement	-	-	-			-	-	-			Monthly	8 hr.
Suspended solids, Effluent	Sample measurement	0.0	4.6	15.0	kg/day	0	0.0	1.6	5.3	mg/ℓ	0	Biweekly	8 hr.
	Permit requirement	-	262.0	391.0			-	30.0	45.0			Monthly	8 hr.
Percent removal Suspended solids	Sample measurement	-	-	-	-	-	89.6	96.9	100.0	%	0	Biweekly	-
	Permit requirement	-	-	-			85.0	-	-			Monthly	-
Settleable solids, Influent	Sample measurement	-	-	-	-	-	0.1	1.00	40.0	mℓ/ℓ	-	Daily	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Settleable solids, Effluent	Sample measurement	-	-	-	-	-	0.0	0.0	0.0	mℓ/ℓ	-	Daily	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Residual chlorine, Effluent	Sample measurement	-	-	-	-	-	0.5	0.7	1.7	mg/ℓ	-	Daily	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Temperature, Effluent	Sample measurement	4.0	14.7	20.0	°C	-	-	-	-	-	-	Daily	GRAB
	Permit requirement	-	-	-			-	-	-			Daily	GRAB
Fecal coliform, Effluent	Sample measurement	-	-	-	-	-	0.0	0.0	0.0	n/100 mℓ	0	Weekly	GRAB
	Permit requirement	-	-	-			-	200.0	400.0			Monthly	GRAB

- Indicates not required

(a) Total for the year

the ground water in this manner during 1981 are shown in Table 11. These were calculated on the additional assumption that the average concentrations of the contained nuclides corresponded to those in the output from the beds, as observed at the chlorine house.

A higher than normal α-activity noted at the clarifier could be attributed to an accidental discharge of ^{241}Am into the sanitary system. An analysis of the radionuclide concentrations at the chlorine house over the past several years has indicated a time lag between input and output from the sand filter beds. This lag appears to be greater for ^{134}Cs and ^{137}Cs than for ^{90}Sr, which explains why larger amounts of the latter were found in the effluent relative to those in the influent. During 1981, other radionuclides such as ^{22}Na, ^{57}Co, ^{58}Co, ^{95}Zr-Nb, ^{125}Sb, ^{140}Ba-La and ^{144}Ce, which have been detected in previous years, were all at or below MDL (Table 20) and as such were not reported in the Table 11.

Flow and activity concentration data for the former site boundary sampling location, 0.8 km downstream (see Fig. 5), and at the present site boundary are also shown in Table 11. Climatic conditions during 1980 and 1981 resulted in decreased flows when compared to previous years due to below average rainfall. This resulted in a very low flow at the site perimeter, which was essentially zero during most of the year except during spring and early summer. This resulted in a loss during 1981 of about 54% of the flow at the former perimeter between it and the present site boundary. Due to the sporadic nature of the flow over the measuring weir, the flows at the site perimeter were estimated during the months of March to July. Based on the decrease in total flow between the former site boundary and the perimeter, upper limit estimates of the activity that may have percolated to the underlying aquifer are also shown in Table 11.

Analysis of monthly composite samples of the Peconic River at the former site boundary (0.8 km downstream from the chlorine house) during this period showed that, on the average <1% of the annual total activity (excluding tritium) consisted of ^{90}Sr and that no appreciable amounts of long-lived radioactive iodine or bone-seeking nuclides such as radium were present. Under these circumstances, the applicable RCG was 300 pCi l^{-1} (0.3×10^{-6} μCi ml^{-1}). The gross beta concentration in that portion assumed to have percolated to ground water was 21.4 pCi l^{-1} (2.14×10^{-8} μCi ml^{-1}) or 43% of the EPA Drinking Water Compliance Level Standard [17].

At the Laboratory perimeter (2.6 km downstream from the chlorine house), where flows were estimated, the average concentration of ^{90}Sr was 0.42 pCi ℓ^{-1}. Since the Peconic is not a direct source of drinking water, the applicable RCG was 300 pCi l^{-1} (0.3×10^{-6} μCi ml^{-1}) [16]. The observed gross beta concentration of the water released downstream was 23.6 pCi l^{-1} (2.36×10^{-8} μCi ml^{-1}) or <3% of the RCG.

The Safety and Environmental Protection Division also performs routine water quality measurements on samples of the filter beds effluent, of the Peconic River upstream of the effluent discharge point, of the river at the former Laboratory perimeter (0.8 km downstream), and of the river at the present Laboratory perimeter (2.6 km downstream). A summary of these data for 1981 is

TABLE 11

1981 BNL Environmental Monitoring
Total Activities and Concentrations of Identifiable Nuclides[a] in Liquid Effluents
from the Sewage Treatment Plant and in the Peconic River

	Flow $\times 10^{10}$ mℓ	Gross α	Gross β	^{90}Sr	^{3}H	^{40}K	^{51}Cr	^{54}Mn	^{60}Co	^{65}Zn	^{134}Cs	^{137}Cs
						Clarifier (mCi)						
Monthly (Minimum)	8.66	0.12	2.42	0.01	128	0.06	0.07	0.01	0.01	0.01	0.01	0.02
Monthly (Maximum)	14.65	9.80	14.24	0.13	1271	1.90	1.69	0.09	0.26	0.14	0.05	0.16
Average (Monthly)	11.00	1.00	3.99	0.05	659	0.81	0.41	0.02	0.06	0.06	0.03	0.05
Total (Annual)	132.01	12.00	47.81	0.62	7988	8.90	2.05	0.26	0.69	0.17	0.19	0.47
Average Concentration (10^{-9} μCi/mℓ)	-	9.09	36.22	0.47	6051	6.74	1.55	0.20	0.52	0.13	0.14	0.36
						Groundwater (Sand-Filter Beds) (mCi)						
Total (Annual)	25.99	0.46	6.99	0.10	1565	0.83	0.05	0.04	0.07	0.05	0.12	0.41
Average Concentration (10^{-9} μCi/mℓ)	-	1.76	26.92	0.40	6021	3.19	0.18	0.17	0.27	0.20	0.48	1.59
						Chlorine House (mCi)						
Monthly (Minimum)	7.04	0.09	1.20	0.02	123	0.10	0.19	0.01	0.02	0.01	0.01	0.06
Monthly (Maximum)	11.65	0.37	8.02	0.07	1032	1.01	0.19	0.14	0.07	0.06	0.08	0.24
Average (Monthly)	8.82	0.16	2.38	0.04	532	0.31	0.19	0.04	0.03	0.04	0.05	0.15
Total (Annual)	106.12	1.87	28.57	0.42	6389	3.39	0.19	0.18	0.29	0.21	0.51	1.69
Average Concentration (10^{-9} μCi/mℓ)	-	1.76	26.92	0.40	6021	3.19	0.18	0.17	0.27	0.20	0.48	1.59
						Former Perimeter (mCi)						
Quarterly (Minimum)	16.61	0.25	3.42	0.03	809	0.21	0.31	0.01	0.07	0.03	0.06	0.15
Quarterly (Maximum)	28.29	0.41	6.42	0.11	1626	1.24	0.31	0.08	0.30	0.09	0.17	0.58
Average (Monthly)	7.50	0.12	1.60	0.02	416	0.28	0.31	0.05	0.18	0.06	0.10	0.38
Total (Annual)	89.94	1.38	19.21	0.29	4987	3.31	0.31	0.09	0.53	0.12	0.29	1.50
Average Concentration (10^{-9} μCi/mℓ)	-	1.53	21.36	0.32	5545	3.68	0.34	0.10	0.59	0.13	0.32	1.67
						Groundwater (Stream Bed) (mCi)						
Total (Annual)	48.24[d]	0.74	10.30	0.15	2675	1.78	0.16	0.05	0.28	0.06	0.15	0.81
Average Concentration (10^{-9} μCi/mℓ)	-	1.53	21.36	0.32	5545	3.68	0.34	0.10	0.59	0.13	0.32	1.67
						Site Perimeter (mCi)						
Quarterly (Minimum)	7.00	0.11	2.03	0.02	143							
Quarterly (Maximum)	34.00	0.49	7.94	0.16	1674							
Average (Monthly)	10.40	0.15	2.45	0.07	917	Flow inadequate to collect representative sample						
Total (Annual)	52.00[e]	0.76	12.26	0.22	2752	for γ-analysis; as such, no γ-analysis done.						
Average Concentration (10^{-9} μCi/mℓ)	-	1.46	23.58	0.42	5292							
Radiation Concentration Guide (16) (10^{-9} μCi/mℓ) (See also Table)	-	15[b]	3×10^{3}[c] 50[b]	3×10^{2} 8[b]	3×10^{6} 2×10^{4}[b]	3×10^{5}	2×10^{6}	1×10^{5}	5×10^{4}	1×10^{5}	9×10^{3}	2×10^{4}

(a) Below the Minimum Detection Limit (MDL) of the system used in estimating the activity. Other nuclides such as ^{7}Be, ^{22}Na, ^{47}Sc, ^{59}Fe, ^{75}Se, ^{95}Nb were detected in the influent and effluent from the Laboratory at MDL but are not reported in the above table.

(b) EPA Drinking Water Regulations apply to groundwater on Long Island {17,25}.

(c) For mixtures of radionuclides containing < 10% ^{90}Sr, $^{125\text{-}131}I$, or long lived alpha emitters. The concentration guides for unknown RCG's, and the sum of the fractions of the RCG's for all such radionuclides is less than 0.25.

(d) Estimated loss to groundwater; this loss is considered conservative as no corrections have been made for spreading and evaporation.

(e) No flow: flow figures where given are estimated. Activity based on "grab sample" data.

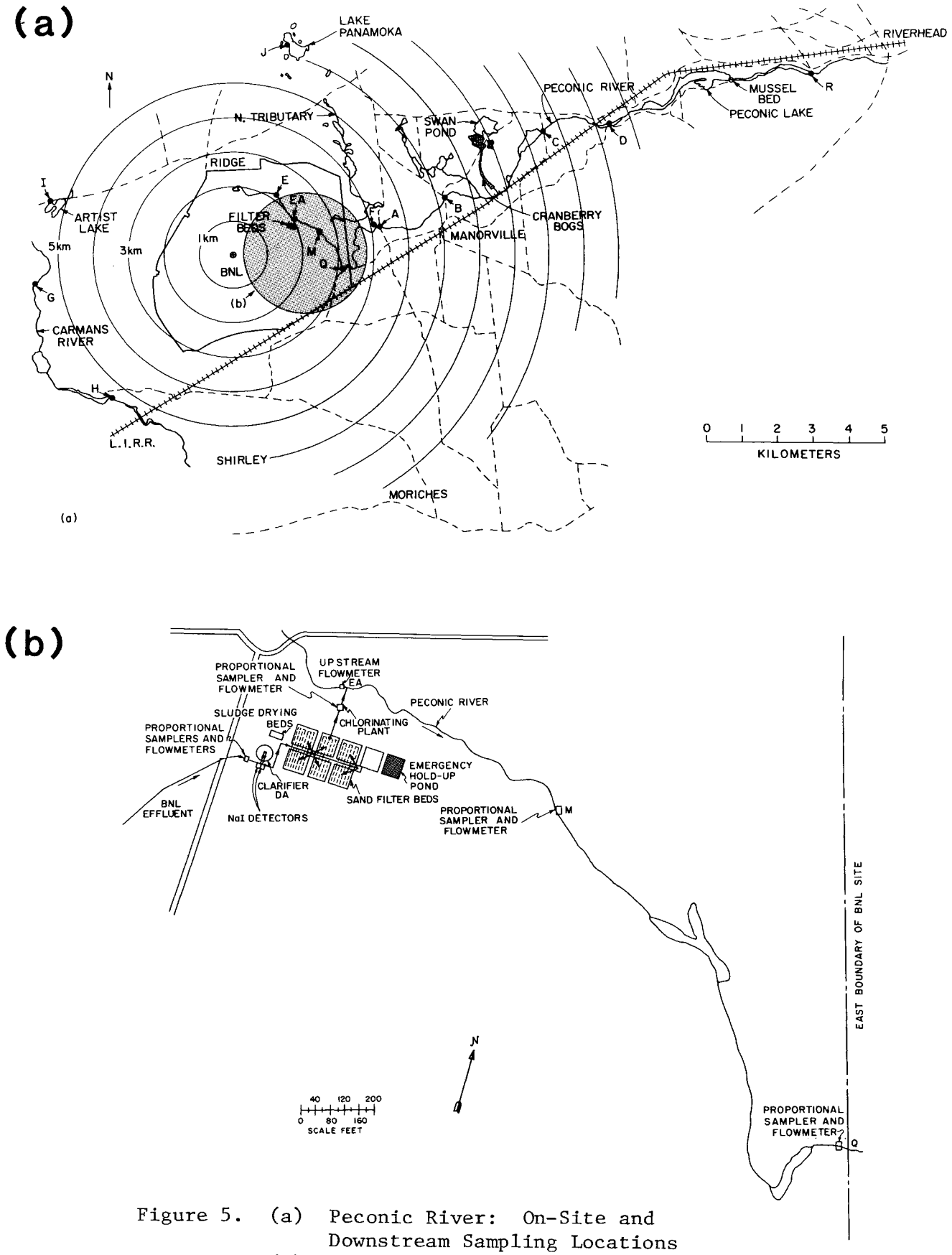

Figure 5. (a) Peconic River: On-Site and Downstream Sampling Locations
(b) Sewage Treatment Plant: Sampling Locations

shown in Table 12. From the table it is seen that the portion of the Peconic River within the Laboratory site showed compliance with the NYS DEC Water Quality Standards [19]. After mixing with the upstream flow, the temperature increment was within the standard [21] at the Laboratory perimeter. Yearly average concentrations of metals for which analyses were made were all at or within the standard for the receiving body of water [15,20].

Monthly "grab" water samples were obtained at on- and off-site locations along the Peconic River. A battery operated fixed flow sampler was operated at Riverhead (at the mouth of the Peconic River) between March and December. Reference "grab" samples were obtained from other nearby streams and bodies of water outside the Laboratory drainage area. As shown in Figure 5, the sampling locations were as follows:

Off-Site (Peconic River, proceeding downstream)

A - Peconic River at Schultz Road, 4.85 km downstream,

R - Peconic River at Riverhead, 19.35 km downstream,

Controls (Not in the Laboratory drainage area)

E - Peconic River, upstream from the Laboratory effluent outfall,

F - Peconic River, north tributary (independent of the Laboratory drainage area),

H - Carmans River, outfall of Yaphank Lake,

Yearly average gross beta, tritium and ^{90}Sr concentrations at downstream (A and R) and control locations (E,F) are shown in Table 12. In comparison with the on-site and perimeter concentrations, as shown in Table 12, the concentrations of radionuclides in the Peconic River downstream of the Laboratory outfall, diminished rapidly to near background levels at the more distant sampling locations.

Measurements of selected water quality and purity parameters were performed at downstream locations on the Peconic River and at control locations in order to provide a comparison with the same parameters in the Laboratory effluent. These limited "grab" sample data are also shown in Table 12. Other control locations (E, F and H as indicated in Figure 5) were also monitored for the same parameters. The results (Table 12) indicate that, in general, the levels are comparable to that seen in the Peconic River downstream of the site perimeter.

3.3.3 Recharge Basin:

After use in "once through" heat exchangers and process cooling, on the average 22 million l d^{-1} (MLD) of water was returned to the aquifer through on-site recharge basins; 6.6 MLD to basin N located about 610 m northeast of the AGS; 6.6 MLD to basin O about 670 m east of the HFBR; and 6.9 MLD to basin P

TABLE 12

1981 BNL Environmental Monitoring
Sewage Treatment Plant, Peconic River and Offsite Locations
Average Radionuclide, Metals and Water Quality Data

Location	Gross α	Gross β	^{90}Sr	^{3}H Tritium	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphoros	Dissolved Solids	Conductivity (μmhos/cm)	Temperature °C	pH	Coliform - Fecal #/100 mℓ	Coliform - Total #/100 mℓ	Ag	Cd	Cr	Cu	Fe	Hg	Pb	Zn
Peconic River	10^{-9} μCi/ml				ppm										ppm							
Sewage Treatment Plant Influent (DA)	9.09	36.22	0.47	6051	b	b	0.08	1.3	b	b	22	6.7	b	b	0.004	0.0013	0.012	0.086	0.419	b	0.027	0.126
Sewage Treatment Plant Effluent (EA)	1.76	26.92	0.40	6021	8.6	134.4	3.25	0.65	122	192	15	5.9	1	3	0.003	0.0015	0.003	0.103	0.178	0.0006	0.011	0.281
Former Perimeter (M)	1.53	21.36	0.32	5545	8.2	101.2	3.48	0.64	127	193	13	6.1	26	360	0.002	0.0015	0.004	0.095	0.243	0.0001	0.007	0.124
Site Perimeter[a] (Q)	1.46	23.58	0.42	5292	9.3	30.7	1.84	0.63	98	158	9	6.5	b	49	b							
A	0.31	4.24	b	1900	7.7	6.2	0.32	0.02	64	70	18	6.2	b	20	b							
R	0.33	6.72	0.39	2200	8.1	12.4	0.37	0.05	79	106	17	6.8	17	65	b							
Control																						
Upstream of Laboratory Outfall (E)	1.5	10.87	-	2450	6.5	15.7	1.09	0.19	98	122	12	6.1	b	47	b							
F-North Tributary into Peconic River	0.37	4.20	-	1900	7.5	5.7	0.24	0.02	81	53	18	6.2	b	12	b							
H-Carmen's River	0.23	3.66	-	1900	9.3	10.5	0.88	0.01	110	101	17	6.6	b	12	b							
Radiation Concentration Guide {16}	$6x10^{2}$	$3x10^{3}$	$3x10^{2}$	$3x10^{6}$																		
New York State Water Quality Standard {19,20}					-	500	20	-	1000	-	-	-	-	4	0.1	0.2	0.1	0.2	0.6	0.5	0.1	0.3

b - Not Done

Applicable Standards - See also Table 20.

located 305 m south of the MRR (see Figs. 6 and 7). A polyelectrolyte and dispersant is added to the AGS cooling and process water supply, to maintain a phosphate concentration of about 2 ppm in order to maintain the ambient iron in solution. Of the total AGS pumpage, on the average, 3.1 MLD was discharged to the N basin, and 6.1 MLD to the O basin. The HFBR secondary cooling system water recirculates through mechanical cooling towers and is treated to control corrosion and deposition of solids. Blowdown from this system, 0.5 MLD, which contains about 6-8 ppm inorganic polyphosphate and 3-4 ppm mercaptobenzothiozone, is also discharged to the O basin. The untreated MRR-MRC "once through" coolant, which amounts to 6.9 MLD, is discharged to the P basin.

Concentrations of radioactivity and other constituents in the water discharged into these basins are monitored by grab sampling on a weekly basis. The average concentrations of gross beta and tritium activity, water quality parameters, and concentrations of heavy metals are given in Table 13. The average concentrations of gross beta activity in the basins were slightly above background. The N basin receives water that has been used to cool the LINAC beam stops at the AGS, which process results in the formation of short lived activation products that are released to it. The average concentration of gross beta activity was about 20% of the EPA Drinking Water Compliance Standard [17]. Since 1980, when the discharge of steam plant boiler washings was rerouted to the sanitary waste system, all the measured parameters in the U sump have decreased considerably. In general, the average concentrations of gross beta and tritium activity in the other basins were slightly above those in the Laboratory supply wells and were about 5% of the applicable EPA Drinking Water Standards [17,25].

All water quality results were within established standards for ground water quality. Elevated metal concentrations, such as for Cu, Fe, and Zn, indicate effects of chemical treatment in the cooling water systems.

3.3.4 Aquatic Biological Surveillance:

Samples of sediment, vegetation, and fish were collected at Station Q (site boundary) and were analyzed for gamma emitters and ^{90}Sr. The data is shown in Table 14. It is limited to ^{90}Sr and ^{137}Cs, since these radionuclides were the only ones found in detectable concentrations above the MDL. Table 14 also summarizes corresponding data from the previous years [11] in order to indicate the change in radioactivity with time in the different ecological compartments.

There is an increase in concentration factors, on a unit weight basis, across the food chain: water-vegetation-fish, for ^{90}Sr and ^{137}Cs at Station Q. For ^{90}Sr, the concentration factor for fish ranges from 80 to 110 in flesh. For ^{137}Cs, the concentration factor for fish ranged from 930-1630. These results concur with other observations in aquatic environments [22,23]. Using an assumed intake of 1.36 kg/yr [24] of fish flesh (edible portions) by adults and the indicated range of concentrations of ^{90}Sr and ^{137}Cs in fish flesh (edible portions), the committed effective dose-equivalent for these radionuclides to an adult man was estimated to be ranging from 0.01% to 0.02%, respectively, of the permissible dose limits to the general public under the DOE Standard [16].

TABLE 13

1981 BNL Environmental Monitoring
Recharge Basins - Average Radionuclide, Metals and Water Quality Data

Location[a]	# of Samples		Gross α	Gross β	Tritium (^{3}H)	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphoros	Dissolved Solids	Conductivity (μmhos/cm)	Temperature °C	pH	Coliform - Fecal #/100 mℓ	Coliform - Total #/100 mℓ	Ag	Cd	Cr	Cu	Fe	Pb	Zn
			— 10^{-9} μCi/ml —			ppm										ppm						
N (North of AGS)	17	Minimum	0.13	2.31	1700																	
		Maximum	0.52	22.16	3500																	
		Average	0.31	9.88	2000	9.1	16.9	0.31	0.28	80	100	17	6.8	125	139	0.002	0.0006	0.002	0.100	1.965	0.006	0.028
O (East of HFBR)	18	Minimum	0.22	2.37	1000																	
		Maximum	0.56	16.57	15600																	
		Average	0.33	5.19	2600	9.3	20.1	0.40	0.40	88	114	16	6.7	0	3	0.002	0.0006	0.002	0.014	0.610	0.003	0.065
P (South of MRR)	11	Minimum	0.23	1.81	1700																	
		Maximum	0.52	4.69	2200																	
		Average	0.28	3.00	1900	7.0	25.7	2.76	0.03	142	180	15	7.5	0	0	0.002	0.0006	0.002	0.004	0.640	b	0.001
T (North of Linac)	18	Minimum	0.21	1.31	1700																	
		Maximum	0.58	5.51	2200																	
		Average	0.32	2.82	1800	9.3	20.3	0.32	0.03	101	122	16	7.0	0	17	0.002	0.0006	0.002	0.036	0.411	0.003	0.019
U (East of Steam Plant)	4	Minimum																				
		Maximum																				
		Average[c]	0.24	10.50	1700	8.8	15.3	0.45	0.05	81	142	19	6.6	6	22	0.002	0.0006	0.002	0.008	0.155	0.022	0.006
S (South of Warehouse)		Minimum																				
		Maximum																				
		Average	—	b	—	9.2	28.8	0.60	0.13	99	164	15	6.6	63	10	—			b			
EPA Drinking Water Standard {17}			15	50[b]	20	-	-	10	-	-	-	-	-	-	-	0.05	0.01	0.05	-	-	0.05	-

[a] Locations of Recharge Basins given in Figure 7.

[b] Not done.

[c] Flow to Recharge Basin "U" has been reduced since 1980 (BNL 5147 - 1981). Hence sample collected only when flow is seen.

Applicable Standards - See also Table 20.

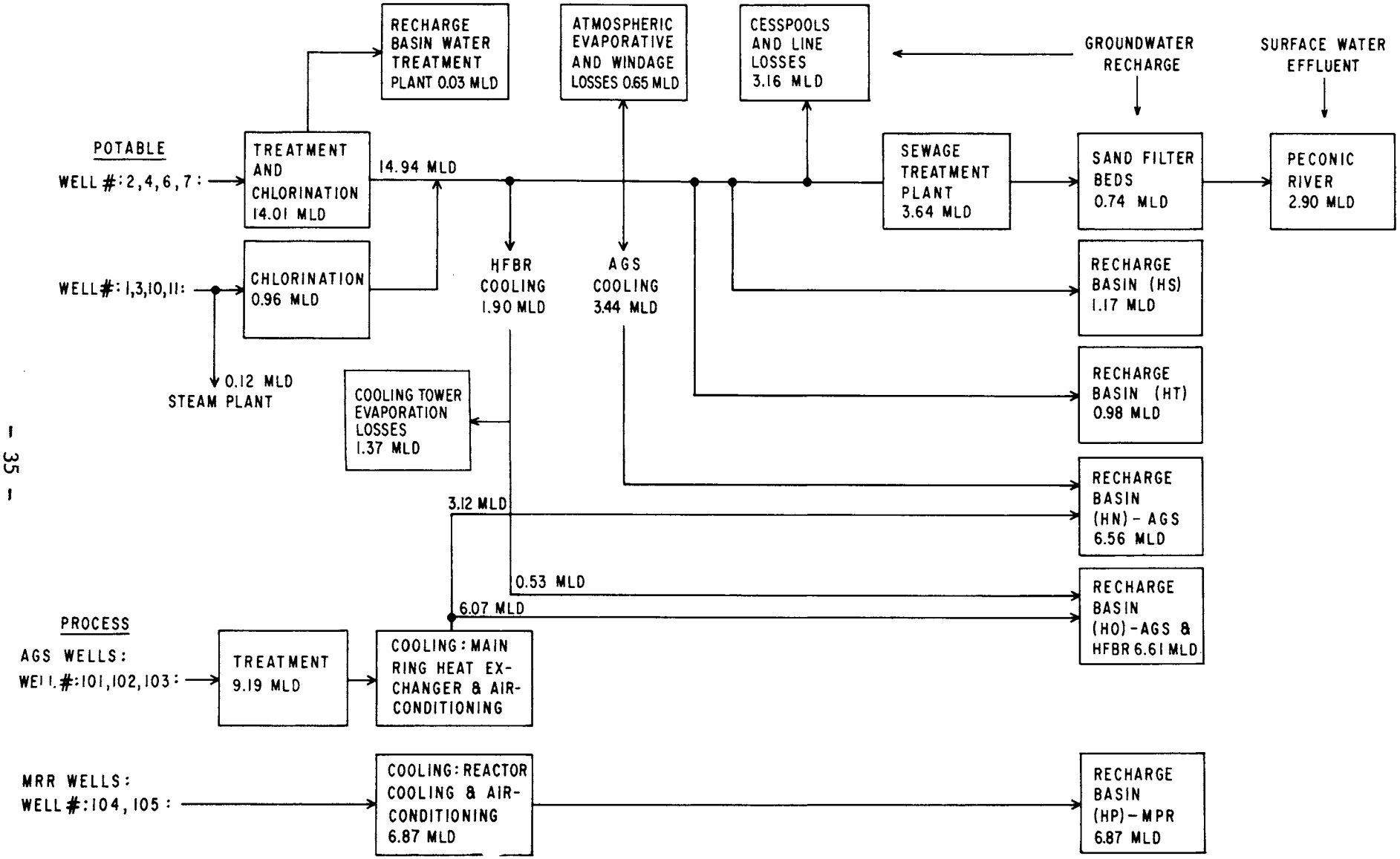

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FIGURE 6

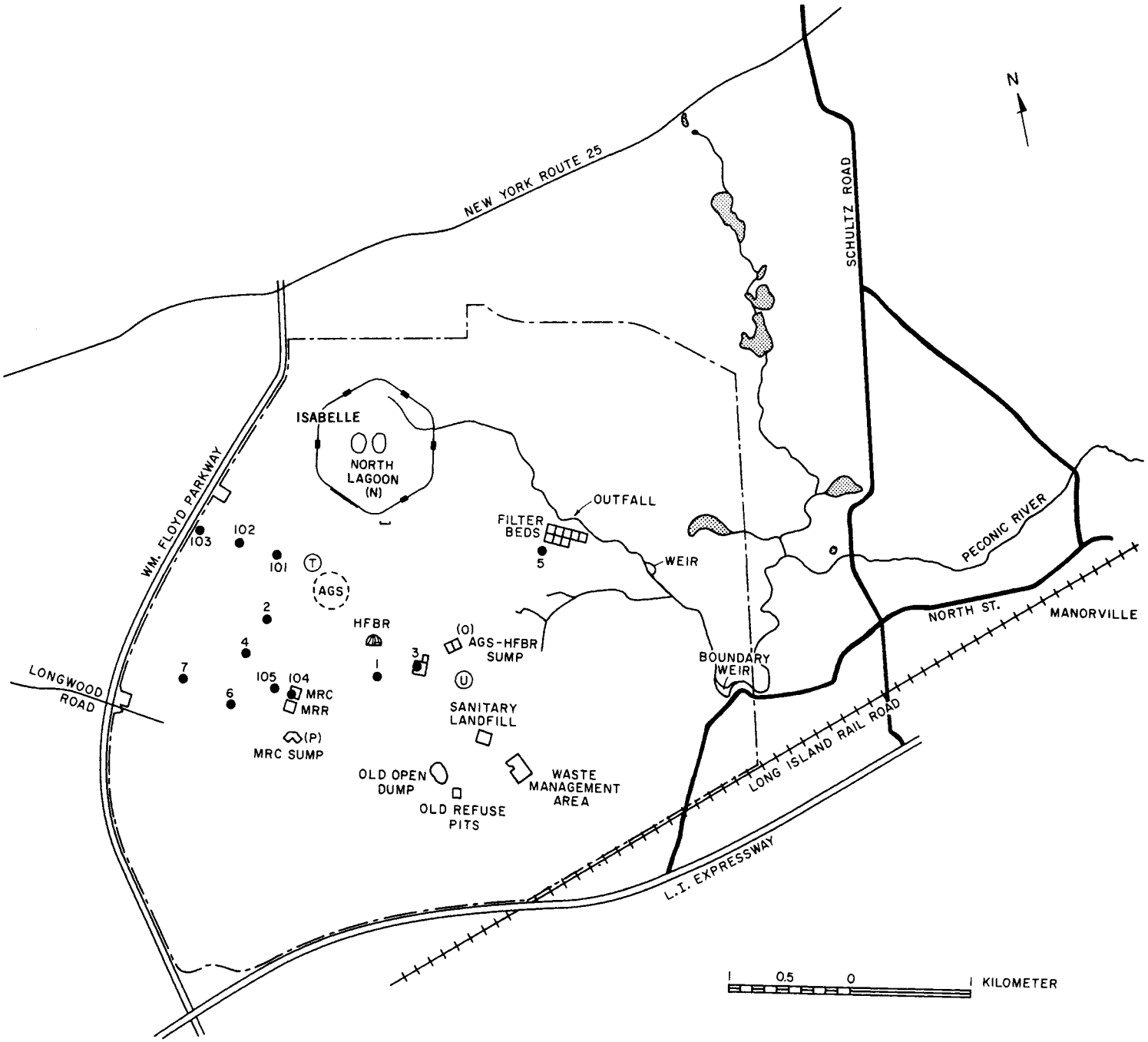


FIGURE 7: ON-SITE: POTABLE AND SUPPLY WELLS AND RECHARGE SUMPS

TABLE 14

1981 BNL Environmental Monitoring
Concentration of ^{90}Sr and ^{137}Cs in Water, Sediment, Vegetation
and Fish Obtained from the Peconic River at the
Site Perimeter as Observed During 1974-1981

	Water		Sediment		Vegetation		Fish	
	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs
Year	(pCi/ℓ)		(pCi/Kg-wet) [a]		(pCi/Kg-wet) [a]		Flesh (pCi/Kg-wet)	Flesh [a]
1974	1.23	1.13	-	306	-	220	-	112-326
1975	1.74	4.46	-	525	-	1010	-	397
1976	1.37	1.86	-	440	-	257	-	700
1977	1.09	1.60	-	1656	-	1128	25-30	772-3400
1978	1.11	0.79	-	920	-	990	27-34	536-1192
1979	0.58	0.87	19	188	86	585	40-60	1036-1113
1980	0.64	0.67	67	214	76	727	54-72	626-1094
1981	0.42	0.81	45	130	63	292	35-42	542- 927

[a] Original results given in dry weight; the results shown are corrected to wet weight to facilitate estimation of concentration factors.

3.3.5 Surveillance Wells:

3.3.5.1 Potable Water and Process Supply Wells:

The Laboratory's potable water wells and cooling water supply wells are screened at a depth of about 30 m, about 15 m below the water table, in the Long Island surface layer of glacial outwash, sand and gravel. As shown in Figure 7, most of these wells are located west to northwest of the Laboratory's principal facilities which is 'upstream' of the local groundwater flow pattern. About 31.2 MLD was pumped from them in 1981.

Quarterly grab samples were obtained from these wells. These were analyzed for radioactivity and water quality. The results are shown in Table 15. All gross alpha concentrations were <1 pCi/liter (<1 x 10^{-9} μCi $m\ell^{-1}$) except well #2 which was about 1.5 pCi/liter. Such variations are considered normal. All tritium concentrations were <1.0 nCi/liter (<10^{-6} μCi/ml). There are some fluctuations in the gross beta concentrations among these wells but are not significant.

Concurrently, potable water is routinely tested for water quality as part of the Suffolk County Water Authority Compliance Assurance Program.

3.3.5.2 Groundwater Surveillance:

Samples of groundwater were obtained from a network of shallow surveillance wells which have been installed in the vicinity of several locations where a potential has existed for the percolation of radioactivity from the surface downward into the saturated zone of groundwater. These include areas adjacent to the on-site recharge basins, the sand filter beds, the Peconic River, the solid waste management area, the former open dump, the sanitary landfill and the decontamination facility sump. The locations of most of these groundwater surveillance wells are shown in Figure 8, except for those installed at the landfill and solid waste management area which are shown in Figure 9.

For convenience in assessing the data, the wells have been divided into several groups. Yearly average gross alpha, gross beta, and tritium activity concentrations of the wells adjacent to the sand filter beds, and downstream on the Peconic River are summarized in Table 16. During the year, at least one sample each from locations adjacent to the recharge basins and from locations immediately adjacent to the sand filter beds and the Peconic River were analyzed for ^{90}Sr and ^{137}Cs. Corresponding information for wells downstream (with reference to groundwater movement) of the solid waste management area, the landfill and former dump zones, and the decontamination facility sump (about 1 km east of the HFBR) are also summarized in Table 16. It is to be noted that only those wells that have been showing consistently higher levels than those concentrations observed over the years have been included in the table. Since the aquifer underlying Nassau and Suffolk Counties has been designated as a "Sole Source" (25), the EPA Drinking Water Standards are applicable (17). The data, therefore, are evaluated in terms of the EPA standard and not the DOE RCGs.

TABLE 15

1981 BNL Environmental Monitoring
Potable and Cooling Water Wells - Average Radionuclide, Metals and Water Quality Data

Well #	Number of Samples	Gross α	Gross β	^3H	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Dissolved Oxygen	Chlorides	Nitrate-Nitrogen	Total Phosphoros	Dissolved Solids	Conductivity (μmhos/cm)	Temperature °C	pH
		10^{-9} μCi/ml			ppm														
1	4	b			0.002	0.0007	0.002	0.174	0.078	0.003	0.029	8.5	9.9	0.78	0.03	82	124	12	5.7
2	4	1.46	9.01	180	0.002	0.0007	0.002	0.143	3.033	0.032	0.011	7.6	21.4	1.42	0.02	98	156	14	5.4
3	2	0.38	10.31	190	0.002	0.0006	0.002	0.019	0.076	0.003	0.006	7.1	15.7	0.71	0.04	84	148	16	6.2
4	4	0.41	2.57	320	0.002	0.0007	0.002	0.021	2.845	0.003	0.004	7.8	11.9	0.23	0.03	67	97	11	6.0
5	2	0.26	1.21	180	0.002	0.0007	0.002	0.010	0.246	0.003	0.082	10.6	6.8	0.11	0.04	41	42	10	5.9
6	4	0.79	1.85	240	0.002	0.0007	0.002	0.008	4.125	0.006	0.009	7.7	25.5	0.53	0.03	98	158	12	5.9
7	4	0.30	1.54	180	0.002	0.0007	0.002	0.013	2.055	0.003	0.009	7.8	16.1	0.18	0.03	60	101	12	5.5
10	2	b			0.002	0.0006	0.002	0.005	0.018	0.003	0.008	6.8	16.2	0.22	0.02	88	151	13	6.0
102	4	0.34	3.25	180	0.002	0.0007	0.002	0.006	3.463	0.003	0.015	6.9	13.5	0.21	0.45	79	102	12	6.0
104	2	0.48	1.75	180	0.002	0.0007	0.002	0.006	0.845	0.006	0.038	6.9	23.0	0.98	0.03	123	185	16	6.5
105	2	0.31	2.53	180	0.002	0.0006	0.002	0.066	1.820	0.003	0.005	5.9	19.8	1.32	0.01	112	234	15	6.1
Tap Water[c]	4	b											20.3	0.38	0.02	94	b		
EPA Drinking Water Standard {17}		15	50[d]	20000	0.05	0.01	0.05	-	-	0.05	-								
New York State Drinking Water Standard {25}												>4	250	-	-	500	-	<30	6.5-8.5

[a] Locations of Potable and Cooling Water Wells given in Figure 7.

[b] Not Done.

[c] Tap Water from Building 535.

[d] Compliance Level.

Applicable Standards - Table 20

Coliform - Total or Fecal was not present in all the samples.

TABLE 16

1981 BNL Environmental Monitoring
Groundwater Surveillance Wells - Average Radionuclide, Metals and Water Quality Data

Well #	# of Samples Analyzed	Gross α	Gross β	^{90}Sr	^{40}K	^{3}H	Ag	Cd	Cr	Cu	Fe	Pb	Zn	Dissolved Oxygen	Chlorides	Nitrate Nitrogen	Total Phosphates	Dissolved Solids	Conductivity (μmhos/cm)	Temperature °C	pH
		10^{-6} μCi/ℓ					ppm														
Sand Filter Beds and Peconic River Area																					
XA	2	0.31	9.91	0.99	27	4600	0.002	0.0008	0.002	0.013	0.211	0.011	0.318	6.6	28.1	4.75	0.02	166	165	19	5.4
XC	1	0.59	5.88	1.34	3	200	0.002	0.0008	0.002	0.002	0.730	0.003	0.189	6.2	7.0	0.01	0.01	d	55	10	5.5
XE	1	0.18	4.63	1.28	c	2040	0.002	0.0006	0.002	0.014	0.490	0.003	0.570	7.1	12.7	1.54	0.01	138	125	14	5.2
XG	2	0.24	5.98	2.04	23	3640	0.002	0.0009	0.002	0.004	7.270	0.003	0.182	8.5	23.3	0.26	0.02	91	106	10	6.0
XI	1	0.25	3.18	1.19	71	170	0.002	0.0006	0.002	0.003	0.032	0.003	0.144	7.4	5.0	0.02	d	44	48	9	4.8
XK	3	0.57	11.06	5.13 [2.28, 7.97]	15	6100	0.002	0.0007	0.002	0.009	1.697	0.003	0.275	5.5	29.9	0.24	0.02	178	171	11	6.2
XL	2	1.12	18.27	2.56	30	6090	0.002	0.0006	0.002	0.004	2.460	0.003	0.211	4.5	29.6	0.15	0.02	163	175	15	5.8
XM	3	0.65	19.79	0.78	29	6320	0.002	0.0007	0.002	0.054	0.779	0.005	0.843	9.6	29.6	2.91	0.29	145	202	13	6.1
XQ	1	d	d	1.36	c	d	0.002	0.0006	0.002	0.003	0.410	0.003	0.130	d	8.7	0.11	0.01	124	71	12	4.9
XR[a]	1	0.59	6.12	1.32	46	190	0.002	0.0140	0.002	0.005	0.035	0.003	1.000	9.5	2.5	0.00	0.01	30	31	9	5.3
XS[b]	2	1.25	7.13	1.90	28	190	0.002	0.0007	0.002	0.009	4.620	0.004	0.125	8.8	13.3	0.18	0.01	92	112	11	5.4
XT[b]	2	d	d	<0.09	c	c	0.002	0.0006	0.002	0.006	2.100	0.003	0.080	3.7	4.3	0.28	0.05	d	111	12	5.9
XW[b]	2	d	d	<0.09	c	c	0.002	0.0006	0.002	0.003	0.480	0.003	0.170	2.5	45.3	0.01	0.01	d	232	12	5.0
XX	4	0.62	8.11	2.87	9	2040	0.002	0.0020	0.002	0.020	13.600	0.003	0.168	5.8	14.8	0.22	0.01	82	107	11	5.8
XY	1	0.27	3.11	1.33	c	2250	0.002	0.0008	0.002	0.004	0.290	0.003	0.291	4.5	15.0	0.13	0.01	80	75	11	5.7
X4	2	d	d	1.10	c	c	0.002	0.0006	0.002	0.003	0.570	0.003	0.030	0.6	d	0.11	0.02	d	170	12	6.0
Waste Management Area																					
WB	2	0.30	17.47	3.86	32	5690	0.002	0.0006	0.002	0.006	0.154	0.005	0.254	7.4	5.8	2.32	0.01	71	103	15	5.3
WC	1	0.90	29.98	5.91	3	8410	0.002	0.0006	0.002	0.007	0.515	0.003	0.340	5.9	6.0	3.09	0.01	63	105	13	4.9
WD	2	0.38	29.51	5.51 [2.62, 8.40]	52	23100	0.002	0.0008	0.002	0.006	0.101	0.017	0.792	9.3	8.3	3.58	0.02	123	140	11	5.3
WE	1	0.28	10.47	2.96	3	1340	0.002	0.0006	0.002	0.005	0.117	0.003	0.610	9.1	3.6	0.29	0.05	54	60	13	5.7
WK	2	0.35	82.05	27.27 [27.0, 31.53]	41	64200	0.002	0.0006	0.002	0.005	0.098	0.006	0.313	8.6	4.5	2.38	0.02	74	85	11	5.5
WL	2	0.32	42.43	14.30	12	4680	0.002	0.0006	0.002	0.004	0.173	3.003	0.314	9.3	6.0	1.93	0.01	53	88	11	5.5
WM	1	0.19	11.14	1.14	9	940	0.002	0.0006	0.084	0.003	0.213	0.003	0.146	7.6	3.5	0.80	0.04	76	140	12	5.6
W1	2	0.27	21.41	8.08	53	27900	0.002	0.0006	0.002	0.005	0.194	0.003	0.621	8.9	3.3	1.07	0.01	47	73	11	5.4
W2	1	0.24	29.70	7.35	c	650	0.002	0.0006	0.002	0.005	0.310	0.033	0.900	9.5	18.4	4.18	0.01	160	245	12	6.1
W5	2	0.20	2.03	0.29 [0.46, 0.12]	c	170	0.002	0.0006	0.002	0.004	0.018	0.003	0.631	8.6	3.3	0.10	0.01	42	45	10	5.6
W8	2	0.27	3.23	0.36	c	170	0.002	0.0006	0.002	0.006	0.288	0.045	1.420	8.5	4.3	0.14	0.02	100	43	11	5.6
Landfill Area																					
WR	4	1.31	21.90	-	9	220	0.002	0.0007	0.002	0.003	64.90	0.003	0.112	6.7	57.5	0.66	0.04	300	530	14	6.5
WS	4	3.43	45.40	2.43	11	11080	0.002	0.0007	0.002	0.004	50.35	0.003	0.174	4.1	17.1	0.22	0.06	274	660	13	6.6
WT	3	0.98	2.33	<0.09	3	170	0.002	0.0008	0.002	0.002	1.11	0.003	0.490	1.9	16.0	0.26	0.01	76	100	11	5.5
W9	4	4.36	77.26	7.06	11	27130	0.002	0.0015	0.003	0.004	37.47	0.019	0.046	4.6	3.4	0.43	0.06	532	760	13	6.6
1K	4	3.65	41.81	1.59 [2.65, 0.52]	16	4170	0.002	0.0007	0.002	0.010	58.10	0.039	0.103	4.6	41.6	0.30	0.05	337	680	14	6.5
2C	3	4.92	120.50	14.29	6	28730	0.002	0.0007	0.002	0.004	24.57	0.006	0.015	2.2	2.0	0.38	0.02	661	1127	13	6.5
2D	1	7.28	85.57	2.13	6	220	0.002	0.0008	0.002	0.005	56.00	0.003	0.004	1.6	30.0	0.57	0.01	173	650	13	6.4
650 Sump Area																					
1A	2	0.20	23.90	9.20 [16.3, 2.1]	73	180	0.002	0.0006	0.002	0.004	0.248	0.007	0.571	8.2	5.5	0.36	0.01	56	61	12	6.1
1E	2	0.21	19.42	8.69 [7.62, 9.77]	31	180	0.002	0.0006	0.002	0.007	0.234	0.007	0.890	8.2	8.7	0.93	0.01	92	77	13	6.1
1H	2	0.06	160.20	81.5 [81, 82]	76	180	0.002	0.0006	0.002	0.007	0.130	0.014	0.960	6.8	18.3	4.58	0.01	98	120	14	6.0
Former Dump Area																					
WP	1	0.08	1.51	0.16	c	180	0.002	0.0008	0.002	0.009	0.740	0.003	0.011	8.0	6.4	0.07	0.01	47	98	12	4.9
WQ	1	0.31	3.22	<0.09	c	180	0.002	0.0040	0.002	0.011	10.50	0.003	0.070	10.8	5.9	0.03	0.01	59	65	12	5.9
EPA Drinking Water Standard {17}		15	50	8	-	20000	0.05	0.01	0.05	-	-	0.05	-	-	-	10	-	-	-	-	-

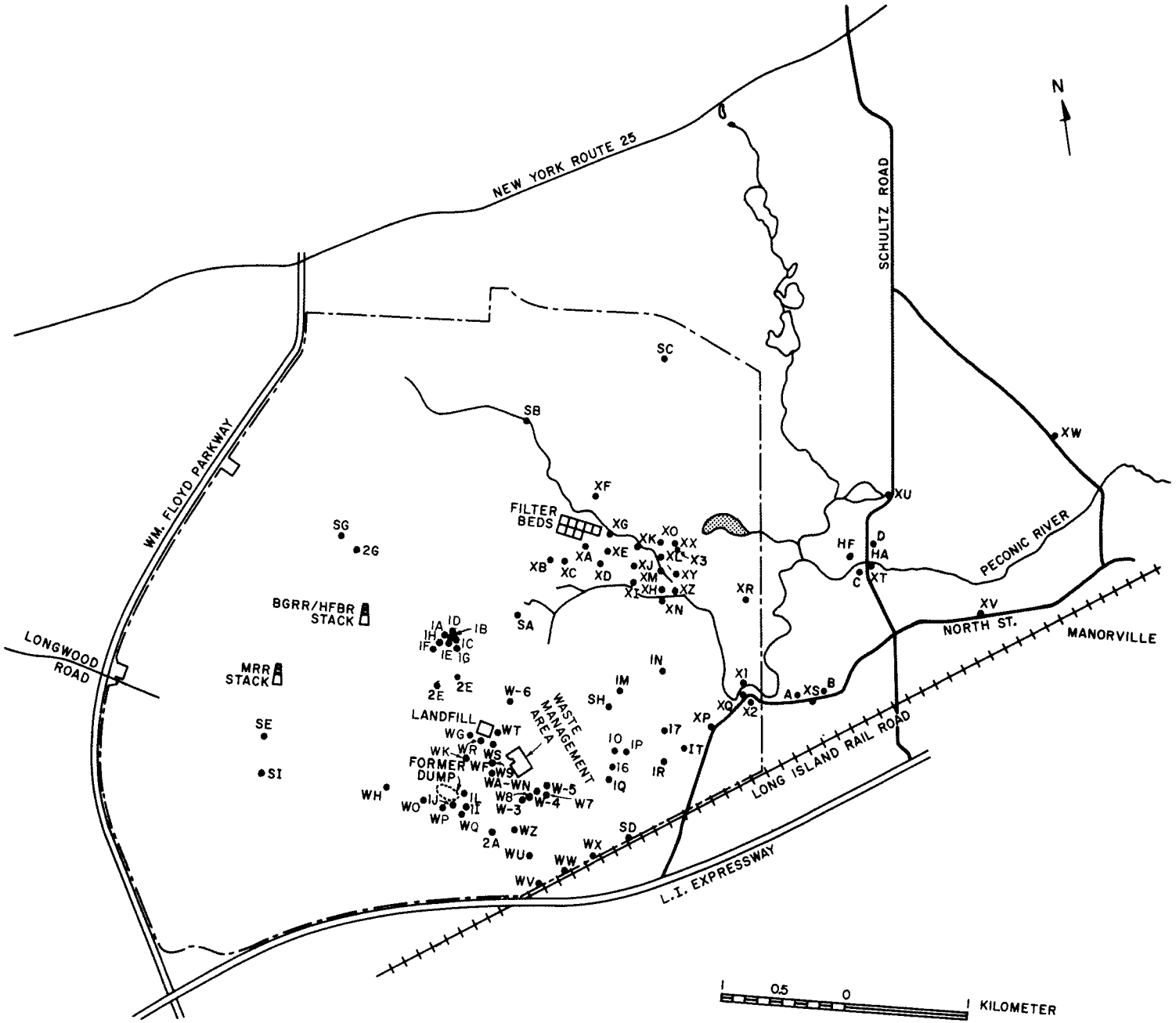
(a) Control

(b) Off-Site

(c) Below the MDL of the System used.

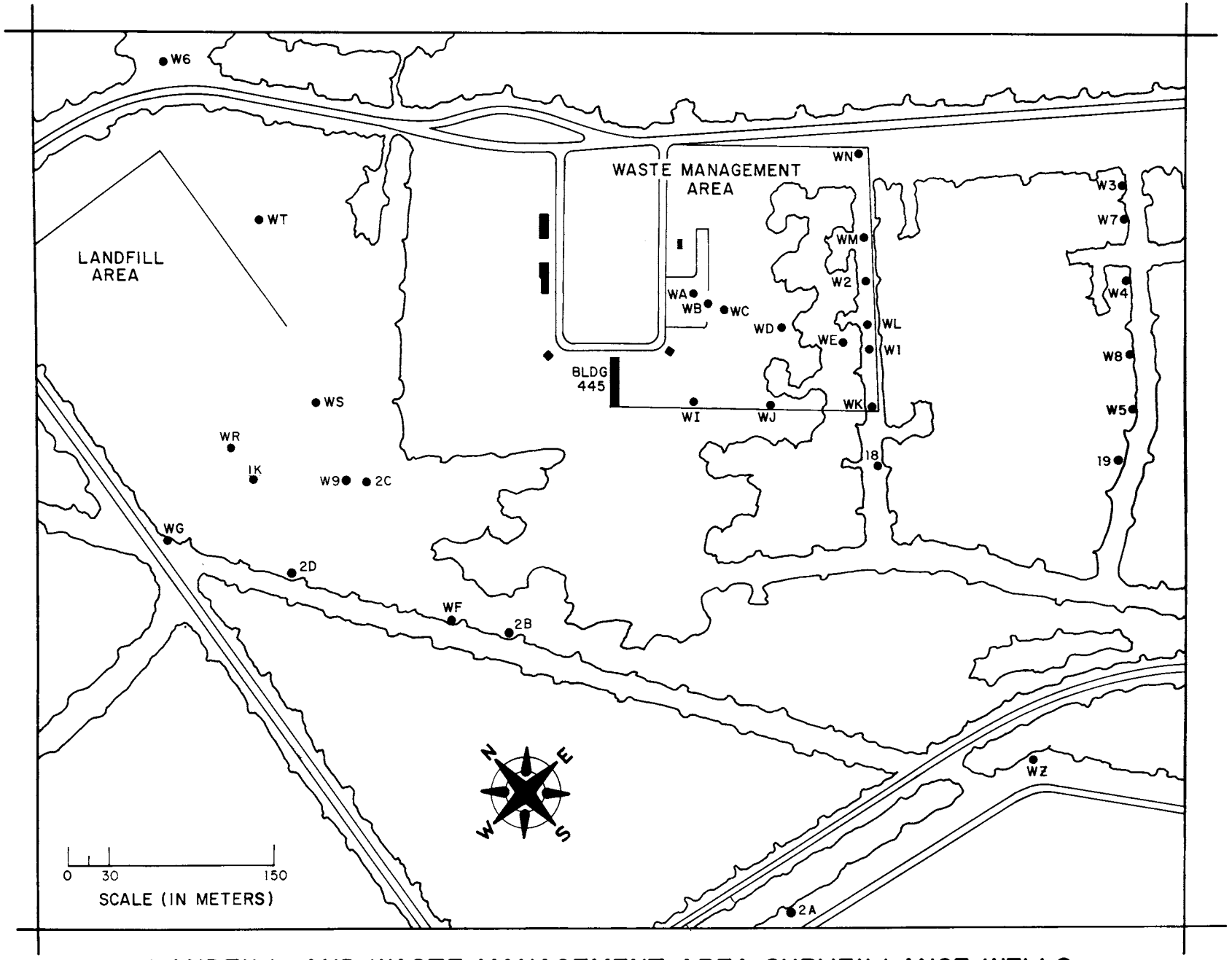
(d) Not done.

Applicable Standards - Table 20.



LOCATION OF GROUNDWATER SURVEILLANCE WELLS

FIGURE 8



LANDFILL AND WASTE MANAGEMENT AREA SURVEILLANCE WELLS

FIGURE 9

In analyzing the data over the past decade, it is apparent that the spread of radioactivity in the groundwater from Laboratory operations has remained within a few hundred meters of the identifiable foci. Above background concentrations of gross beta emitters, tritium and ^{90}Sr have been found on-site adjacent to the sand filter beds and the Peconic River. In 1981, they were up to 10-40% for gross beta, 10-30% for ^{3}H, and 10-100% for ^{90}Sr of the Drinking Water Standards (17). In 1981, the concentrations of radioactivity were generally less than those noted in 1974 and 1975 (11), and had further decreased when compared to those found during 1976-1979 (11), indicating that radionuclides have not moved significantly since 1976, but have undergone dilution and decay. Wells XF, XH, XJ, and XZ, which had shown a significant increase in gross beta activity in 1978 over previous years (11) were reduced by more than 80% in 1981 and as such were not reported in the table. It must be noted, however, that the increases in gross β activity in 1978 were not accompanied by similar increases in ^{90}Sr activity. Of the wells located adjacent to the Peconic River and the sand filter beds, in the direction of the groundwater flow, only well XL which had shown a slight increase in gross beta activity over the 1979 values was reduced by about 40% in 1981. Adjacent to the Peconic River at the site boundary, all gross beta and tritium concentrations were less than or equal to 4% of the Drinking Water Standards. In 1978, samples of well water collected from homes (stations A, B, C and D - Figure 8) and well XS, all of which are downstream with reference to groundwater movement of the Laboratory and the Peconic River had indicated ^{90}Sr concentrations approaching one to two $pCi\ell^{-1}$. In 1981, all were <1 $pCi\ell^{-1}$, and less than the EPA drinking water limit of 8 $pCi\ell^{-1}$ (17). An extensive study of wells throughout Suffolk County in 1979 indicated that, on the average, shallow wells contained greater concentrations of ^{90}Sr than deeper wells, regardless of their proximity to the Laboratory. This is attributed to fallout from past nuclear tests during the 1950's and early 1960's.

In several wells adjacent to the solid waste management area, the concentrations of gross beta activity, tritium and ^{90}Sr activity concentrations for 1981 showed a continuing decline. Concentrations of ^{90}Sr, exceeding Drinking Water Standards, were found in wells WD, WK, WL, W1, and W2. They reflect the inadvertent injection in 1960 of approximately one Ci of aged fission products into groundwater at well WA. The concentrations of ^{90}Sr in these wells, however, has decreased when compared to 1979 and 1980. Such fluctuations appear to represent the complex interaction of groundwater movement rates and distribution coefficients of the elements in the soil matrix. The concentrations of gross beta activity and tritium also decreased when compared to those of recent years in several wells immediately adjacent to the Landfill. This is attributed both to the discontinuation of the disposal of radioactive waste on the Landfill in 1976, as well as the movement and dilution of radioactivity in the groundwater adjacent to the Landfill. Wells 2C and 2D showed an increase in the concentration of gross beta activity and tritium. Similar fluctuations have been seen for several years in the past. At the decontamination facility (Bldg. 650) sump, the concentrations of gross beta activity and ^{90}Sr in well 1A, and the concentrations of gross beta activity and tritium in other wells have continued to decrease, except in wells 1E and 1H. The ^{90}Sr concentrations in wells 1A, 1H and 1E exceeded the EPA limits for groundwater of 8 $pCi\ell^{-1}$ and 1H exceeded the gross beta compliance limit of 50 $pCi\ell^{-1}$. However, calculations done using groundwater travel times of 16.2 cm d^{-1} (7), the ^{90}Sr distribution coefficient

for ion exchange, and distance to the nearest potential user of drinking water, have predicted travel times of about 60 years for ^{90}Sr to reach the site boundary. In addition to physical decay (covering a period of two ^{90}Sr half-lives), considerable dilution by infiltration of precipitation would also be anticipated. Based on the existing levels in the above wells, the Laboratory does not foresee that this inadvertent discharge of ^{90}Sr into well WA and at the 650 sump area could cause the concentrations of ^{90}Sr in any well off-site to exceed EPA drinking water limits.

In most of the groundwater surveillance wells, several water quality and purity parameters were also evaluated. The data for those wells adjacent to on-site sumps, the sand filter beds, and downstream of the Peconic River on- and off-site, are also shown in Table 16. Similarly, the data for wells adjacent to the solid waste management area, the landfill, the dump area and the 650 sump, are also shown. Analyses for selected metals were also conducted for a few wells immediately adjacent to the sand filter beds, to the Peconic River, to the waste management, landfill and former dump areas. These data are also shown in Table 16.

In general, the data were comparable to that observed during 1974-1980. With the exception of pH, all analyzed water quality parameters were within New York State Water Quality Standards [19,25]. The somewhat lower pH levels appear to reflect natural ambient levels, since higher pH levels were present in the input to and output from the sewage treatment plant (see Table 10). Concentrations of Fe and Zn in excess of water quality standards were found in some of the wells immediately adjacent to the sand filter beds, the Peconic River, landfill areas, and the 650 sump area. Since these results may be an artifact produced by corrosion from well casings, a program to compare effects of well casings was instituted in 1980 and continued in 1981. The results indicate that the effect is measurable. Tracing the levels of these elements in the groundwater system by means of the Laboratory surveillance wells downstream in the direction of the ground water flow, has indicated significant decreases as one proceeds away from the Laboratory, such as 60-70% along the Peconic River, 25-30% in the waste management area and 50-60% in the 650 sump area. Much lower levels of Zn were found in the Laboratory supply wells. Several contain Fe in excess of the standard, but most of this is removed prior to use. It is to be noted that high Fe concentration is indigenous to groundwater in this region. Zn and Fe are considered as nuisance elements and not as a health hazard.

The general rate and direction of groundwater movement is 16.2 cm d^{-1} and predominantly in the southeast direction [7]. It appears, therefore, that many years of travel time would be required for groundwater containing radioactivity or other pollutants to reach an off-site well, during which considerable dilution by infiltration of precipitation would be anticipated. The data from all the surveillance wells are reviewed at frequent intervals in order to evaluate the monitoring program and appropriate action is taken, such as, rescheduling the sampling of wells and follow up analysis if required.

3.4 Unusual Occurrences:

3.4.1 Oil Spills:

During 1981, three oil spills occurred. All the spills occurred on asphalted pavements and as such the potential of groundwater contamination did not exist. Contamination of the storm drains was prevented by rapid clean-up operations. Reporting and clean-up procedures were instituted immediately. The absorbents used to clean up the spills were disposed of according to New York State Department of Environmental Conservation (NYSDEC) approved procedures.

3.4.2 Nuclear Tests:

No atmospheric nuclear tests were conducted during 1981. Fallout radionuclide concentrations were detected in milk, grass and soil samples collected from dairy farms in the vicinity of the site and are reported in Table 17. As was the case in recent years, the average concentration of ^{90}Sr in the milk from the farm in Center Moriches, was higher than the more remote 'control' location in Southhampton. This effect is attributed to differences in the availability and uptake of radioactivity from fallout from past atmospheric weapon test and to differences in soil conditions and/or farming practices (26).

4.0 OFF-SITE DOSE ESTIMATES

Levels of radiation and concentrations of radioactivity, in air and water, above ambient background, with resulting doses to people, are attributable to the following three Laboratory sources:

1. airborne radioactive effluents, primarily tritium,

2. radioactive liquid effluents,

3. skyshine from the Alternating Gradient Synchrotron (AGS).

These are discussed below, and the collective dose-equivalent rate due to Laboratory operations during 1981 is calculated.

4.1 Annual Average Collective Dose-Equivalent Rate Due to Airborne Effluents:

Table 4 indicates that 355 Ci of tritium in the form of vapor was released from various Laboratory facilities during 1981, making it the largest source of dose equivalent to persons off-site relative to other Laboratory released radionuclides. For equivalent concentrations, the dose equivalent from tritium in the gaseous form is insignificant by comparison.

Except for the anamolous results discussed in Section 3.2.3, the concentrations in the air at the site boundary were generally close to the MDL. The data given in Table 8 indicates an average yearly concentration (including background) of 6.2 pCi m^{-3} at the site boundary ($\sim$2500 meters from the HFBR stack). Continuous exposure at the Radiation Concentration Guide (2 x 10^5 pCi m^{-3}) would result in a per capita annual average dose-equivalent rate of 500

TABLE 17

1981 BNL Environmental Monitoring
Radionuclide Concentrations in Milk, Grass and Soil Samples
Collected from Dairy Farms in the Vicinty of the Site

Location of Farm	^{90}Sr			^{40}K			^{137}Cs		
	Milk	Grass	Soil	Milk	Grass	Soil	Milk	Grass	Soil
	pCi/ℓ ←	pCi/Kg (dry) →		pCi/ℓ ←	pCi/Kg (dry) →		pCi/ℓ ←	pCi/Kg (dry) →	
Center Moriches	15.96	1420	5080	1700	7500	5600	a	a	200
Southampton	5.68	1110	21210	2000	6800	5300	2.3	52	780
Average[b]	-	1090	12350	-	8400	5500	-	13	410

[a] Below the MDL of the System used.

[b] Represent average values for the three farms located in Mt. Sinai, Yaphank and Ridge.

mrem a^{-1}. Thus, the per capita annual average dose-equivalent rate at this distance attributable to Laboratory air effluent tritium vapor was (6.2x500)/ ($2x10^5$) or 0.0156 mrem, 0.003% of the Radiation Protection Standard (16). Since the individual external background per capita dose-equivalent rate (Table 2) in this area was about 65.3 mrem a^{-1}, the tritium dose-equivalent rate contribution amounts to an increase at the site boundary of about 0.02%. This is within the temporal and spatial variations of the background itself.

As was previously stated, the dose equivalents due to ^{41}Ar, ^{15}O and ^{127}Xe were not measurable and as such were not included in the final estimates.

Table 18 gives the doses to the general public due to BNL tritium releases. It indicates that beyond the site boundary, the dose rates due to tritium in air effluents from the Laboratory were very small, compared with background and variations in background. The parameters X/Q, tabulated in the second column, are the ratio of ground level concentration to rate of emission, i.e., concentration per unit emission rate, and are functions of meteorological conditions and distance from the source. They are long-term average values which have been calculated for the 97.5 m release height of the HFBR stack over the entire year and for all the sixteen tabulated directions. While their use may produce an underestimate at close-in distance for releases from shorter stacks, overall, it results in some overestimation of population exposure, since X/Q values in the direction of major population centers to the west of the Laboratory are lower than the 360° averages. Values of the annual average per capita dose-equivalent rate due to tritium are derived by multiplying the actual measured values for the 1.6 to 3.2 km interval (0.0156 mrem a^{-1}) by the appropriate ratios of X/Q. The collective dose equivalent (total population dose) due to the Laboratory tritium effluent was 1.35 rem a^{-1}, and that due to natural background (65.3 mrem a^{-1} - Table 2) was estimated to be 313,273 rem a^{-1}.

4.2 Doses Due to Liquid Effluents:

Since the Peconic River is not utilized as a drinking water supply, nor for irrigation, its waters do not constitute a direct pathway for the ingestion of radioactivity. However, the upper portions of the river are utilized for occasional recreational fishing.

Based on discussions with the New York State Department of Environmental Conservation regarding fish productivity in the Peconic River, it was assumed that 100 fishermen caught 500 kg of fish in 1981 and that their families consumed all of these fish. Furthermore, it was assumed that the distribution of adults and children (based on an average family of 2 adults and 2 children) was 367 adults and children above 12 years of age and 64 children below 12 years [4,5]. Thus, the estimated annual average fish consumption by the adult group was 1.36 kg/yr and for children below 12 years was 0.46 kg/yr (as compared to the USNRC Regulatory Guide [24] value of 21 kg/yr and 6.9 kg/yr respectively). Based on these values for consumption of fish and other relevant assumptions recommended in the NRC Regulatory Guide 1.109 [24], and the maximum observed concentration of ^{90}Sr and ^{137}Cs in fish (as shown in Table 14), the estimated maximum individual dose-equivalent commitment is tabulated below (pp. 49).

TABLE 18

1981 Environmental Monitoring
Collective Annual Average Dose-Equivalent Rate Due to Airborne Effluents
From BNL Facilities in Comparison with Background

Distance from HFBR Stack (km)	Average[a] $\frac{X}{Q}$ ($sec\ m^{-3}$)	Population[b]	HTO[c] Per Capita Dose-Equivalent Rate (mrem $Person^{-1}\ a^{-1}$)	HTO[c] Collective Average Dose-Equivalent Rate (rem a^{-1})	Background Collective Average Dose-Equivalent Rate (rem a^{-1})
1.6- 3.2	2.4×10^{-7}	1,624	0.0156	0.03	106
3.2- 4.8	1.0×10^{-7}	5,556	0.0065	0.04	363
4.8- 6.4	6.0×10^{-8}	11.795	0.0039	0.05	770
6.4- 8.0	3.9×10^{-8}	20,571	0.0025	0.05	1,343
8.0-16.1	1.7×10^{-8}	232,437	0.0011	0.26	15,178
16.1-24.2	8.0×10^{-9}	246,770	0.0005	0.13	16,114
24.2-32.2	5.5×10^{-9}	157,116	0.0004	0.06	10,260
32.2-48.4	3.8×10^{-9}	998,851	0.0002	0.25	65,225
48.4-64.5	2.7×10^{-9}	1,379,404	0.0002	0.24	90,075
64.5-80.6	2.1×10^{-9}	1,743,318	0.0001	0.24	113,839
1.6-80.6	-	4,797,442	-	1.35	313,273

[a] Average X/Q from Final Environmental Impact Statement, Brookhaven National Laboratory, ERDA -15.40 (1977).

[b] Population data estimated from information supplied by Long Island Regional Planning Board [4,5].

[c] Tritiated water vapor.

Maximum Individual Dose-Equivalent Commitment for One Year of Ingestion of Fish Obtained from the Peconic River (mrem a^{-1})

	^{90}Sr		^{137}Cs	
	Children below 12 yrs	Adults	Children below 12 yrs	Adults
Total Body	0.08	0.01	0.02	0.06
Bone	0.33	0.07	0.14	0.09

For the above population, the collective dose-equivalent rate to total body from this indirect pathway can be estimated to be 0.026 rem a^{-1} (0.07 mrem x 367 persons) for adults and 0.006 rem a^{-1} (0.10 mrem x 64 persons) for infants. Similarly, the collective dose-equivalent rate to bone from this indirect pathway, for the above population, can be estimated to be 0.059 rem a^{-1} (0.16 mrem x 367 persons) for adults and 0.03 rem a^{-1} (0.47 mrem x 64 persons) for infants.

Although not directly related to the Laboratory liquid effluents during 1981, a ^{90}Sr concentration of 1.90 pCi l^{-1} was found in off-site surveillance well (XS), about 0.35 km east of the Laboratory site boundary along the Peconic River. This level corresponds to 24% of the EPA Drinking Water Standard [17]. Assuming that during 1981 all of the 27 people [4,5] living in the vicinity of this well obtained their drinking water from shallow water supply wells containing ^{90}Sr at the same concentration, then their collective dose equivalent does not exceed 0.03 rem (since 8 pCi/l corresponds to 4 mrem). Their collective dose-equivalent commitment (total dose) from natural background (including internal radiation) would have been about 1.80 rem (person-rem) during 1981.

4.3 Doses Due to Alternating Gradient Synchrotron:

The AGS is located 1180 meters from the nearest site boundary. Although the machine is heavily shielded, some neutrons do penetrate the shield or escape from areas where experiments are in progress. Some of these neutrons reach off-site areas directly, or more likely by scattering from the air which is called skyshine.

With the advent of the ISABELLE project in 1978, the Safety and Environmental Protection Division has instituted an extensive program to evaluate different neutron detectors in the field and also to determine appropriate sampling locations. These studies should provide data on neutron dose distribution around the AGS and ISABELLE (when operational) facilities and thus provide a basis for more accurate estimates of off-site doses. Preliminary results, derived by using a neutron monitor (Ludlum 55) at P2 (Figure 2), indicated an annual dose equivalent of 6.1 mrem resulting from neutrons other than those generated by the AGS facility. This dose-equivalent rate has been observed to be similar to levels at other accelerator facilities [27]. Since this study is still in the preliminary stage, it was decided to estimate the dose-equivalent rate from skyshine at the site boundary by comparing the total proton flux for 1977 to that for 1981 and using this ratio to derive the 1981 dose-equivalent

rates from the 1977 values (Table 31-1977, BNL-50813). As such, Table 19 gives the derived dose-equivalent rate (mrem a^{-1}) and the collective dose-equivalent rates for each population segment and for each distance from the source.

Since the dose-equivalent rate from this source decreases rapidly with distance, only population segments with radii of 1.6 to 3.2 and 3.2 to 4.8 kms were considered. The off-site derived collective dose-equivalent rate was 0.02 rem a^{-1} (person-rem a^{-1}) and applicable contributions were found only in the NW and NNW sectors.

4.4 Collective Average Dose-Equivalent Rate (Total Population Dose):

The collective dose-equivalent rate (total population dose) beyond the site boundary, within a radius of 80 km, attributed to Laboratory operations during 1981 is the sum of the values due to the three components discussed above, as shown below:

Pathway	Collective Dose-Equivalent rem a^{-1} (person-rem a^{-1})
External	
AGS Skyshine	0.02
Airborne	
Tritium	1.35
Liquid	
Fish Consumption	0.03*
Well Water	0.02
Total	1.42

* Infants 0.006, Adults 0.026

The collective dose-equivalent (total annual dose) due to external radiation from natural background, to the population within a 80 km radius of the Laboratory, amounts to about 313,273 rem a^{-1}, to which about 96,438 rem a^{-1} (person-rem a^{-1}), should be added for internal radioactivity from natural sources.

TABLE 19

1981 BNL Environmental Monitoring
Off-Site Collective Annual Average Dose-Equivalent Rate Due to
External Radiation Exposure from AGS Operations

Sector	Km	Population[a]	AGS		
			Distance (Km)	Dose-Equivalent Rate ($mrem\ a^{-1}$)	Person-rem
SSW	1.6-3.2	0	-	-	-
	3.2-4.8	267	4.4	1.00×10^{-4}	2.67×10^{-5}
SW	1.6-3.2	0	-	-	-
	3.2-4.8	100	4.3	1.25×10^{-4}	1.25×10^{-5}
WSW	1.6-3.2	0	-	-	-
	3.2-4.8	348	4.0	2.31×10^{-4}	8.04×10^{-5}
W	1.6-3.2	282	2.5	7.52×10^{-3}	2.12×10^{-3}
	3.2-4.8	881	3.9	3.25×10^{-4}	2.86×10^{-4}
WNW	1.6-3.2	272	2.1	1.75×10^{-2}	4.76×10^{-3}
	3.2-4.8	611	3.6	4.87×10^{-4}	2.98×10^{-4}
NW	1.6-3.2	208	2.0	2.94×10^{-2}	6.12×10^{-3}
	3.2-4.8	247	3.5	7.52×10^{-4}	1.86×10^{-4}
NNW	1.6-3.2	170	2.0	2.94×10^{-2}	5.00×10^{-3}
	3.2-4.8	80	3.5	7.52×10^{-4}	6.02×10^{-5}
N	1.6-3.2	220	2.3	1.13×10^{-2}	2.49×10^{-3}
	3.2-4.8	0	-	-	-
NNE	1.6-3.2	223	2.5	7.52×10^{-3}	1.68×10^{-3}
	3.2-4.8	391	3.6	4.87×10^{-4}	1.90×10^{-4}
NE	1.6-3.2	134	2.9	3.07×10^{-3}	4.11×10^{-4}
	3.2-4.8	201	3.5	4.87×10^{-4}	9.79×10^{-5}
ENE	1.6-3.2	0	-	-	-
	3.2-4.8	0	-	-	-
E	1.6-3.2	0	-	-	-
	3.2-4.8	356	4.0	2.25×10^{-4}	8.01×10^{-5}
ESE	1.6-3.2	0	-	-	-
	3.2-4.8	341	4.4	1.13×10^{-4}	3.85×10^{-5}
SE	1.6-3.2	0	-	-	-
	3.2-4.8	68	3.1	6.13×10^{-5}	4.17×10^{-6}
SSE	1.6-3.2	64	3.5	8.74×10^{-4}	5.59×10^{-5}
	3.2-4.8	722	4.5	7.52×10^{-5}	5.43×10^{-5}
S	1.6-3.2	51	3.3	1.13×10^{-3}	5.76×10^{-5}
	3.2-4.8	943	4.5	7.52×10^{-5}	7.09×10^{-5}
Total					2.42×10^{-2}

[a] Population data estimated from information supplied by Long Island Regional Planning Board {4,5}. See Table 1 for estimated population distribution for 1981.

TABLE 20

Maximum Permissible Levels of Contaminants in Air and Water
With Their Decection Limits

Contaminant		DOE 5484.1[16] Radiation Protection Guide (RPG) Air	DOE 5484.1[16] Radiation Protection Guide (RPG) Water	EPA-Drinking Water [17] and NYS Drinking Water Standard [25](a) Water	NYS Standard [19,28] Air	NYS Standard [19,28] Water	Minimum Detectable Concentration (b) Air	Minimum Detectable Concentration (b) Water
Radioactive								
Gross α μCi/ml		1×10^{-13}	6×10^{-7}	1.5×10^{-8}	1×10^{-13}	6×10^{-7}	3×10^{-16}	3×10^{-10}
Gross β μCi/ml		1×10^{-10}	1×10^{-7}	5×10^{-8} *	1×10^{-10}	1×10^{-7}	1×10^{-15}	1×10^{-9}
^{3}H μCi/ml		2×10^{-7}	3×10^{-3}	2×10^{-5}	2×10^{-7}	3×10^{-3}	2×10^{-12}(c)	2×10^{-7}(d)
^{90}Sr μCi/ml	S	3×10^{-11}	3×10^{-7}	8×10^{-9}	3×10^{-11}	3×10^{-7}	Not Determined	1×10^{-10}
	I	2×10^{-10}	4×10^{-5}					
Gamma Emitters							Intrinsic Detector Air #1 & 2	Air #3
^{7}Be μCi/ml	S	2×10^{-7}	2×10^{-3}	1.5×10^{-5}	2×10^{-7}	2×10^{-3}	1.1×10^{-14}	1.1×10^{-14}
	I	4×10^{-8}	2×10^{-3}					
^{54}Mn μCi/ml	S	1×10^{-8}	1×10^{-4}	7×10^{-7}	1×10^{-8}	1×10^{-4}	2.0×10^{-15}	1.3×10^{-15}
	I	1×10^{-9}	1×10^{-4}					
^{60}Co μCi/ml	S	1×10^{-8}	5×10^{-5}	4×10^{-7}	1×10^{-8}	5×10^{-5}	2.6×10^{-15}	2.0×10^{-15}
	I	3×10^{-10}	3×10^{-5}					
^{95}Zr μCi/ml	S	4×10^{-9}	6×10^{-5}	4×10^{-7}	4×10^{-9}	6×10^{-5}	3.5×10^{-15}	2.3×10^{-15}
	I	1×10^{-9}	6×10^{-5}					
^{95}Nb μCi/ml	S	2×10^{-8}	1×10^{-4}	7×10^{-7}	2×10^{-8}	1×10^{-4}	1.9×10^{-15}	1.4×10^{-15}
	I	3×10^{-9}	1×10^{-4}					
^{125}Sb μCi/ml	S	2×10^{-8}	1×10^{-4}	1.5×10^{-7}	2×10^{-8}	1×10^{-4}	4.2×10^{-15}	3.4×10^{-15}
	I	9×10^{-10}	1×10^{-4}					
^{131}I μCi/ml	S	1×10^{-10}	3×10^{-7}	1.5×10^{-8}	1×10^{-10}	3×10^{-7}	1.5×10^{-15}	1.4×10^{-15}
	I	1×10^{-8}	6×10^{-5}					
^{134}Cs μCi/ml	S	1×10^{-9}	9×10^{-6}	6.5×10^{-8}	1×10^{-9}	9×10^{-6}	2.2×10^{-15}	1.5×10^{-15}
	I	4×10^{-10}	4×10^{-5}					
^{137}Cs μCi/ml	S	2×10^{-9}	2×10^{-5}	1.5×10^{-7}	2×10^{-9}	2×10^{-5}	2.1×10^{-15}	1.3×10^{-15}
	I	5×10^{-10}	4×10^{-5}					
^{144}Ce μCi/ml	S	3×10^{-10}	1×10^{-5}	7×10^{-8}	3×10^{-10}	1×10^{-5}	8.7×10^{-15}	7.3×10^{-15}
	I	2×10^{-10}	1×10^{-5}					

Contaminant		Intrinsic Detector Well Water #1 & 2	Well Water #3	Surface Water #1 & 2	Surface Water #3
Gamma Emitters					
^{7}Be μCi/ml	S	1.3×10^{-9}	1.2×10^{-9}	2.5×10^{-9}	2.3×10^{-9}
	I				
^{54}Mn μCi/ml	S	2.3×10^{-10}	1.3×10^{-10}	4.3×10^{-10}	2.5×10^{-10}
	I				
^{60}Co μCi/ml	S	2.7×10^{-10}	2.0×10^{-10}	5.1×10^{-10}	3.8×10^{-10}
	I				
^{95}Zr μCi/ml	S	4.0×10^{-10}	2.5×10^{-10}	7.5×10^{-10}	4.6×10^{-10}
	I				
^{95}Nb μCi/ml	S	2.1×10^{-10}	1.5×10^{-10}	3.9×10^{-10}	2.8×10^{-10}
	I				
^{125}Sb μCi/ml	S	5.4×10^{-10}	4.1×10^{-10}	1.0×10^{-9}	7.6×10^{-10}
	I				
^{131}I μCi/ml	S	1.9×10^{-10}	1.6×10^{-10}	3.6×10^{-10}	3.0×10^{-10}
	I				
^{134}Cs μCi/ml	S	2.5×10^{-10}	1.6×10^{-10}	4.6×10^{-10}	3.0×10^{-10}
	I				
^{137}Cs μCi/ml	S	2.4×10^{-10}	1.5×10^{-10}	4.5×10^{-10}	2.8×10^{-10}
	I				
^{144}Ce μCi/ml	S	1.2×10^{-9}	9.3×10^{-10}	2.3×10^{-9}	1.8×10^{-9}
	I				

Contaminant		EPA-Drinking Water [17] and NYS Drinking Water Standard [25](a) Water	NYS Standard [19,28] Water	Minimum Detectable Concentration (b) Water
Non-Radioactive				
Temperature °C		T_{max} <30 $\Delta T \leq \pm 2.8$		
pH		6.5-8.5		
Dissolved Oxygen	ppm	>4.0		0.2
Chlorides	ppm	250	500	0.1
Nitrogen-Nitrate	ppm	10	20	0.05
Dissolved Solids	ppm	500	1000	20.00
Coliform	#/100 ml	Zero	4	Zero
Silver (Ag)	ppm	0.05	0.1	0.001
Cadmium (Cd)	ppm	0.01	0.2	0.004
Chromium (Cr)	ppm	0.05	0.1	0.001
Copper (Cu)	ppm	-	1.2	0.001
Iron (Fe)	ppm	-	0.6	0.02
Mercury (Hg)	ppm	0.002	-	0.00007
Lead (Pb)	ppm	0.05	0.1	0.005
Zinc (Zn)	ppm	-	0.3	0.002

(a) Aquifer underlying Long Island declared as "Sole Source" - Applicable Standard is EPA National Interim Primary Drinking Water Regulations [17]

(b) See Appendix B

(c) As tritiated vapor

(d) For ^{3}H: 2×10^{-7} to 1×10^{-6} μCi/ml α Volume

S - Soluble

I - Insoluble

* - EPA Annual Compliance Level

APPENDIX A

QUALITY CONTROL

Radioactive Measurements:

a. Alpha (α), Beta (β) and Gamma (γ):

Certified radioactive standards from the National Bureau of Standards, U.S. Department of Commerce, are used to standardize radiation measurement instruments. These standards are certified to be within 5% of stated values. In some cases, certified standards, traceable to the National Bureau of Standards, were also obtained from Amersham/Searle. Daily checks of instrument performances are made with these standards. Backgrounds are collected daily for gross alpha and beta counting systems. Backgrounds are collected weekly for gamma and alpha spectroscopy equipment. For tritium measurements a number of standards and blanks are included with each run of a liquid scintillator counter which has a programmed automatic sample changer.

The Analytical Laboratory of BNL's Safety and Environmental Protection Division was a participant in an inter-laboratory comparisons of samples of different matrices such as water, air filters, soil, vegetation and bone, which contain a number of frequently encountered radionuclides. These samples are distributed, on a semiannual basis, by the Department of Energy through its Environmental Measurements Laboratory. The radionuclides assayed for were ^{3}H, ^{90}Sr, plutonium isotopes, and several gamma emitting nuclides. Results were usually within the ±20% acceptance criteria. Outliers do occasionally occur. These results are examined and corrective action is implemented immediately.

b. TLD Dosimeters:

The Dosimetry Services Group of the Safety and Environmental Protection Division participated in the Fifth International Intercomparison of Environmental Dosimeters conducted at Idaho Falls, Idaho from mid August to mid November 1980. There were a total of 120 participants in this test.

The estimated field exposure, as measured by the BNL environmental monitoring TLD dosimeters, agreed with 11% of the value measured by a continuously operated recording pressurized ion chamber corrected for energy response. In the Laboratory exposure test, the BNL dosimeter agreed within 9% for the calculated "beginning" ($\sim$75 mR exposure) and agreed within 22% for the "end" ($\sim$88 mR exposure).

Although this test was concluded in mid November of 1980, the dosimeters were not returned for evaluation until December 1, 1980. There may have been an unknown transit exposure to account for the higher than normal deviation from the mean values recorded by the Brookhaven dosimeters.

Measurements of Water Quality Parameters:

Procedures for nonradioactive contaminants are those presented in Standard Methods for the Examination of Water and Wastewater (14th edition, 1975). All standards are prepared from standard reference grade and analytical grade reagents in accordance with the requirements of standard methods. Standards are run with each set of samples analyzed and at least one duplicate and blank is run with each set.

APPENDIX B

Minimum Detectable Concentration for Gamma (γ) Emitting Radionuclides in Air and Water Samples

Medium	Air		Well Water		Surface Water	
Detector-Intrinsic	#1 & #2	#3	#1 & #2	#3	#1 & #2	#3
Units	← μCi/mℓ →		← μCi/mℓ →		← μCi/mℓ →	
Nuclide						
^{7}Be	1.1×10^{-14}	1.1×10^{-14}	1.3×10^{-9}	1.2×10^{-9}	2.5×10^{-9}	2.3×10^{-9}
^{54}Mn	2.0×10^{-15}	1.3×10^{-15}	2.3×10^{-10}	1.3×10^{-10}	4.3×10^{-10}	2.5×10^{-10}
^{60}Co	2.6×10^{-15}	2.0×10^{-15}	2.7×10^{-10}	2.0×10^{-10}	5.1×10^{-10}	3.8×10^{-10}
^{95}Zr	3.5×10^{-15}	2.3×10^{-15}	4.0×10^{-10}	2.5×10^{-10}	7.5×10^{-10}	4.6×10^{-10}
^{95}Nb	1.9×10^{-15}	1.4×10^{-15}	2.1×10^{-10}	1.5×10^{-10}	$3.9x^{10-10}$	2.8×10^{-1}
^{125}Sb	4.2×10^{-15}	3.4×10^{-15}	5.4×10^{-10}	4.1×10^{-10}	1.0×10^{-9}	7.6×10^{-10}
^{131}I	1.5×10^{-15}	1.4×10^{-15}	1.9×10^{-10}	1.6×10^{-10}	3.6×10^{-10}	3.0×10^{-10}
^{134}Cs	2.2×10^{-15}	1.5×10^{-15}	2.5×10^{-10}	1.6×10^{-10}	4.6×10^{-10}	3.0×10^{-1}
^{137}Cs	2.1×10^{-15}	1.3×10^{-15}	2.4×10^{-10}	1.5×10^{-10}	4.5×10^{-10}	2.8×10^{-1}
^{144}Ce	8.7×10^{-15}	7.3×10^{-15}	1.2×10^{-9}	9.3×10^{-10}	2.3×10^{-9}	1.8×10^{-9}

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