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HEALTH PHYSICS AND SAFETY DIVISION

1974 ENVIRONMENTAL MONITORING REPORT

BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973

April 1975

Compiled by A. P. Hull and J. A. Ash

Contributors

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Operated by Associated Universities, Inc.
Under Contract to the U.S. Energy Research & Development Administration

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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL MONITORING REPORT

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INTRODUCTION

Brookhaven National Laboratory is a multidisciplinary scientific research center situated in the geographical center of Suffolk County on Long Island, about 70 miles east of New York City. Its location with regard to surrounding communities is shown in Figure 1. The principal nearby population centers are located in shoreline communities. Much of the land area within ten miles is mostly either forested or under cultivation. However it is in transition and considerable recent and projected development of surburban housing is located within the environs of the Laboratory.

The Laboratory site is shown in Figure 2. It consists of some 5,265 acres, most of which is wooded, except for a central developed area of about 1,000 acres. The site terrain is gently rolling, with elevations varying between 120 and 40 feet above sea level. The land lies on the western rim of the shallow Peconic River watershed, with the river itself rising in marshy areas in the north and east sections of the site.

In terms of meteorology, Brookhaven can be characterized as a well ventilated site. In common with most of the eastern seaboard, its prevailing winds are from the southwest during the summer of the year, from the northwest during the winter, and about equally from these two directions during the spring and fall. This is reflected in the annual wind distribution, as observed by the BNL Meteorology Group between 1960 - 1973, which is shown in Figure 3.

Studies of the hydrology and geology[1,2,3] of Long Island in the vicinity of Brookhaven indicate that the uppermost Pleistocene deposits, which are locally between 100 - 200 feet 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 48 inches per year. About half is lost to the atmosphere

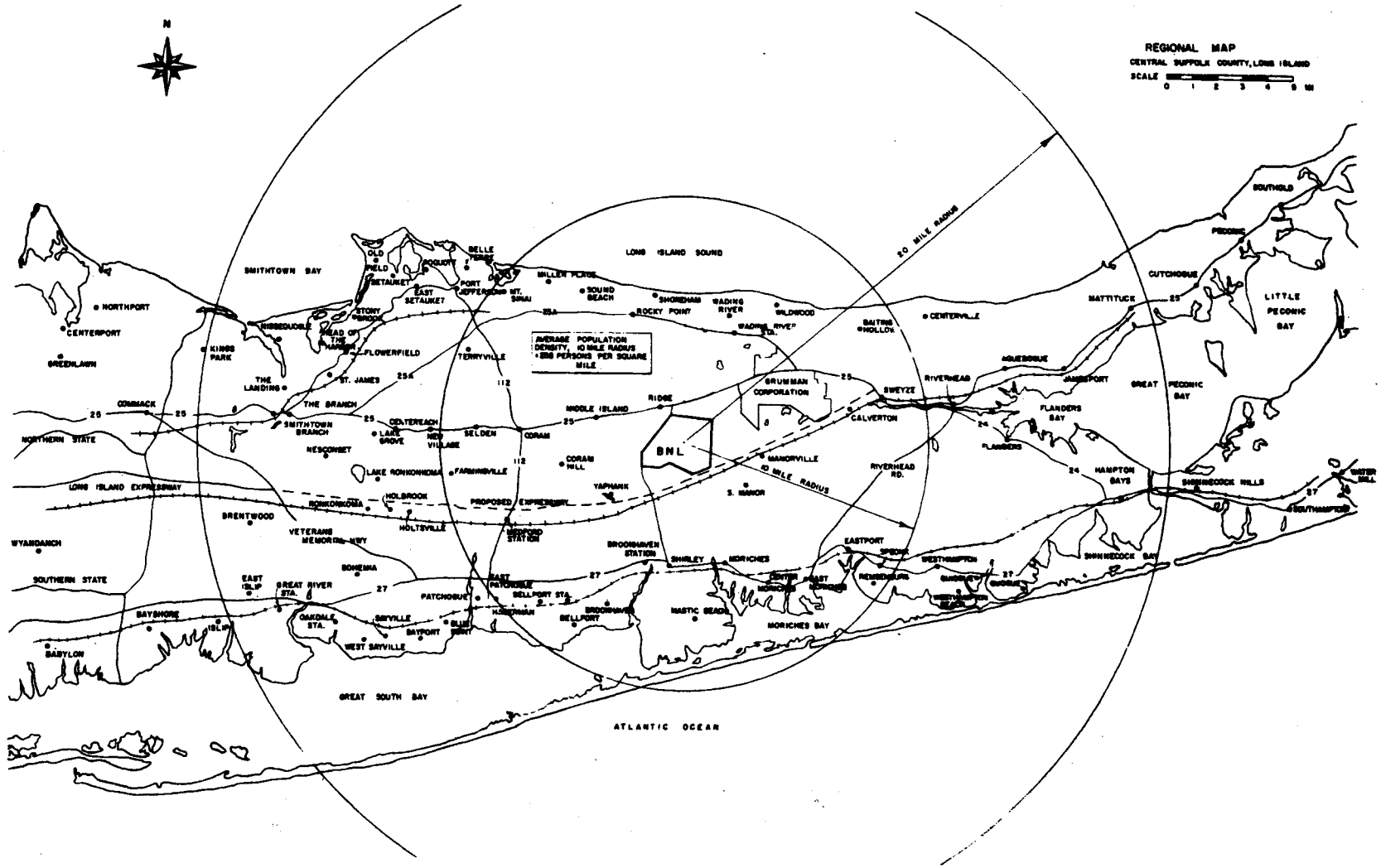
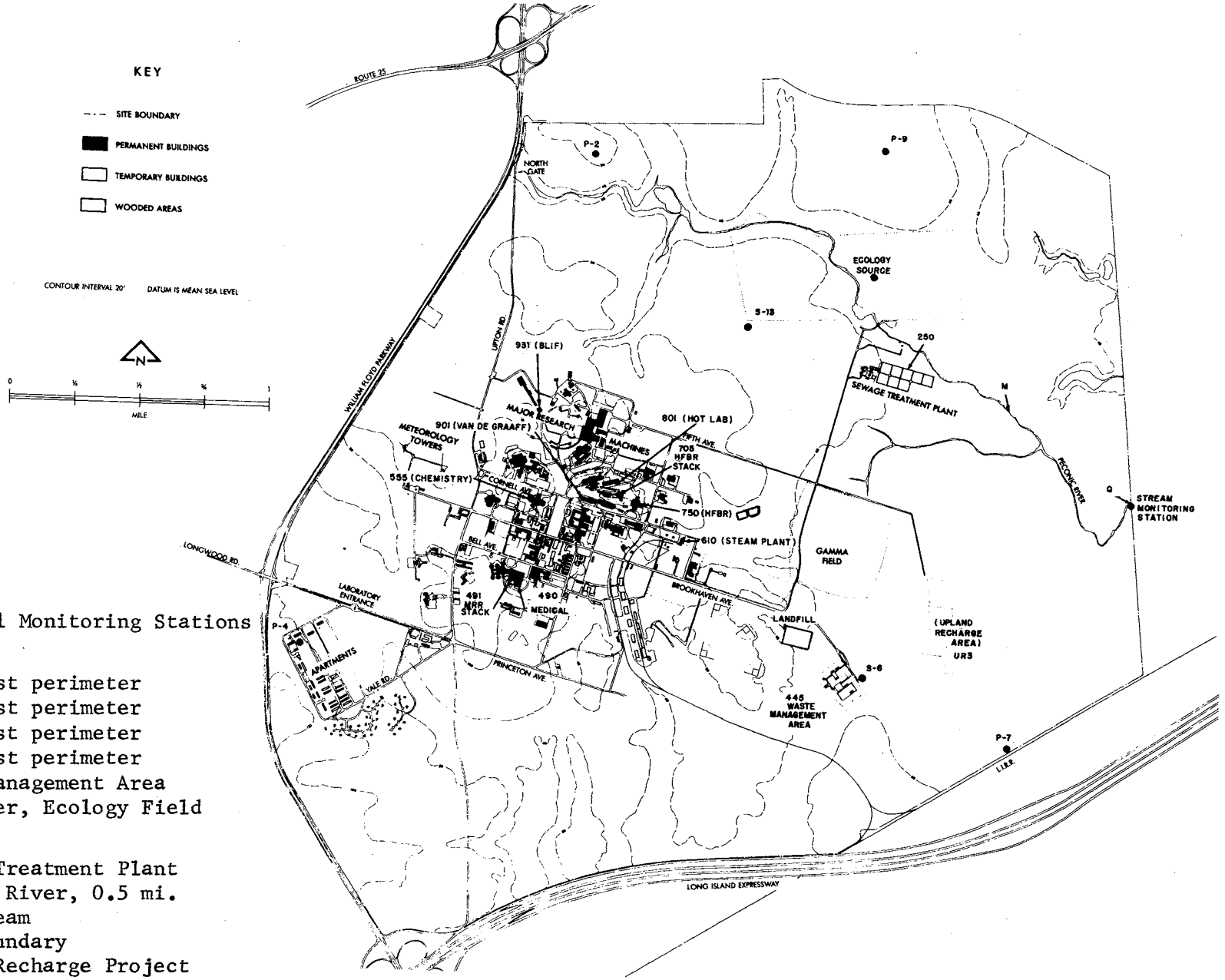


Figure 1 Map of the central area of Suffolk County around Brookhaven National Laboratory.



Environmental Monitoring Stations

Air

P-2 Northwest perimeter
P-4 Southwest perimeter
P-7 Southeast perimeter
P-9 Northeast perimeter
S-6 Waste Management Area
S-13 SW Corner, Ecology Field

Water

250 Sewage Treatment Plant
2M Peconic River, 0.5 mi. downstream
Q Site Boundary
UR-3 Upland Recharge Project

FIGURE 2

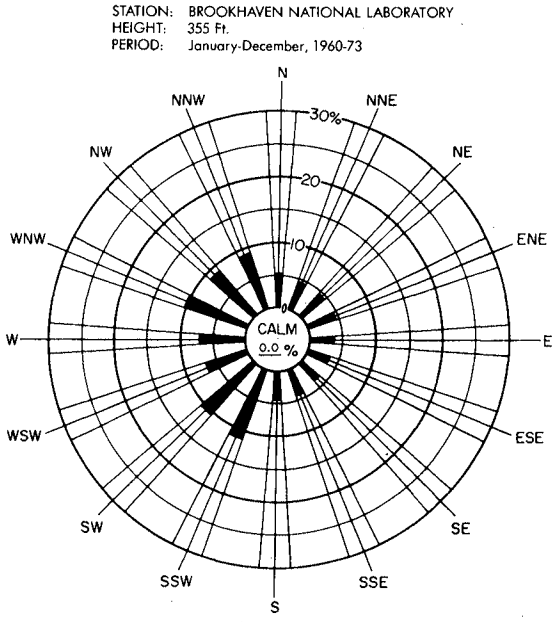

STATION: BROOKHAVEN NATIONAL LABORATORY
HEIGHT: 355 Ft.
PERIOD: January-December, 1960-73
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
30%
20
10
0
CALM
0.0 %

FIGURE 3

through evapotranspiration and half percolates to recharge ground water. As indicated in Figure 4 (from ref. 1), the ground water in Laboratory vicinity moves predominantly in a horizontal direction to the Great South Bay. This is modified toward a more easterly direction in the Peconic River watershed portion of the site. The estimated rate of movement at the ground water surface is about 6 in/day.

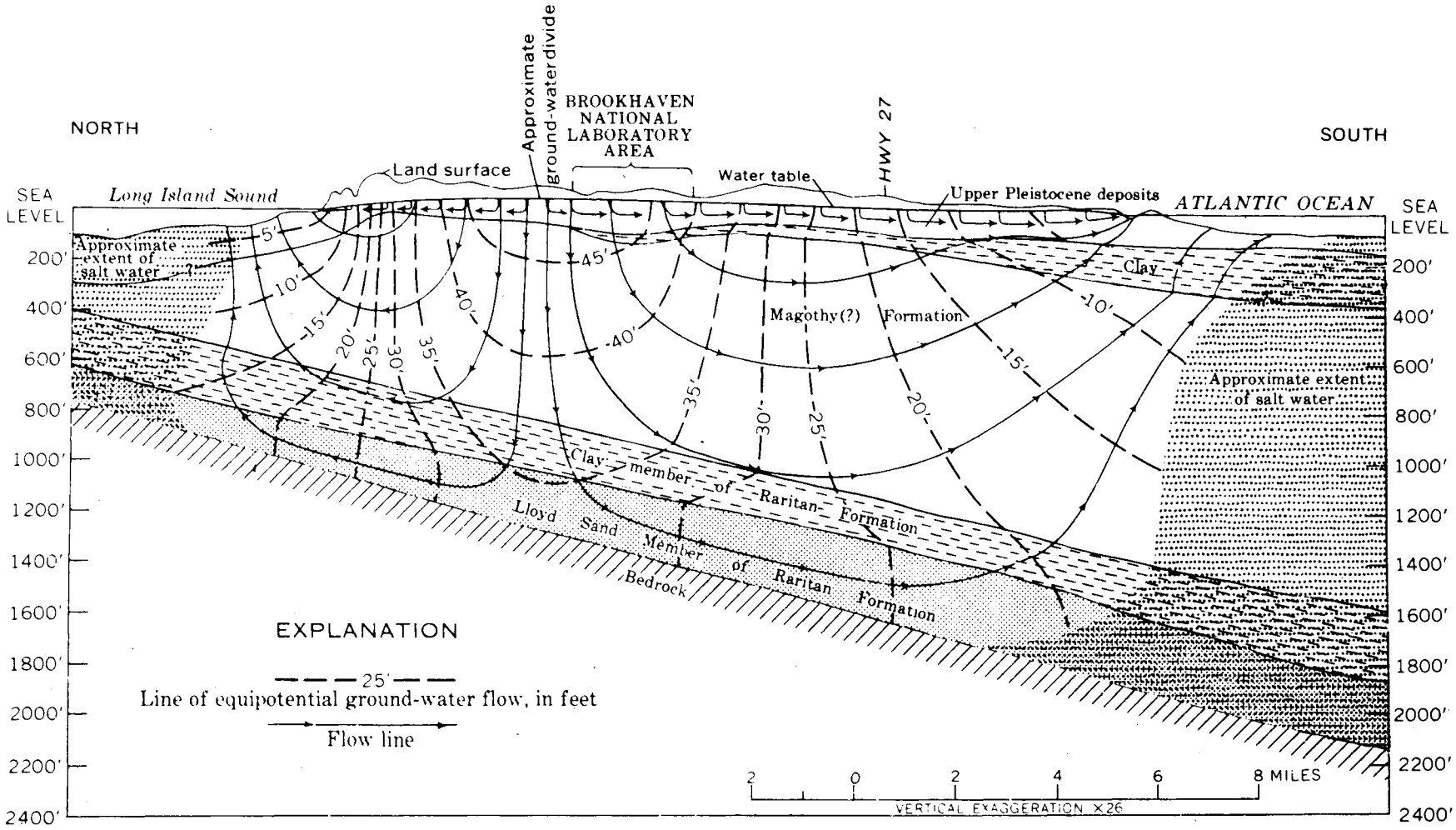
A wide variety of scientific programs are conducted at Brookhaven, including research and development in the following areas:

1) Fundamental structure and properties of matter.
2) The interactions of radiation, particles and atoms with other atoms and molecules.
3) Physical, chemical and biological effects of radiation, and of other energy-related environmental pollutants.
4) Radioisotopes and other nuclear applications.
5) Nuclear and energy-related technology.
6) Energy sources, transmission and utilization, including their environmental effects.

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

1) The High Flux Beam Reactor (HFBR) which is fueled with enriched uranium, heavy water moderated and cooled, and has a routine power level of 40 MW.
2) The Medical Research Reactor (MRR), which is an integral part of the Medical Research Center (MRC). It is enriched uranium fueled, natural water moderated and cooled, and is operated intermittently at power levels up to 3 MW.
3) The Alternating Gradient Synchrotron (AGS), a proton accelerator which operates at energies up to 33 GeV.
4) The 200 MeV Proton Linac, which serves as an injector for the AGS, but also supplies continuous currents of protons for isotope production by spallation reactions, in the Brookhaven Linac Isotopes Production Facility (BLIP).
5) The Tandem Van de Graaff, 60-inch Cyclotron, Research Van de Graaff, Vertical Accelerator and Chemistry Van de Graaff, which are used in medium energy physics investigations, as well as for special isotope production.

Additional programs involving irradiations and/or the use of radionuclides for scientific investigations are carried on at other Laboratory facilities



Schematic ground-water flow lines, central Upton area.

FIGURE 4

including the Medical Research Center, the Biology Department (including one multicurie field irradiation source) , the Chemistry Department, and the Department of Applied Science. The latter includes the Hot Laboratory, where special purpose radioisotopes are developed and processed for on- and off-site use. This facility also contains a Waste Treatment Center, which includes an Evaporator for the decontamination 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 effluents, but additional significant contributions origninate from the Medical Research Center, the Hot Laboratory complex, as well as from decontamination and laundry operations.

The Department of Applied Science, in cooperation with the Town of Brookhaven, conducts the Upland Recharge Project, a study of the use of natural ecosystems to treat sewage and to return clean water to the ground water aquifer. This experiment is conducted in an agricultural and forested area zone in the southeast of the Laboratory site. It utilizes a portion of the flow from the sanitary waste treatment plant, and therefore constitutes a potential route for the release of small amounts of radioactivity to ground water.

SUMMARY

The environmental levels of radioactivity and other environmental pollutants found in the vicinity of Brookhaven National Laboratory during 1974 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 include external radiation levels; radioactive air particulates; tritium and iodine concentrations; the amounts and concentrations of radioactivity in precipitation; the amounts and concentrations of radioactivity in and the 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 quality of ground waters underlying the Laboratory; and concentrations of radioactivity in milk, grass and soil samples obtained in the vicinity of the Laboratory.

The external radiation level for 1974 at the north boundary of the Laboratory attributable to an ecology forest irradiation source was 6.3 mrem, or 1.3% of the applicable radiation protection standard.*

At the boundary of the Laboratory, about 1.0 km northwest of the Alternating Gradient Synchrotron (AGS), the calculated dose due to skyshine (reflected radiation) was about 1.1 mrem/yr or 0.2% of the standard. This is too small to be measurable. Due to their limited range, the external radiations from the AGS and those from the gamma forest source do not produce a measurable additive effect (<0.1 mrem/yr).

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, 3.5 pCi/m^3 (3.5 x 10^{-11} μCi/ml) was 0.01%

* The applicable radiation protection standards and radiation concentration guides for persons in uncontrolled areas are shown with the relevant tabulated data.

of the radiation concentration guide (RCG). The largest average concentration of tritium in precipitation, 365 pCi/l (3.65×10^{-7} μCi/ml) was 0.1% of the RCG for drinking water.

At the Central Steam Plant, one measurement of the stack emission of air particulates indicated that the rate was 0.6 $lb/10^6$ BTU. This was 600% of the emission standard. However, a calculation based on meteorological parameters indicates that at the site boundary, the concentration of air particulates was 0.4 $\mu g/m^3$, or 0.5% of the yearly average ambient air quality standard. The calculated concentrations of SO_2 and NO_x emitted from the plant were both 0.002 ppm, which were 0.7% and 0.4% of their respective ambient air quality standards.

About two-thirds of the liquid effluent released onto the sand filter beds of the BNL sewage treatment plant flowed directly into the Peconic River. Most of the balance is assumed to have percolated into the ground water underlying the beds. The gross beta concentration of the bed output was 97.3 pCi/l (9.73×10^{-8} μCi/ml), or 3.1% of the RCG. However, 61% was ^{24}Na, with a half-life of 15 hours. This is so short with regard to the ~0.5 ft/day velocity of ground water, that it may be discounted, in which case the effective concentration was only 1.2% of the RCG. The tritium concentration was 10.75 nCi/l (1.075×10^{-5} μCi/ml) or 0.4% of the RCG.

Of the combined flow from the sand filter beds and upstream from the Peconic River, about 13% permeated into the ground water underlying the stream bed between the sewage treatment plant outfall and the Laboratory perimeter, mostly during the latter half of the year. As established at a midway stream sampling location, the gross beta concentration was 38.9 pCi/l (3.89×10^{-8} μCi/ml) or 1.3% of the RCG, and the tritium concentration was 9.35 nCi/l (9.35×10^{-6} μCi/ml) or 0.3% of the RCG. At the site boundary, the gross beta concentration was 20.6 pCi/l (2.06×10^{-8} μCi/ml), or 0.7% of the RCG, and the tritium concentration was 4.6 nCi/l (4.6×10^{-6} μCi/ml), or 0.2% of the RCG.

About 3% of the total flow at the Clarifier was utilized by the Upland Recharge Project. Its average gross beta concentration was 20.8 pCi/l (2.08×10^{-8} μCi/ml) or 0.7% of the RCG, and its tritium concentration 10.75 nCi/l (1.075×10^{-5} μCi/ml), or 0.4% of the RCG.

The effluent utilized by part of the Upland Recharge Project contained Cu in a concentration of 0.8 ppm, which is twice the water purity standard, and Zn in a concentration of 1.9 ppm, which is about 3x the water purity standard. However, there is no direct runoff of these effluents and the project is designed to assess the retention of agents commonly present in sewage by various plant systems.

For all the above effluents, the average water quality was within standards, except for the pH of the effluent from the sand filter beds, for which the geometric average was 6.0, as compared with the water quality standard of 6.5 - 8.5. However, the average pH in the upstream flow was 5.8, indicating that local waters are naturally somewhat below the standard.

Bimonthly sampling indicated a rapid decrease in concentrations of radioactivity downstream in the Peconic. At locations 3.0 and 4.4 mi. downstream, the average gross beta concentration as established by bimonthly "grab" sampling was 5.9 pCi/l (5.9×10^{-9} μCi/ml or 0.2% of the RCG, and the tritium concentration 1.2 nCi/l (1.2×10^{-6} μCi/ml) or $<0.1\%$ of the RCG. About 15 mi. downstream, at the river's mouth, where the flow was about 25 times that at the BNL site boundary, the gross beta concentration averaged 9.7 pCi/l (9.7×10^{-9} μCi/ml) and that of tritium 0.5 nCi/l (5×10^{-7} μCi/ml). Thus the total gross beta and tritium activity in the river at that location greatly exceeded that at the BNL site boundary.

Seasonal sampling of Peconic River bottom sediments, stream vegetation and of miscellaneous aquatic fauna was conducted. The data indicated that small concentrations of ^{60}Co and ^{65}Zn, which are unique to BNL effluents, as well

as ^{137}Cs and ^{144}Ce in slight excess of ambient fallout related concentrations, were present in sediments and vegetation. The data from a very few fish obtained from the river at the site boundary and at a location 6.6 mi. downstream, were inconclusive with regard to BNL effluents. The largest concentration of ^{137}Cs, 815 pCi/kg (or 8.15×10^{-7} μCi/gm), was 0.9% of an RCG, calculated on an assumed average ingestion of 50 gms/day.

The concentrations of gross-beta radioactivity in water used for "once-through" cooling, about 5 million gallons per day, which was returned to ground water in on-site recharge basins, was only slightly greater than that of the supply wells and was less than 0.2% of the RCG. Tritium concentrations were less than the minimum detectable, which is 0.02% of the RCG.

Ground water surveillance was conducted in a network of some seventy-five sampling wells installed adjacent to and downstream from identified areas where there is a potential for the percolation to and migration of radioactivity and other agents in ground water. Immediately adjacent to the sand filter beds and to the Peconic River, gross-alpha, gross-beta, tritium and ^{90}Sr concentrations up to a few percent of the RCG's were found. The largest gross-alpha concentration, 6.1 pCi/l (6.1×10^{-9} μCi/ml) was 6% of the RCG for unidentified mixtures containing alpha activity other than ^{226}Ra. The largest average gross-beta concentration, 40.1 pCi/l (4.01×10^{-8} μCi/ml) was accompanied by a ^{90}Sr concentration of 33.5 pCi/l (3.3×10^{-8} μCi/ml), which was 11% of the controlling RCG. The largest average tritium concentration, 8.8 nCi/l (8.8×10^{-6} μCi/ml), was 0.3% of the RCG.

Slightly larger concentrations of gross-alpha and gross-beta and ^{90}Sr radioactivity were found in a sampling well about 1,000' east of the site boundary, than those at the boundary itself. The gross alpha concentration, 1.4 pCi/l (1.4×10^{-9} μCi/ml) was 1.4% of the RCG. However, this is not directly relatable to any known current or recent Laboratory effluents. The gross-beta

concentration was 18.3 pCi/1 (1.83×10^{-8} μCi/ml) and the ^{90}Sr concentration 4.3 pCi/1 (4.3×10^{-9} μCi/ml). The latter was 1.4% of the RCG. At a site boundary sampling well, the average tritium concentration was 4.2 nCi/1 (4.2×10^{-6} μCi/ml) or 0.1% of the RCG.

Except for pH levels slightly less than the water quality standard, which have been discussed previously, other indices of water quality were small relative to the standards. In a limited sampling of a few on-site wells immediately adjacent to the sand filter beds and to the Peconic on-site, Fe and Zn were found up to 10 times and 2 times their respective standards (Fe 0.6 ppm, and Zn 0.6 ppm).

On-site, adjacent to the solid waste management area, the sanitary landfill, the former open dump, the decontamination facility storm sewer sump, and at the Upland Recharge Project area, above ambient background concentrations of gross beta activity, ^{90}Sr and tritium were found in a number of adjacent ground water surveillance wells. Most of the gross beta activity appeared to be related to ^{90}Sr.

At the waste management area, the largest ^{90}Sr concentration 93.3 pCi/1 (9.33×10^{-8} μCi/ml) or 0.5% of the RCG, was found in a well 50 feet south of this pad.

At the landfill, a gross alpha concentration of 10.7 pCi/1 (1.07×10^{-8} μCi/ml) or 11% of the RCG, a gross beta concentration of 8.4 pCi/1 (8.4×10^{-8} μCi/ml) or 0.3% of the RCG, and a tritium concentration of 54.1 nCi/1 (5.41×10^{-5} μCi/ml) were the largest found. They occurred in wells up to 200' south of the working area.

At the former dump, a gross alpha concentration of 15.2 pCi/1 (1.52×10^{-8} μCi/ml) or 15% of the RCG, a gross beta concentration of 52.0 pCi/1 (5.2×10^{-8} μCi/ml) or 0.2% of the RCG were the largest found. They occurred in wells about 500' southeast of the former working area.

At the decontamination facility storm sewer sump, a ^{90}Sr concentration of 56.6 pCi/l (5.66×10^{-8} μCi/ml) or 19% of the RCG was found in a surveillance well about 150' southeast of the sewer outfall into the sump.

At the Upland Recharge Project, the largest gross beta concentration was 10.7 pCi/l (1.07×10^{-8} μCi/ml) or 0.3% of the RCG, and the largest tritium concentration was 4.6 nCi/l (4.6×10^{-6} μCi/ml) or 0.2% of the RCG.

With the exception of the presence of Fe and Zn in wells adjacent to the landfill area and in the Upland Recharge Project, all on-site water quality and purity parameters were within the established standards. Immediately adjacent to the landfill, the concentration of Fe was 127 ppm, or 210 times the standard and Zn 1.32 ppm, or 2.2 times the standard. At the Upland Recharge Project, Fe was found up to a concentration of 10.25 ppm or 17 times the ground water standard.

All of the above on-site levels of radioactivity or other agents above ambient background in ground water appear to be confined to within a few hundred feet of their origin, and 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) were at or near background, and only a few percent of RCG's.

Milk samples were obtained by the New York State Department of Environmental Conservation on a monthly basis from two Suffolk dairy farms, one 10 km southeast, and one 40 km east of the BNL site. Duplicates were obtained quarterly for BNL analysis. The yearly average concentration of ^{90}Sr in the closer farm, 11.2 pCi/l (1.12×10^{-8} μCi/ml) or 6% of the RCG, was 60% greater than at the more distant farm, but does not seem connected with BNL effluents. The data were ~~otherwise~~ within the variations of ^{90}Sr concentrations recent ~~typical of the prevailing levels~~ within New York State ~~in milk samples in the northeast United States~~.

Off-site soil and grass samples also reflected prevailing background, while ^{60}Co and ^{137}Cs in excess of background were found adjacent to two on-site BNL facilities. No pathways leading to off-site doses were apparent.

The total population dose (up to a distance of 50 mi. or 80 km) attributable to BNL sources was calculated to be 7.34 person-rems, as compared to a natural background dose to the same population of about 400,000 person-rems.

MONITORING DATA COLLECTION, ANALYSIS AND EVALUATION

External Exposure Monitoring

External radiation levels at the site boundary, including natural background (as influenced by fallout) and increments attributable to BNL activity, were measured by the use of thermoluminescent dosimeters exposed for monthly periodds at each of the four perimeter air monitoring stations shown on Fig. 2. From their initial employment for environmental monitoring at BNL in 1972, the TLD measurements have been somewhat lower on the average, than monthly levels determined by an ion chamber and dynamic condensor electrometer (DCE) of the type operated at Brookhaven for the past twenty-five years. In May of 1974, comparison measurements were made using the DCE and a high-pressure ion chamber developed by the ERDA Health and Safety Laboratory (HASL). The data indicated that at ambient background levels, the DCE's read about 15% above the pressurized ion chamber. This is attributed to internal contamination, the effect of which is suppressed by the high-pressure (25 atm) of the HASL device. Accordingly, no adjustments have been made in the measured 1974 TLD data for reporting purposes.

The observed monthly average radiation levels are set forth in Table I. There was no addition to the natural background attributable to BNL activities, except at the northeast perimeter. At this location, the Ecology Forest irradiation source, which contained about 6,660 curies of ^{137}Cs*, produced a radiation level of 6.3 ± 3.6 mrem/yr, or 1.3% of the radiation protection standard for a hypothetical individual at this location. This direct TLD measurement is somewhat less than the previously indicated source levels for this location, which were obtained from DCE data obtained 250 meters south of the perimeter. These were adjusted on the basis of previous one-time comparisons using a portable DCE, which had indicated an average ratio of 0.2 between the station and the actual north perimeter radiation levels.

*As of 1/1/74.

AIRBORNE EFFLUENTS AND GROUND-LEVEL AIR PARTICULATES, TRITIUM AND RADIOIODINE MONITORING

Facilities and Effluents

The principal BNL facilities that currently discharge radioactive effluents to the atmosphere are listed in Table II, in which the installed on-line effluent monitoring and sampling devices are also indicated. The location of these facilities on the BNL site is shown in Figure 2. The types and amounts of these effluents released during 1974 are shown in Table III.

Oxygen-15 and Argon-41 are radioactive gases and are environmentally significant as sources of increased external radiation. Calculations indicate that Oxygen-15, which has a half-life of two minutes, is evolved from the Linear Isotopes Production Facility (BLIP) at the rate of 0.6 Ci/min, when it is operated at full beam current of 180 μamps. Thus, at equilibrium, the largest ambient amount at any one time would be 1.75 Ci. Argon-41, which has a half-life of 110 minutes, is evolved from the Medical Reactor Stack at a rate of 1 Ci/hr when it is operated at full power of 3 MW, so that the maximum ambient amount would be 3.8 Ci. These amounts of Oxygen-15 and Argon-41 are too small to produce a detectable increase in radiation levels at the site boundary.

Tritium has a half-life of 12.3 years, and is a very low energy beta emitter. Its principal environmental significance is in the tritium oxide or vapor form, in which it is taken up and utilized by living systems as is water vapor. Of the 1,117 Ci of tritium released from BNL facilities during 1974, 697 Ci (62%) was in the gaseous form, and 420 Ci was released as tritium vapor.

The amounts of conventional pollutants released from the Central Steam Plant are shown in Table IV. They are derived from reported emission factors for comparable plants, supplemented by analysis for S content of the fuel oil utilized by the plant and modified to take into account the average concentration of particulates found in stack sampling of the principal steam boiler unit in a series of

tests conducted during February. The stack emission rate of particulates, 0.6 $lb/10^6$ BTU, was above the emission limit of 0.1 $lb/10^6$ BTU set forth by the New York State Department of Environmental Conservation (Part 227, Stationary Combustion Installations). The Laboratory is currently planning measures to improve the combustion efficiency of this unit, and thereby to reduce it particulate emission rate.

Sampling and Analysis

The Brookhaven Environmental Monitoring air sampling program is conducted so as to distinguish between concentrations of airborne radioactivity attributable to natural sources, to activities remote from the Laboratory, i.e., above ground nuclear weapons tests, and to Laboratory activities. Almost all of that detected during 1974 was attributable to the first two sources.

High volume (500 l/min) positive displacement air pumps (Gast 3040) were operated at a monitoring station east of the Solid Waste Management Area (Fig. 2, S-6), and at the northeast and southwest perimeter stations (P-9 and P-4). The air sampling media consisted of a 3-inch diameter air particulate filter (Gelman Type G) followed by a 3" x 1" bed of petroleum-based charcoal (Columbia Grade LC 12/28 x mesh) for sampling of radiohalogens. Short-term fluctuations in air particulate concentrations may be indicative of the presence of recent weapons tests debris. Accordingly, the Solid Waste Management Area air particulate filter was changed and counted on a daily (during work week) basis. The remaining samples were changed and counted on a two-week basis.

After allowing several days for the decay of short-lived natural radioactivity, gross alpha counts of air particulate samples from the Solid Waste Packaging Area station were made using a 5" diameter Zn-S coated photomultiplier. After a similar delay, gross beta counts were made of air particulate samples from all locations using a 5" beta scintillator. These data are shown in Table V. No consistent differences between sampling locations were apparent and there was no indication of BNL effluent radionuclides in

air particulate samples at any location.

Sampling for tritium vapor was accomplished at the above air sampling stations by drawing a small side stream (~ 100 cm^3/min) through a silica gel cartridges. These were changed on a monthly basis, except during colder months when their absolute capacity of air for unsaturated water vapor decreased so that the sampling cycle was lengthened accordingly. The collected vapor was subsequently removed from the gel by heating. It was then condensed and assayed by beta scintillation counting. The tritium air concentration data obtained during 1974 is indicated in Table VI. The background concentration was inferred from that found in precipitation collected off-site. The largest yearly average net concentration at the site boundary, about 3.46×10^{-11} $\mu Ci/cm^3$, was 0.01% of the applicable radiation concentration guide (RCG).

In addition to the gross beta counts indicated above, shortly after the end of each month, analyses for gamma-emitting nuclides were performed on a monthly composite of all individual air particulate samples.

Additional gamma analyses were also scheduled at six-month and one-year post-collection to facilitate the resolution of short- and long-lived nuclides with photopeaks too close to be resolved by the NaI detection system employed. The charcoal samples were reanalyzed at one month post-collection to determine ^{131}I by decay in its photopeak region during this time. Available data are reported in Table VII. Since recent fission products such as ^{131}I or ^{140}Ba-La were not detectable during most of the year, it was assumed that 32.5 day ^{141}Ce was also absent in evaluating the reported concentrations of ^{144}Ce. The ten-fold increases in ^{95}Zr-Nb and ^{144}Ce concentrations during the first half of 1974 as compared to the same months during 1973, are attributed to the reported atmospheric nuclear weapons test by the Chinese on June 26, 1973[6].

The presence in July of ^{131}I in a concentration barely above the minimum detectable is attributed to the reported Chinese test on June 17, 1974[7]. These data did not disclose any indication of BNL effluent components.

The current BNL environmental monitoring program does not include air sampling for other than radioactive substances. The calculated annual average concentrations at the site boundary of the conventional pollutants released from the Central Steam Plant are indicated in Table IV. All were less than 1% of the EPA Primary Air Quality Standard for these constituents. Approximately 22% of the fuel utilized by the Central Steam Plant during 1974 was waste oil, most of which was used automotive lubricating oil. Analysis on 2/74 by the New York State Department of Environmental Conservation[8] of a BNL mixture of 78% #6 and 22% waste oil, indicated a Pb content of 3,910 mg/l. Its significance was assessed by the BNL Biomedical and Environmental Assessment Group[9] which concluded that the average concentration of Pb in air at the site boundary would be 0.02-0.08 $\mu g/m^3$, as compared with the American Industrial Health Association Community Air Pollution Guidelines of 10 $\mu g/m^3$.

During the Safety evaluation of the Upland Recharge Project, the possibility of the generation of microbial aerosols was considered. The literature[10,11] indicates an initial rapid die-off of such aerosolized bacterial within a few hundred meters of the sources studied (trickling filter sewage plants). In view of this and the remoteness of the Upland Recharge Project from any nearby population, these aerosols do not seem to present a significant off-site airborne hazard. To date, sampling for them has not been conducted, on- or off-site.

About 200 pounds of various pesticides, chiefly organo-phosphates, carbaryl and parathion, were applied[12] on-site at Brookhaven during 1974, principally to protect crops which were grown for biological research purposes. All of these pesticides were considered biodegradable, with persistence times in the

order of a week, and were furthermore applied with a "sticker" additive to minimize their subsequently becoming airborne.

Precipitation

Two pot-type rain collectors, each with a surface area of 0.33 m^2, are situated adjacent to the BNL filter beds. During 1974, two routine collections were made from these, one whenever precipitation was observed during a previous 24-hour (or weekend) period, and the other once a week whether or not precipitation had occurred. Part of each collection was evaporated for gross beta counting, a small fraction composited for monthly tritium analysis, and the balance put through ion exchange column for subsequent quarterly ^{89}Sr-^{90}Sr and gamma analyses. The data for 1974 are reported in Table VIII (with the exception of tritium). There was no detectable indication in the on-site precipitation collection of the washout of BNL released airborne radioactivity.

In addition to the pot-type collectors, small precipitation collectors were established at the perimeter stations (P-2, P-4, P-7, P-9) and at Blue Point, some 20 km southwest of BNL site. As indicated in Table IX, the average tritium concentration in the collectors located at Station P-9 and at the sewage treatment plant (in the predominant downwind direction) were 2 to 3 times those of other collectors. However, the largest concentration (on-site) was less than 0.02% of the RCG for drinking water. The estimated total deposition of tritium on the BNL site during 1974 was 42.7 curies (using the weighted average of on-site and perimeter concentrations). The washout of BNL effluent appears to have been about 14.4 curies, or about 3% of the reported stack release of tritium vapor.

Liquid Effluent Monitoring

The basic principle of liquid waste management at BNL is confinement and containment, to minimize the volumes of liquids that could require decontamination prior to on-site release or processing into solid form for off-site burial. Accordingly, liquid wastes are segregated according to their anticipated concentrations of radioactivity or other harmful agents.

The primary water cooling systems of such facilities as the Alternating Gradient Synchrotron, the High Flux Beam Reactor, and the Medical Research Reactor, each of which contain up to multicurie amounts of radioactivity, are closed with no direct connection to any Laboratory waste system.

Small volumes (up to a few gallons) of concentrated liquid wastes containing radioactivity or other hazardous agents are withheld from the Laboratory waste systems. They are stored at their sources in small containers for pickup by the BNL Waste Management Group and subsequent packaging for off-site disposal (for hazardous agents by an EPA licensed contractor).

Facilities which may produce larger amounts (up to several hundred gallons per batch) 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 - improbably contaminated) wastes. As shown in Figure 5, in the active system, wastes are collected in holdup tanks. After sampling and analysis, they are either transferred by installed pipelines or tank trucks to storage tanks for concentration in a liquid waste evaporator and ultimate disposal as solid wastes, or if found to be of sufficiently low concentration routed directly to the Laboratory sanitary waste system.

As shown in Figure 5, inactive wastes are routed directly to the Laboratory sanitary waste system, where they are diluted by large quantities (approaching 1,000,000 gpd) of cooling and other uncontaminated water routinely produced by

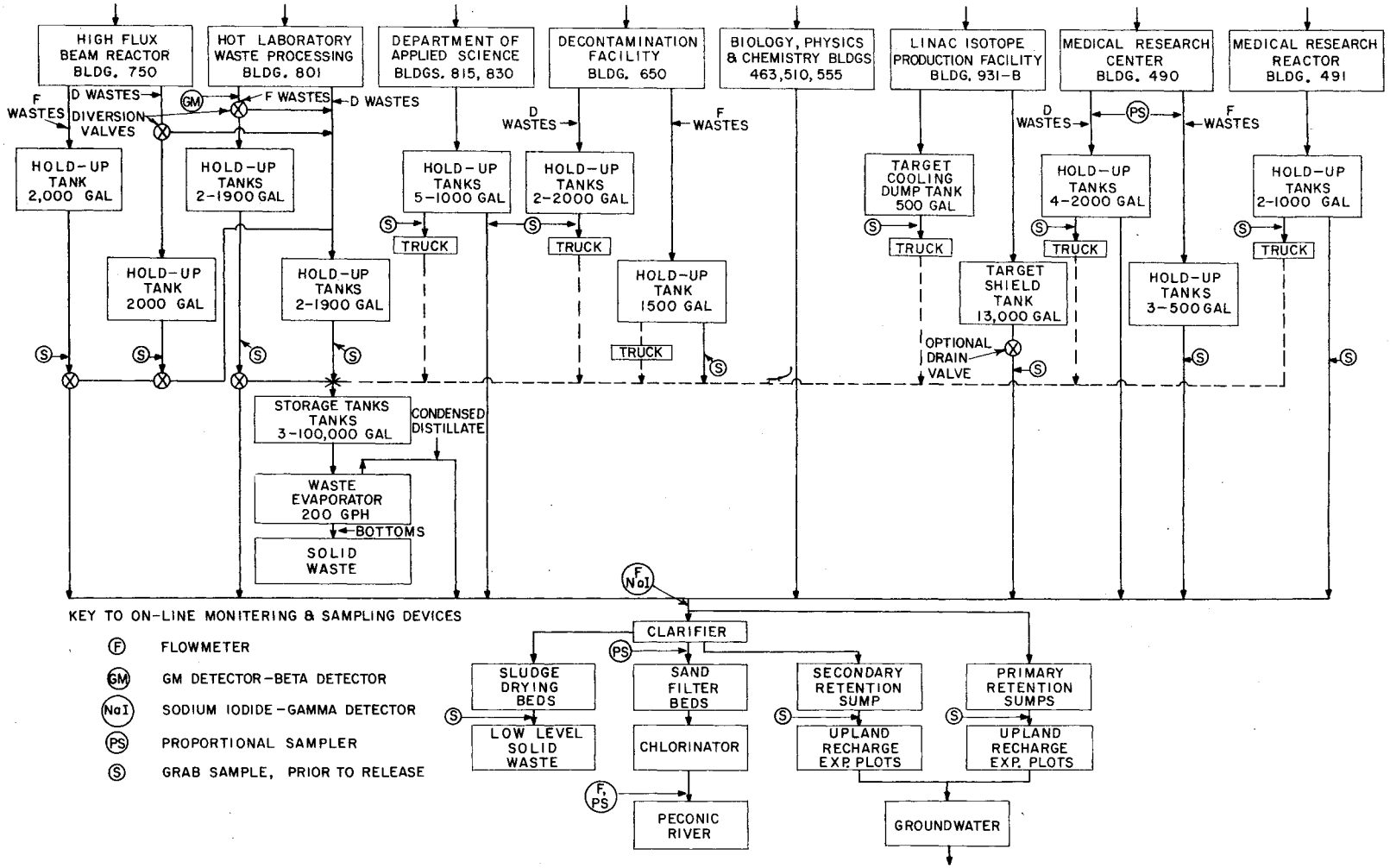

HIGH FLUX BEAM REACTOR BLDG. 750
HOT LABORATORY WASTE PROCESSING BLDG. 801
DEPARTMENT OF APPLIED SCIENCE BLDGS. 815, 830
DECONTAMINATION FACILITY BLDG. 650
BIOLOGY, PHYSICS & CHEMISTRY BLDGS 463,510,555
LINAC ISOTOPE PRODUCTION FACILITY BLDG. 931-B
MEDICAL RESEARCH CENTER BLDG. 490
MEDICAL RESEARCH REACTOR BLDG. 491
F WASTES
D WASTES
DIVERSION VALVES
HOLD-UP TANK 2,000 GAL
HOLD-UP TANKS 2-1900 GAL
HOLD-UP TANKS 5-1000 GAL
HOLD-UP TANKS 2-2000 GAL
HOLD-UP TANK 2000 GAL
HOLD-UP TANK 1500 GAL
TARGET COOLING DUMP TANK 500 GAL
HOLD-UP TANKS 4-2000 GAL
HOLD-UP TANKS 2-1000 GAL
TARGET SHIELD TANK 13,000 GAL
HOLD-UP TANKS 3-500 GAL
TRUCK
OPTIONAL DRAIN VALVE
STORAGE TANKS TANKS 3-100,000 GAL
CONDENSED DISTILLATE
WASTE EVAPORATOR 200 GPH
BOTTOMS
SOLID WASTE
KEY TO ON-LINE MONITERING & SAMPLING DEVICES
FLOWMETER
GM DETECTOR-BETA DETECTOR
SODIUM IODIDE-GAMMA DETECTOR
PROPORTIONAL SAMPLER
GRAB SAMPLE, PRIOR TO RELEASE
CLARIFIER
SLUDGE DRYING BEDS
SAND FILTER BEDS
SECONDARY RETENTION SUMP
PRIMARY RETENTION SUMPS
LOW LEVEL SOLID WASTE
CHLORINATOR
UPLAND RECHARGE EXP. PLOTS
UPLAND RECHARGE EXP. PLOTS
PECONIC RIVER
GROUNDWATER

FIGURE 5

diverse Laboratory operations. Sampling and analysis of facility holdup tanks is done to facilitiate waste management; effluent sampling to establish environmental releases is performed at the sewage treatment plant.

The small amounts of low-level radioactive waste effluents that may be routinely disposed of by release into the Laboratory's sanitary waste system are established by administrative limits[13], which correspond in general to those applicable to sewage systems. Within these limits, individual releases are kept as low as practicable.

Primary treatment to remove suspended solids from the liquid stream collected by the sanitary waste system is provided by a 250,000-gallon clarifier. Its liquid effluent then flows onto sand filter beds, from which about two-thirds of the water is recovered by an underlying tile field. This water is chlorinated and 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 is shown in Figure 6. In addition to the inplant flow measurement and sampling instrumentation, totalizing flowmeters (Leopold & Stevens TF 61-2), with provision for taking a sample for each 2000 gallons of flow in combination with positive-action battery-operated samplers (Brailsford DU-1), are located at the chlorine house, at the former site boundary which is 0.5 miles downstream on the Peconic, and at the site boundary, 1.6 miles 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 is evaporated for gross alpha and gross beta analysis, and another is counted directly for tritium analysis. Samples from the two downstream locations are obtained three times a week. Aliquots of each sample are similarly analyzed for gross beta and for tritium; and another aliquot, proportional to the measured flow during the

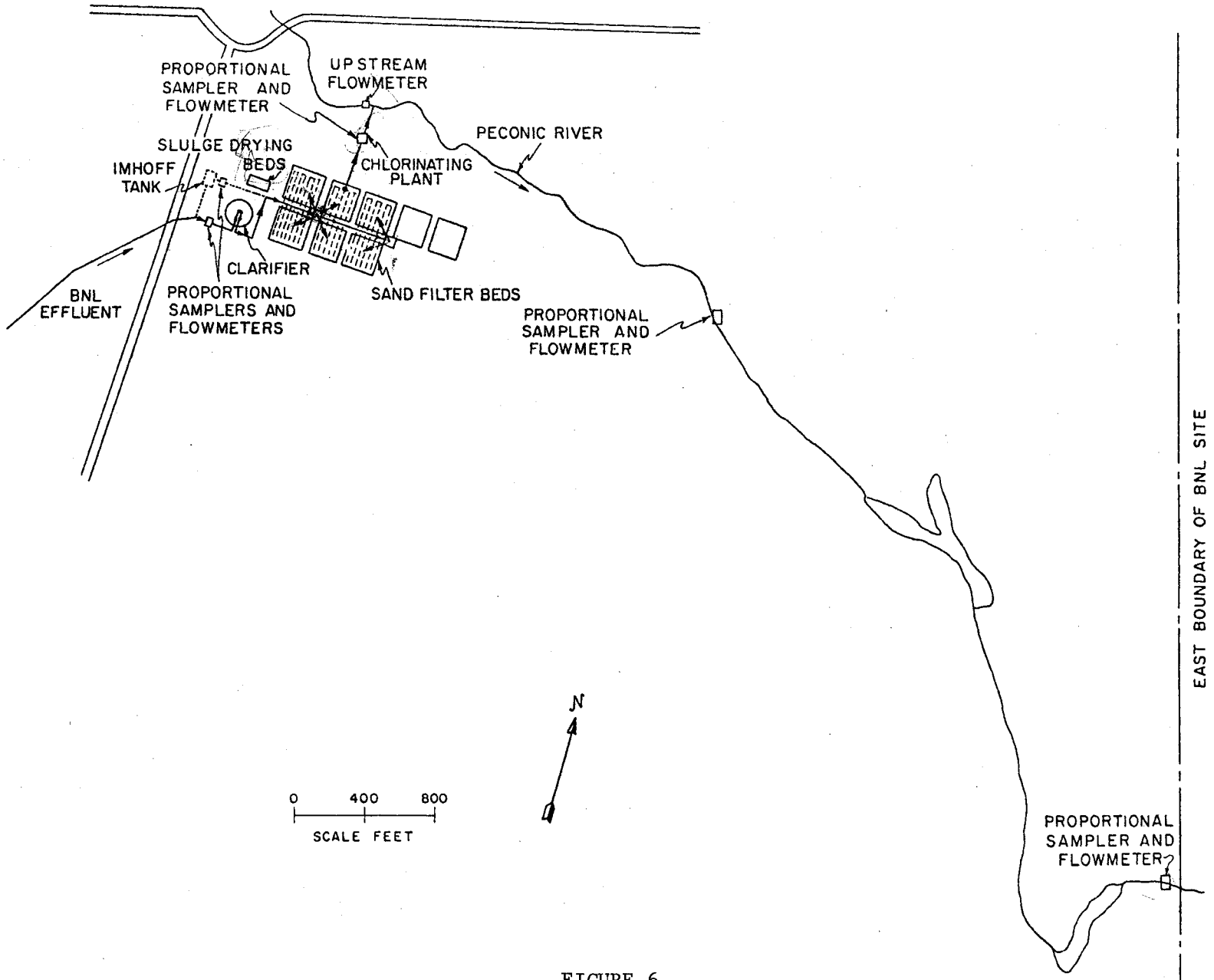

PROPORTIONAL SAMPLER AND FLOWMETER
UPSTREAM FLOWMETER
PECONIC RIVER
SLULGE DRYING BEDS
IMHOFF TANK
CHLORINATING PLANT
CLARIFIER
BNL EFFLUENT
PROPORTIONAL SAMPLERS AND FLOWMETERS
SAND FILTER BEDS
PROPORTIONAL SAMPLER AND FLOWMETER
EAST BOUNDARY OF BNL SITE
N
0 400 800
SCALE FEET
PROPORTIONAL SAMPLER AND FLOWMETER

FIGURE 6

sampling period, is passed through ion exchange columns for subsequent analysis of the integrated sample. Unless the gross beta count indicates a reason for more immediate identification for each location, one set of these columns is analyzed directly on a monthly basis for gamma-emitting nuclides and another is eluted for radiochemical processing for ^{90}Sr analysis.

The monthly average flow and the monthly totals of gross beta and principal nuclide activities at the Clarifier (input to the filter beds) and at the Chlorine House (output from the beds) are shown in Table X. Yearly totals and average concentrations are also indicated. During 1974, 67% of the liquid effluent flow into the sand filter beds appeared in the output from them and 3% was utilized by the Upland Recharge Project. The balance was assumed to have percolated to the ground water flow under the beds. Estimates of the amounts of radioactivity released to the ground water in this manner during 1974 are also shown in Table X. 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.

Flow, activity and concentration information at the former site boundary sampling location, 0.5 mi. downstream (See Fig. 6), and at the present site boundary are shown in Table XI. A much greater stream flow was observed at the former site boundary than at the Chlorine House, reflecting the upstream addition to the BNL stream effluent, which during 1974 totaled 7.06×10^{11} m^3. Although the total yearly flows were comparable, there was a general decrease in the total activity in the stream between these two locations. This was due both to the radioactive decay of short-lived radionuclides and the decrease in flow at the boundary measuring weir during the latter half of the year. Upper limit estimates of the total activity which may in this manner have percolated to the underlying ground water during these months are also shown in Table XI. These are based on the decrease in total activity between the former site boundary and

the perimeter from July through December (inclusive).

Analysis of monthly composite samples of the Peconic River at the former site boundary 0.5 miles downstream from the Chlorine House during this period showed that, on the average, 3% of the total activity consisted of ^{90}Sr and that no appreciable amounts of long half-life radioactive iodine or bone-seeking nuclides such as radium were present. Under these circumstances, the applicable RCG was 3,000 pCi/l (3.0×10^{-6} μCi/ml). The apparent gross beta concentration in the river flow which percolated to ground water, 38.9 pCi/l (3.89×10^{-8} μCi/ml), was 1.3% of this RCG. At the BNL perimeter (1.6 mi. downstream from the Chlorine House outfall), 6% of the yearly activity was ^{90}Sr. The applicable RCG was also 3,000 pCi/l. The observed concentration of the water released downstream in the Peconic River, 20.6 pCi/l (2.06×10^{-8} μCi/ml) was 0.7% of this RCG.

After digestion, the solids removed by the Clarifier are dried on sludge drying beds. After analysis, they are then disposed of to the on-site sanitary landfill. However, no such transfer of dried sludge was made during 1974.

The quality and purity of the Clarifier effluent, the sand filter bed effluent and at two downstream locations are indicated on Table XII-A. The outflow from the sand filter beds and into the Peconic was within water quality standards for DO. Although below the standard, the pH was within the range of local ambient backgrounds. After mixing with the upstream flow, the temperature increment was within the standard 0.5 mi. downstream and the site boundary. A few analyses for selected metals were also performed. The data are shown in Table XII-B. Those for which concentrations were ascertained were within the applicable standard.

During the period from May 13 - 15, a limited plant kill occurred in the Peconic. It was most evident between the sewage treatment outfal and the sampling weir at the former site boundary (0.5 mi. downstream) (See Fig. 6). By May 17th, it became evident that several hundred fish of the several species present in the river

(principally bass, sunfish, bluegill, pickerel and catfish) were also affected. An Investigating Committee[17] concluded that exposure to radiation was not the cause, that operation of the Upland Recharge Project was not a contributing factor, that accidental contamination of the stream by an unidentified potent chemical of a biocidal and herbicidal nature was a likely cause, and that deficiency of oxygen could not be ruled out as a possible cause. In this connection, it may be noted that for the past two years (since these measurements were initiated) typical DO levels at the site boundary have regularly decreased to less than 4.0 ppm during the warmer months (May - August), for reasons which seem unconnected with Laboratory operations. The Investigating Committee reported that other fish kills occurred at about the same time in freshwater locations in Suffolk County. A resurvey of the stream in mid-summer disclosed that the vegetation in the affected area had recovered, and that at least one species of fish (carp) had either been reestablished or had survived the mid-May events.

The sewage used in the Upland Recharge Experiment is prepared at the Brookhaven Sewage Treatment Plant to be equivalent either to the effluent from the primary or the secondary effluent from a typical sewage treatment plant, using cesspool pumpings gathered by scavengers in the Town of Brookhaven. These are blended with the Laboratory sewage, which is normally extremely dilute. The "primary" effluent is a blend of two parts degritted BNL sewage to one part cesspool waste; "secondary" effluent is a blend of clarified BNL sewage and cesspool waste in a 40:1 ratio. A summary of the total flows, the gross beta activity and concentration, and of the tritium activity and concentration in these effluents is set forth in Table XIII.

Water quality parameters of these two mixtures were evaluated by the BNL Biology Department[18] and cooperating outside agencies. Available portions of these data are shown in Table XIV. The applied effluents met the standards for ground surface discharge with the exception of the metals Cu, Fe and Zn. It

should be noted that the purpose of the Upland Recharge Project is to determine the efficiency of natural ecosystems to retain pollutants in the applied effluents sufficiently, so that the percolate to the saturated zone (10-15' below the ground surface in the Upland Recharge area) is within ground water quality standards.

Due to the permeable nature of the local soils, there is no surface runoff from the experimental plots, and hence no direct route by which these effluents might reach a potable water supply.

Monthly "grab" water samples were obtained at on- and off-site locations along the upper tributary of the Peconic River, into which the Laboratory routinely discharges low-level radioactive wastes. Reference "grab" samples were also obtained from other nearby streams and bodies of water outside the Laboratory's drainage area. The sampling locations, as shown in Figure 7, were as follows:

Off-Site (Peconic River, proceeding downstream)

A - Peconic River at Schultz Rd., 15,900 ft. downstream

B - Peconic River at Wading River-Manorville Rd., 23,100 ft. downstream

C - Peconic River at Manorville, 35,000 ft. downstream

D - Peconic River at Calverton, 46,700 ft. downstream

R - Peconic River at Riverhead, 63,500 ft. downstream

Controls (Not in BNL Drainage)

E - Peconic River, upstream from BNL effluent outfall

F - Peconic River, north tributary (independent of BNL drainage)

H - Carman's River - outfall of Yaphank Lake

The individual monthly and yearly average gross beta and tritium concentrations at the downstream and control locations are shown in Table XV. A comparison with the on-site and perimeter concentrations shown in Table XI, suggests that the concentrations of BNL effluents in the Peconic diminish rapidly downstream of the outfall to background levels at the more distant sampling locations. Considering the concentrations of radioactivity near the mouth of the Peconic at Riverhead,

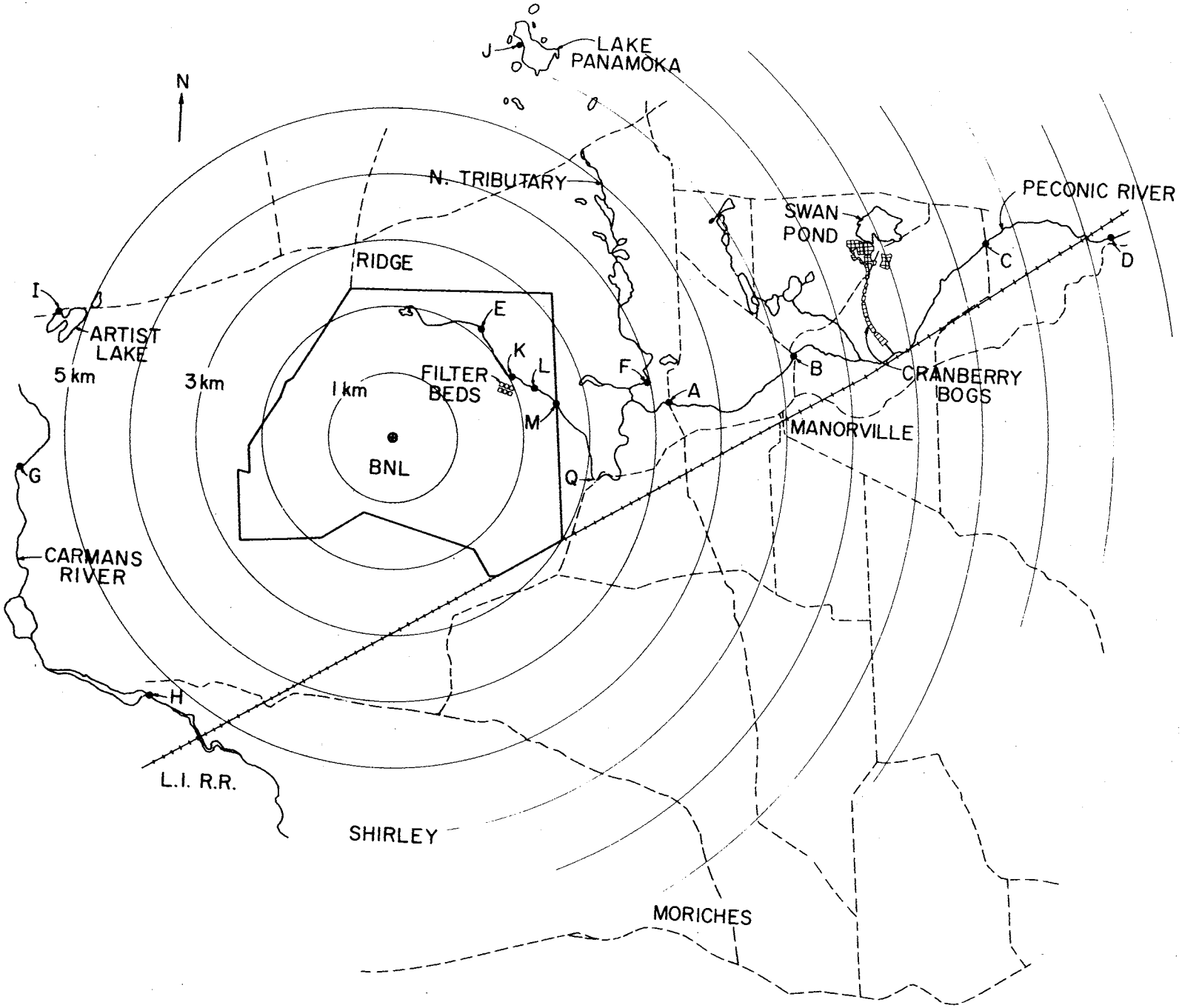

N
LAKE PANAMOKA
J
N. TRIBUTARY
PECONIC RIVER
SWAN POND
RIDGE
I
ARTIST LAKE
5 km
3 km
1 km
FILTER BEDS
BNL
E
K
L
M
F
A
B
C
D
CRANBERRY BOGS
MANORVILLE
G
Q
CARMANS RIVER
H
L.I. R.R.
SHIRLEY
MORICHES

FIGURE 7

where the flow during 1974 was about 25 times that at the BNL perimeter, it is evident that the total amounts of radioactivity at this location were much greater than those released into the Peconic at the BNL perimeter.

During May and June of 1974, additional sampling of the stream bottom sediment, of immersed and emergent vegetation, and of small stream fauna was conducted along the length of the Peconic. Control samples were obtained upstream and from an off-site "control" location. The locations correspond to those used for monthly water samples. In addition, samples were obtained on-site at the following locations:

On-Site (proceeding downstream)

L - Peconic River, 1,300 ft. below effluent outfall

M - Peconic River, 2,600 ft. below effluent outfall (at former BNL boundary)

Q - Peconic River, 6,900 ft. downstream (at BNL boundary).

The sediment data are shown in Table XVI. Small concentrations of ^{60}Co, which is not generally present in the environment and are therefore attributable to BNL effluents were apparent in a few on-site samples. Concentrations of ^{65}Zn, ^{137}Cs and ^{144}Ce in samples obtained on-site and in the upper reaches of the Peconic somewhat greater than those in downstream and control samples, were also indicative of BNL effluent releases. The corresponding vegetation data are shown in Table XVII. These show considerable scatter. Small concentrations of ^{60}Co, which is unique to BNL effluent releases, was found in samples obtained on-site, at the BNL perimeter and in nearby downstream locations.

There was some indication in these samples of BNL effluent activity insofar as larger concentrations of ^{7}Be, ^{65}Zn, ^{137}Cs and ^{144}Ce were found in samples from on-site, at the perimeter and in or nearby the downstream region of the Peconic, as compared with remote downstream and control samples (which reflect accumulations of these nuclides from fallout of atmospheric weapons tests).

A few samples of fish and turtles were also obtained along the upper reaches of the Peconic. These data, which are shown in Table XVIII, are too few to be

conclusive with regard to the extent, if any, to which they contained BNL effluent radioactivity. The largest concentration of ^{137}Cs found in these samples was less than 0.9% of RCG's, calculated on the basis of an assumed intake of 50 grams/day.

Potable Water and Process Supply Wells

The Laboratory's portable water wells and cooling water supply wells are screened at a deph of about 100 feet, or about 50 feet below the water table, in the Long Island surface layer of glacial outwash, sand and gravel. As apparent from Figure 8, most of these wells are located generally west to northwest, and therefore upstream in the local ground water flow pattern[1] of the Laboratory's principal facilities. A total of about 6.5×10^6 gal/day is pumped from them.

Bimonthly grab samples were scheduled for these wells. These were analyzed for gross alpha, gross beta and tritium. All gross alpha concentrations were <1 pCi/l ($<10^{-9}$ μCi/ml), and almost all tritium concentrations were ≤1.0 nCi/l ($<10^{-6}$ μCi/ml). The gross beta and tritium results are set forth in Table XIX. There were no differences in the gross beta concentrations among these wells which might be attributed to BNL effluents.

Recharge Basins

After use in "once through" heat-exchangers and for process cooling, about 4.8 million gallons per day (MGD) is returned to ground water in on-site recharge basins: 1.7 MGD to basin "N" located about 2,000' northeast of the AGS; about 1.5 MGD to basin "O" about 2,200' east of the HFBR; and about 1.6 MGD to basin "P" 1,000' south of MRR (see Fig. 8). Sodium hexametaphosphate is added to the AGS cooling and process water supply, which is independent of the Laboratory potable supply, to establish a PO_4 concentration of about 2 ppm in order to keep the ambient iron in solution. Of the total AGS pumpage, about 1.4 MGD is discharged to the "N" basin, and 0.7 MGD to the "O" basin. The HFBR secondary cooling system recirculates through mechanical cooling towers. It is treated to control corrosion

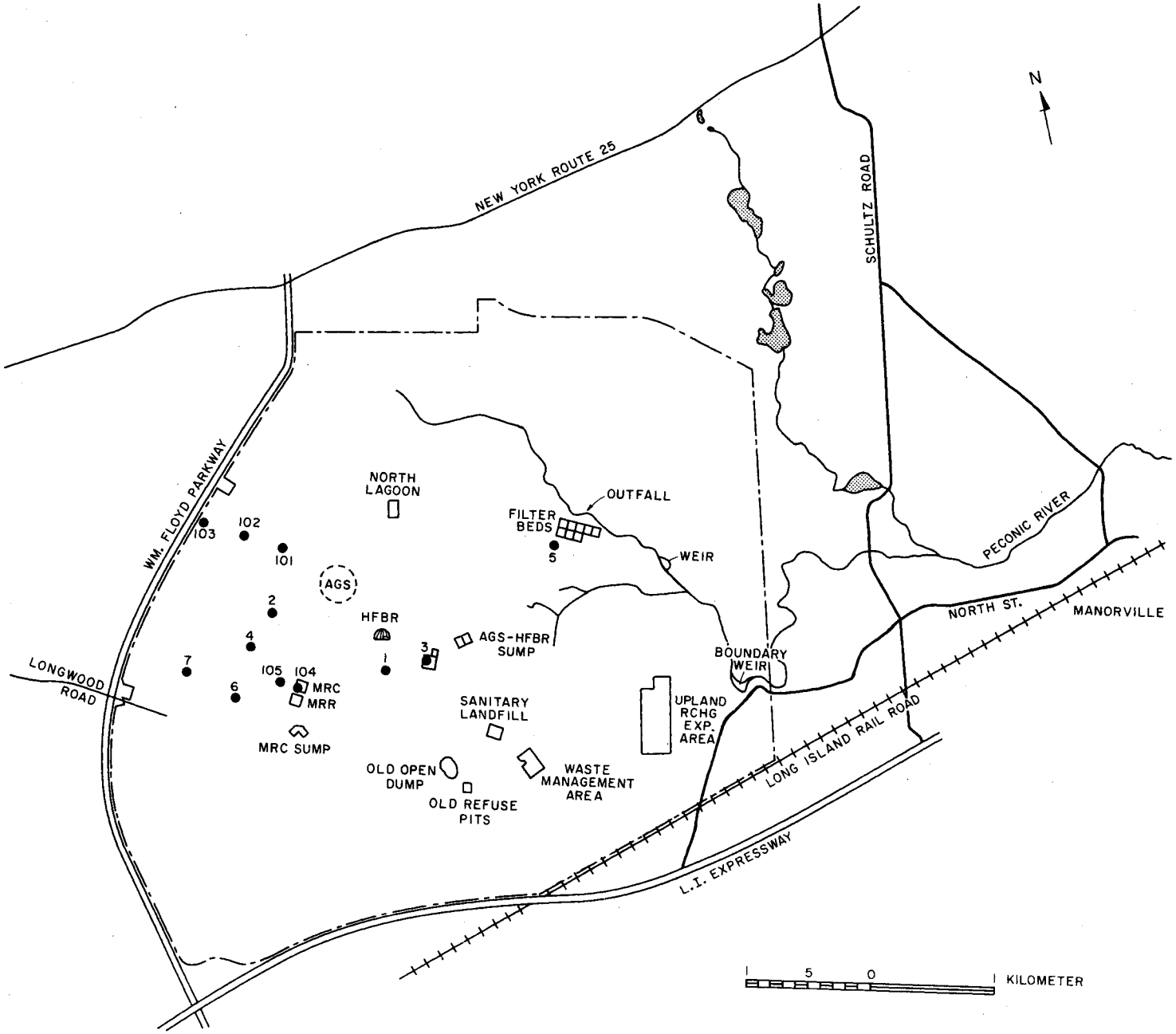

N
NEW YORK ROUTE 25
SCHULTZ ROAD
WM. FLOYD PARKWAY
NORTH LAGOON
OUTFALL
FILTER BEDS
WEIR
PECONIC RIVER
NORTH ST.
MANORVILLE
LONGWOOD ROAD
AGS
HFBR
AGS-HFBR SUMP
BOUNDARY WEIR
MRC
MRR
MRC SUMP
SANITARY LANDFILL
UPLAND RCHG EXP. AREA
LONG ISLAND RAIL ROAD
OLD OPEN DUMP
OLD REFUSE PITS
WASTE MANAGEMENT AREA
L.I. EXPRESSWAY
5
0
KILOMETER

FIGURE 8

and the deposition of solids. Blowdown from this system, about 0.1 MGD, contains PO_4 in a concentration of about 10 ppm and benzotriazole in a concentration of 3-4 ppm. It is also discharged to the "O" sump. The MRR MRC "once through" coolant is untreated and is discharged to the "P" basin. Concentrations of radioactivity and other agents in these basins are monitored by routine weekly grab sampling. The average gross beta and tritium concentrations are shown in Table XX-A. The average gross beta concentration in the sump north of the AGS was slightly above background, due to the occasional release of short-lived nuclides contained in AGS beam stops. It was 0.2% of the applicable RCG. The average gross beta and tritium concentrations in the other basins were only very slightly increased above those in the BNL supply wells, and were less than 0.1% of the applicable RCG for unidentified gross beta emitters, and less than 0.02% of that for tritium in drinking water.

Water quality data is obtained from periodic (approximately monthly) analyses of "grab" samples from the recharge basins. The data for 1974 are shown in Table XX-B. All were within established standards for ground water quality, except for the low pH in the "O" basin, which reflects the natural ambient ground water condition.

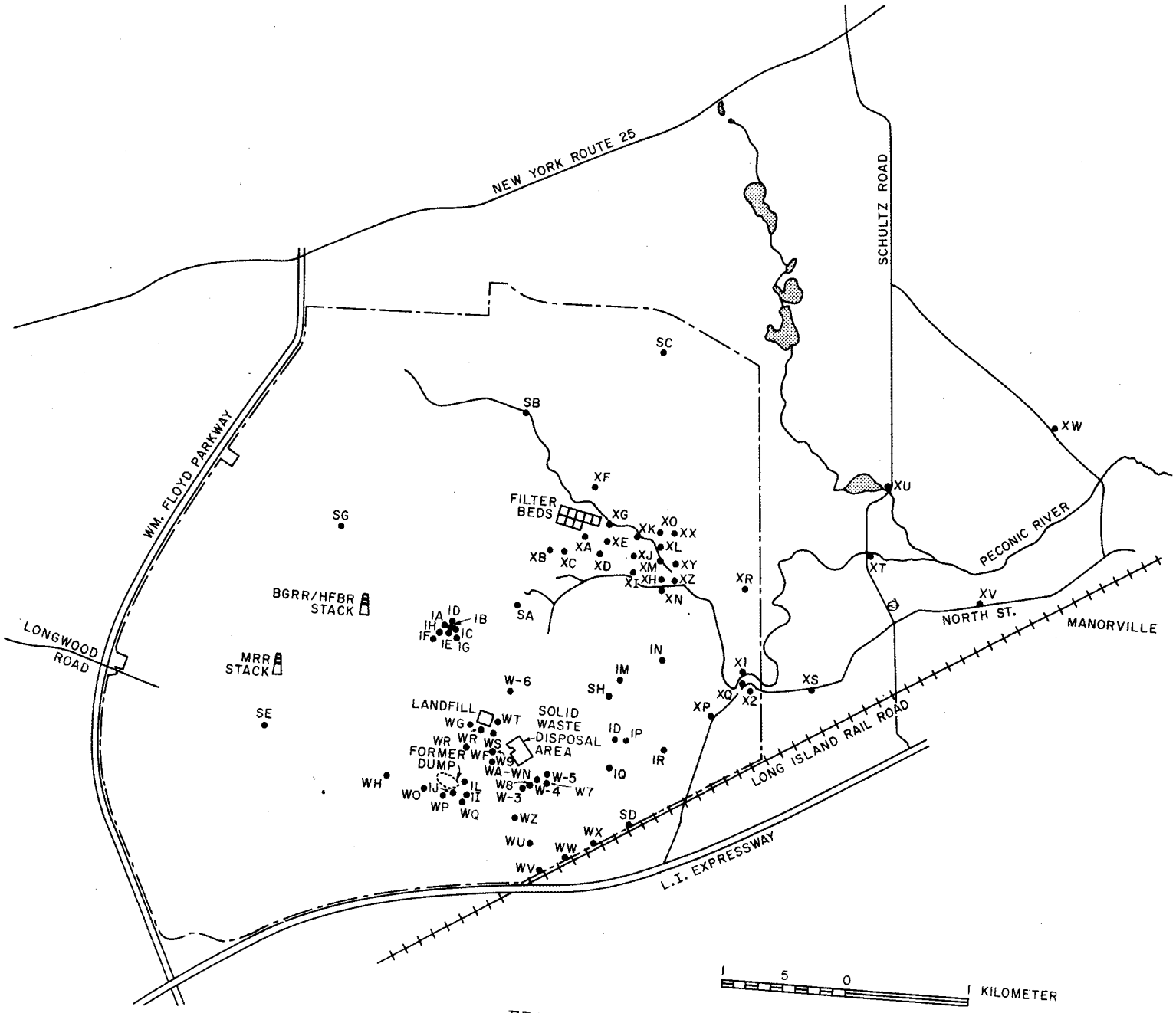
Ground Water Surveillance

Samples of ground water were obtained from a network of shallow wells previously installed in the vicinity of several areas from which there is potential for the migration of radioactivity downward from the surface into the saturated zone of ground water. Included are areas adjacent to on-site recharge basins, to the sand filter beds and downstream along the Peconic, to the Solid Waste Management Area, to the former open dump, to the sanitary landfill which replaced it in 1967, to the Decontamination Facility Sump, and to the Upland Recharge Project Area. The locations of most of these ground water surveil-

water surveillance wells are shown in Figure 9-A. Detailed locations of the several wells installed at the Solid Waste Management area are shown in Figure 9-B, and of those installed in the Upland Recharge Experiment Area in Figure 9-C.

For convenience in assessing the data, the wells have been divided into several groups. Yearly average gross alpha, gross beta and tritium concentrations of the wells generally in the proximity of the on-site recharge basins, the sand filter beds and downstream on the Peconic River are summarized in Table XXI. During the year, one sample from locations adjacent to the recharge basins and from locations most immediately adjacent to the sand filter beds and the Peconic was also analyzed for ^{90}Sr and ^{137}Cs (by gamma analysis) during the year. As available, these data are also indicated. Corresponding information for the wells generally in the proximity of downstream of the Solid Waste Packaging Area, the landfill and dump zones, and of the Decontamination Facility sump (about 1 km east of the HFBR) is summarized in Table XXII, and for the wells in the Upland Recharge Project area in Table XXIII.

From these data it appears that the spread of radioactivity from BNL operations into ground water remains limited to within a few hundred meters of the identifiable foci. Above background concentrations of beta-emitters, tritium and ^{90}Sr were found on-site adjacent to the sand filter beds and to the Peconic, at small fractions of the radiation guide levels. Adjacent to the Peconic at the site boundary, all concentrations were also at on near background. Compared with 1973, gross beta, ^{90}Sr and tritium concentrations were generally slightly increased in several wells immediately adjacent to the Solid Waste Management area and slightly decreased in more distant "downstream" wells. Increased concentrations were also apparent in wells immediately adjacent to the landfill area. Little change was apparent in wells adjacent to the former open dump and the Decontamination Facility (650) sump, except for an increase in ^{90}Sr in well 1-H, about 100 meters southeast of its storm sewer outfall. Tritium above minimum detectable


NEW YORK ROUTE 25
SCHULTZ ROAD
WM. FLOYD PARKWAY
LONGWOOD ROAD
PECONIC RIVER
NORTH ST.
MANORVILLE
LONG ISLAND RAIL ROAD
L.I. EXPRESSWAY
FILTER BEDS
BGRR/HFBR STACK
MRR STACK
LANDFILL
SOLID WASTE DISPOSAL AREA
FORMER DUMP
SC
SB
SG
SA
SE
SH
SD
IN
IM
IR
IQ
IP
ID
IA
IB
IC
IE
IF
IG
IH
IJ
IL
II
XA
XB
XC
XD
XE
XF
XG
XH
XI
XJ
XK
XL
XM
XN
XO
XP
XQ
X1
X2
XR
XS
XT
XU
XV
XW
XX
XY
XZ
W-3
W-4
W-5
W-6
W7
W8
WA-WN
WE
WF
WG
WH
WI
WJ
WO
WP
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WR
WS
WT
WU
WV
WW
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WZ
5
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KILOMETER

FIGURE 9-A

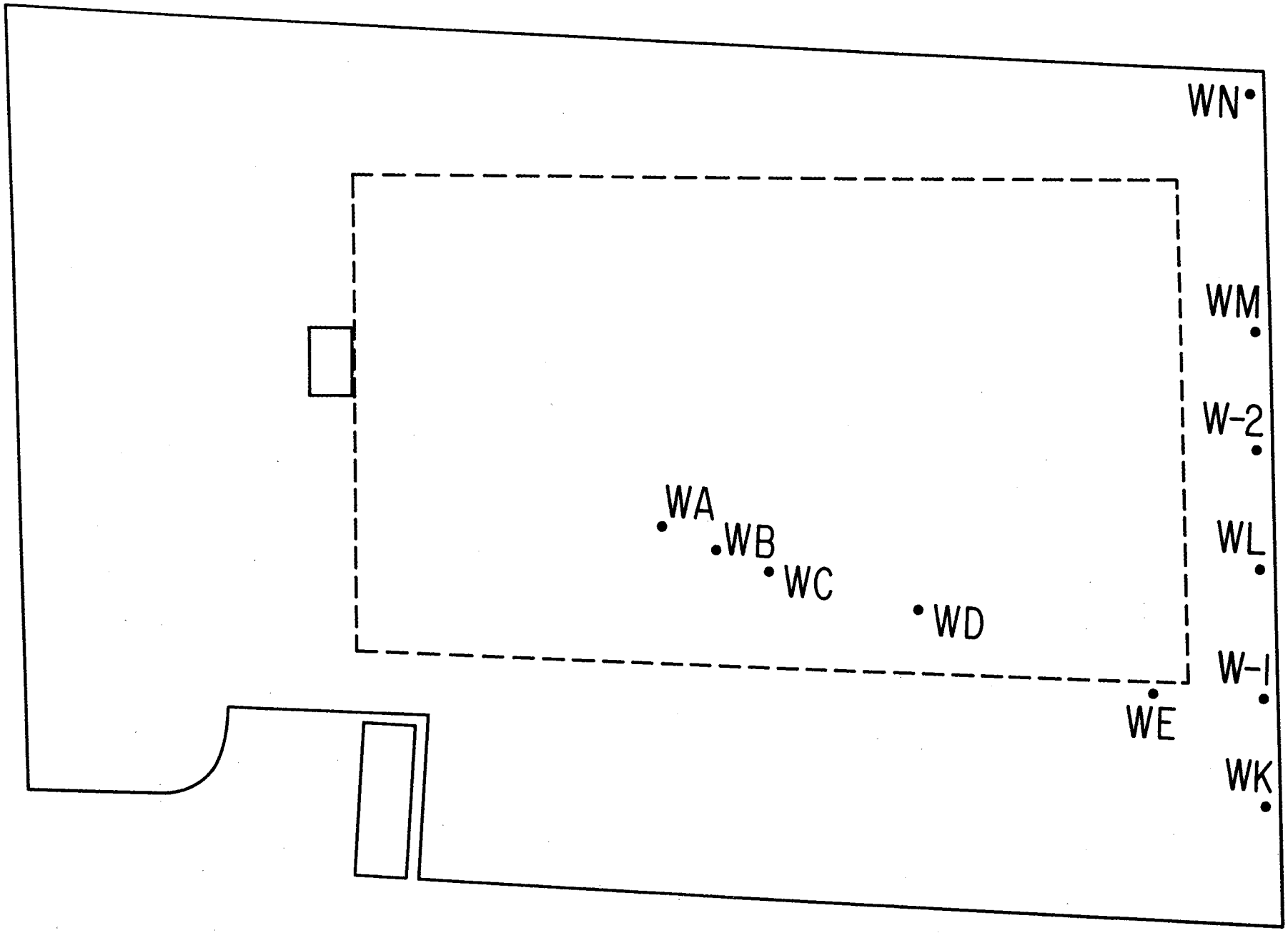
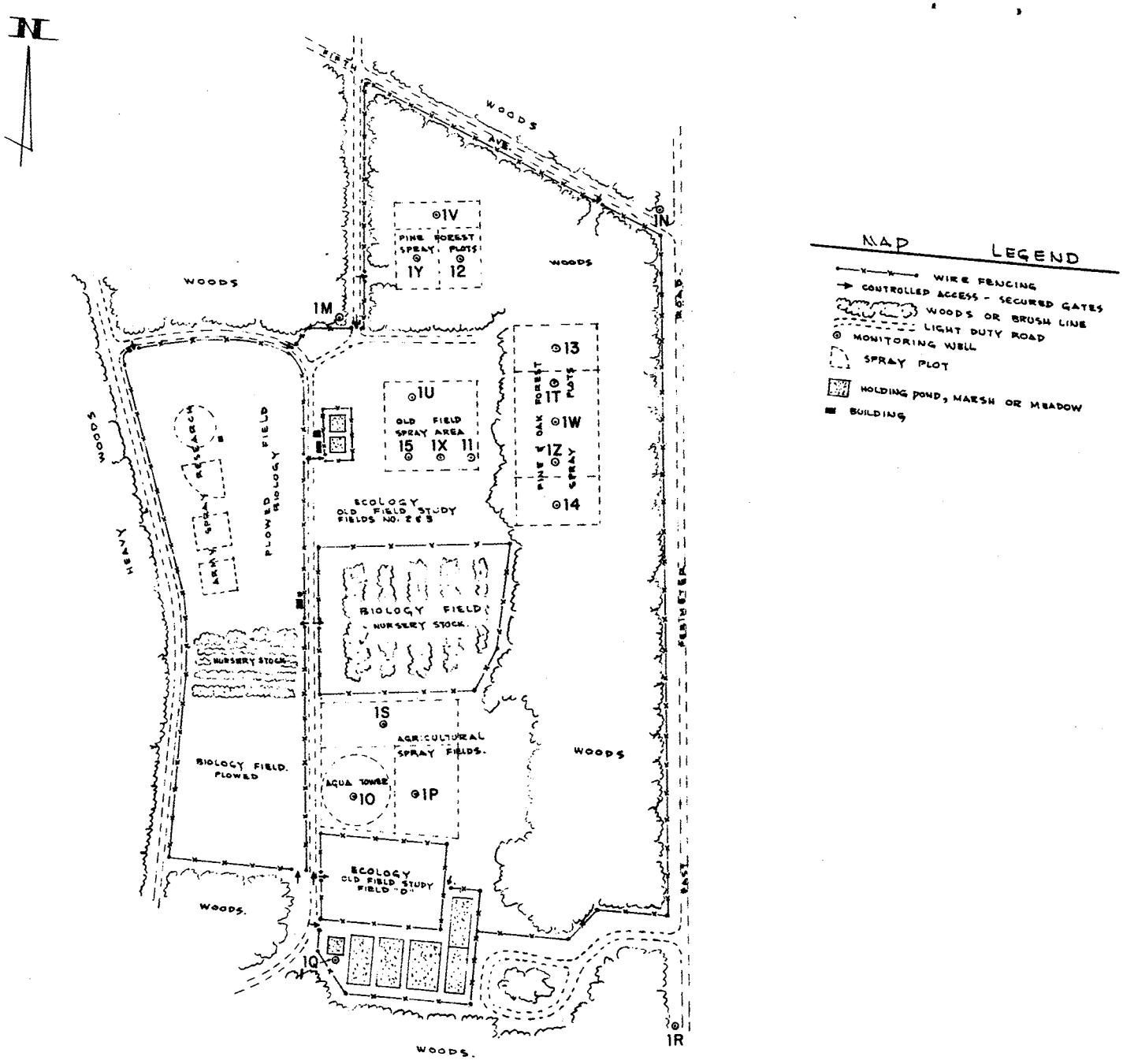


FIGURE 9-B



UPLAND RECHARGE WELLS

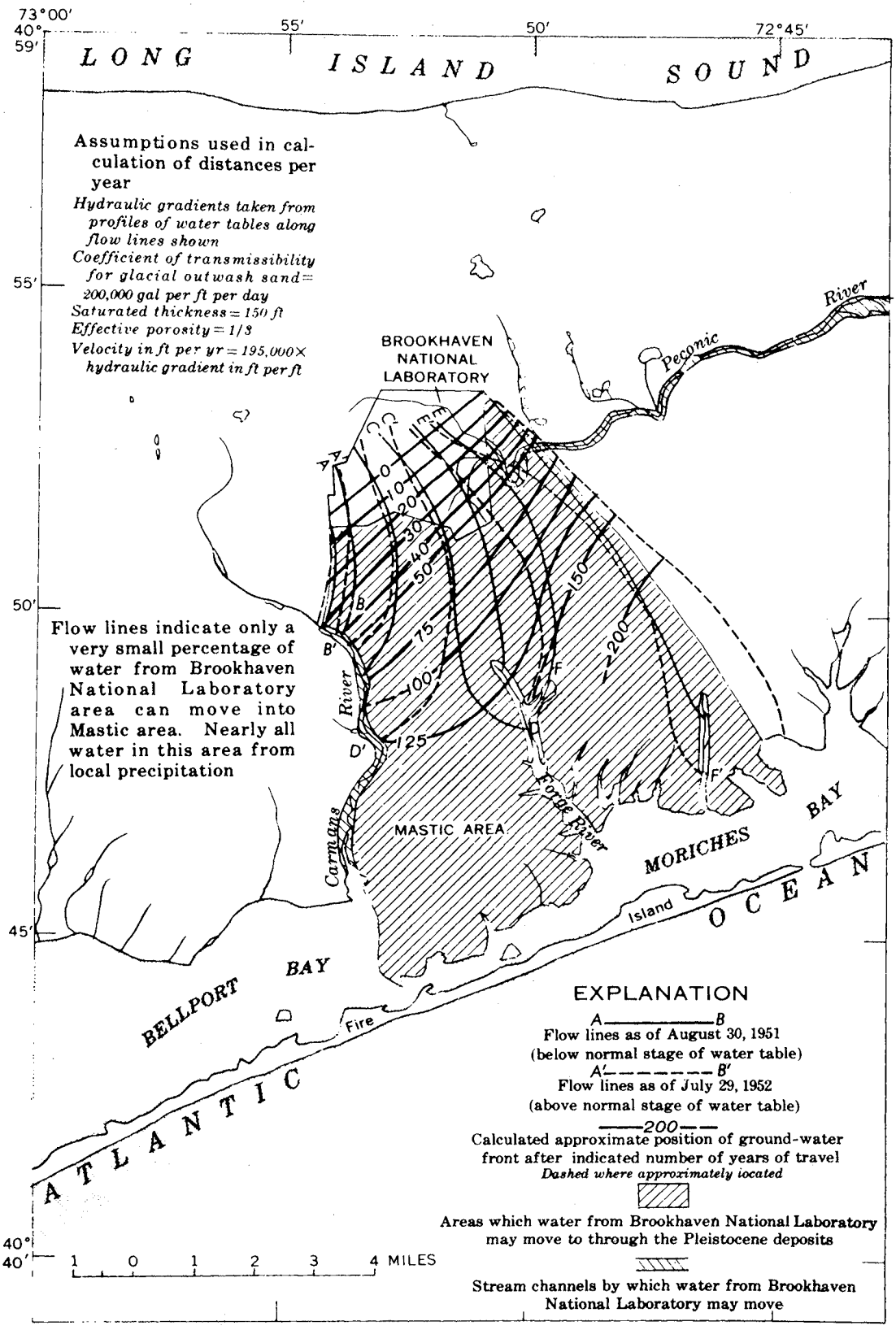
FIGURE 9-C

concentrations was found in most wells within the Upland Recharge Project plots, but not in the "control" wells at its area boundaries. Concentrations of radioactivity in all wells on or near the site boundary were at or only slightly above background levels, and at small fractions of radiation guide levels.

Several water quality and purity parameters were also evaluated, for all ground water surveillance wells. The data for those wells proximate to on-site sumps, the sand filter beds, and downstream on the Peconic River on and off site, are shown in Table XXIV-A. Those for wells proximate to the Solid Waste Management area, the landfill and dump area and the Building 650 sump, are shown in Table XXIV-B. Those for wells in the Upland Recharge Project plots and at its outer perimeter are shown in Table XXIV-C. Analyses for selected metals conducted for a few wells immediately adjacent to the sand filter beds, to the Peconic and to the landfill area. These data are shown in Table XXIV-D.

With the exception of pH, all generally analyzed water quality parameters were well within New York State Water Quality Standards. The generally somewhat lower pH data 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 XIII-A). Concentrations of Fe and Zn in excess of water quality standards were found in wells immediately adjacent to the sand filter beds, the Peconic River and the landfill areas and for Fe in one Upland Recharge well. They appear to reflect the leaching of accumulations of these metals from past BNL releases.

A generalized depiction of the direction and rate of ground water movement originally published in the U.S. Geological Survey Study[1], is shown in Figure 10. More recently, the Upland Recharge Project[18] has determined a ground water velocity of 5.3 in/day (13.4 cm/day), which is in good agreement with the U.S. Geological Survey Study estimate of 6.4 in/day (16.2 cm/day). Thus, it appears that many years of travel time would be required for ground water containing radioactivity or other pollutants to reach an off-site well, during which considerable dilution by infiltration of precipitation would be anticipated.



Direction and time of travel of ground water laterally in upper Pleistocene deposits from the Brookhaven National Laboratory area to points of discharge.

FIGURE 10

Milk Sampling

Quarterly samples of milk were obtained from two dairy farms, one located 10 km south-southeast and a "control" located 40 km east of Brookhaven. These samples were analyzed for gamma-emitters and then processed through an ion exchange column to improve the lower detection capability for ^{131}I. The data are indicated in Table XXV. There was no significant difference between those for the "control" location and the typical 1974 concentrations reported for milk samples in New York City by the Health and Safety Laboratory [20]. As was the case during recent years, the average concentration of ^{90}Sr in the milk from the farm 10 km southeast of the Laboratory, as reported by the New York State Department of Environmental Conservation [21], was among the highest of any of their thirty state-wide sampling locations. This effect is not relatable to any BNL effluents, past or present, and appears to be related to differences in soil conditions and/or farming practices [22-24]. There was no plausible relationship between these concentrations and Laboratory effluents.

Soil and Vegetation Sampling

A few soil and vegetation samples were collected from several off-site farms during 1974. Soil samples were also collected at two locations on-site, at which local deposition of radioactivity from past BNL operations have previously been apparent. The first was adjacent to the former High Intensity Radiation Development Laboratory (which contained facilities for the encapsulation of multi-curie ^{60}Co and ^{137}Cs sources), and which is located about 1,000 feet northeast of the HFBR (see Figure 2). The other was in the vicinity of the Solid Waste Management area.

These samples were analyzed for γ-emitting nuclides. The data for both the off-site and on-site soil samples are shown in Table XXVI. The off-site levels of ^{137}Cs and ^{144}Ce are comparable to or less than those found in recent years at these same locations. In addition to levels of ^{137}Cs comparable to those

off-site, small concentrations of ^{60}Co (not generally present in the environment) remain evident in the vicinity of the High Radiation Development Laboratory (HIRDL). These are confined to a very local area, within a few hundred feet of the facility and most samples at its fence line were at or near the minimum detectable. The origin of this local low-level contamination is unknown, since operations involving significant amounts of radioactivity at HIRDL were conducted within hot cells which were provided with high efficiency air particulate filters.

At the Solid Waste Management Area, ^{54}Mn (also not generally detectable in environmental samples), ^{60}Co, and ^{137}Cs in concentrations considerably in excess of those generally present in the environment were evident in samples collected within its fence line (see Figure 9B). At the fence line, the levels of ^{54}Mn and ^{60}Co were at or near the minimum detectable, and those of ^{137}Cs were at or near generally prevailing levels. Most of this contamination is believed to have originated during outdoor packaging of stored wastes for off-site shipment and ultimate disposal. It does not represent a perceptible pathway for off-site exposure, since it is locally confined to within 500 or so feet of the solid waste storage pad.

Only three off-site vegetation (pasture) samples were analyzed during 1974. The measured concentrations of ^{65}Zn, ^{137}Cs and ^{144}Ce were comparable to or less than those detected at these same locations during recent years. There were no other differences between the nearby and the more remote samples, on which to infer the deposition of any BNL effluent activity.

OFF-SITE DOSE ESTIMATES

Increased levels of radiation and concentrations of radioactivity, above ambient background, with resulting increased doses to people, result from the following four BNL sources:

Airborne radioactive effluents, primarily tritium;
Radioactive liquid effluents;
The ^{137}Cs source in the Biology Department Ecology Forest;
Skyshine from the Alternating Gradient Synchrotron (AGS).

These are discussed below, and the total off-site dose (in man-rem) due to Laboratory operations during 1974 is calculated.

Doses Due to Airborne Effluents

As indicated in Table III, a total of 1117 Ci of tritium were released from various BNL facilities during 1974. For the purpose of computing off-site doses, the conservative assumption is made that all of the 697 Ci of gaseous tritium released from the Van de Graaff was converted to tritium oxide between the point of release on-site and the site boundary.

Concentrations of tritium at the site boundary are so low that measurement is difficult. Data given in Table VI indicate an average concentration of ~~33~~ 27 pCi/m^3 at the site boundary (~2,500 meters from the HFBR stack) in addition to the background value, which equaled about 2 pCi/m^2. Continuous exposure at the radiation concentration guide, 2×10^5 pCi/m^3, would result in a dose of 500 mrem/yr. Thus, the dose rate at this distance attributable to BNL air effluent tritium was $(33/2 \times 10^5)(500)$ or 0.08 mrem/yr, or 0.016% of the radiation protection standard[4]. Since the background exposure rate in this area was about 79 mrem/yr, this tritium dose rate amounts to an increase at the site boundary of only 0.1%, which is much smaller than the temporal and spatial variations in that background.

Some 450 Ci of radioactive argon gas (^{41}A) was released from the stack of the Medical Research Reactor. This quantity is too small to produce a measurable increase in annual dose rates at the site boundary. During operation of the Brookhaven Linac Isotope Facility (BLIP), ^{15}O is released at a rate calculated as 0.6 Ci/min, for a total amount of 22,750 Ci during 1974. Its half-life is only 2 minutes and its effect was not observable at the site boundary.

Routine analyses for air particulates radioactivity and for radiohalogens were made throughout 1974 on air samples collected at several locations. Although several nuclides attributable to fallout from weapons testing were found, there was no evidence of activity attributable to BNL operations.

Dose rates beyond the site boundary due to tritium in air effluents from BNL were very small, compared with background and variations in background. This should be considered in the interpretation of the computation of the population exposure in man-rem attributable to this BNL effluent, which appears in Table XXVIII. The parameter $\underline{X}/\underline{Q}$, tabulated in the second column, is the ratio of ground-level concentration to rate of emission, i.e., concentration per unit emission rate, and is a function of meteorological conditions and distance from the source. The values have been calculated for the 300 m release height of the HFBR stack and are averages for a whole year and for all sixteen tabulated directions. While their use produces an underestimate at close-in distances for releases from shorter stacks, overall it results in some overestimation of population exposure, since $\underline{X}/\underline{Q}$ values in the direction of major population centers to the west of BNL are lower than the 360° averages. Values of dose rate in the third column are derived from the measured value for the 1-to-2 mile interval (0.08 mR/yr) by multiplying by the appropriate ratios of $\underline{X}/\underline{Q}$ values. The total population dose due to the BNL tritium effluent was 6.70 person-rems and due to natural background (79 mR/yr) was 402,386 person-rems.

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. The upper portions of the river, in which a small excess of radioactivity above background concentrations (principally ^{137}Cs) was found in sediments, vegetation and fish, is utilized for occasional recreational fishing. Making the assumption that the total catch of fish by 100 fishermen was 1×10^{3} kg, and the ^{137}Cs concentration was 420 pCi/kg (4.2×10^{-7} μCi/kg) which is the average in fish samples from the Peconic in 1974; the total ingestion would have been 4.2×10^{-7} Ci. This corresponds to an average individual dose commitment of 0.135 mrems, or 0.03% of the radiation protection standard. The estimated total dose from this indirect pathway is 0.0135 person-rems. Although it may reasonably be assumed that there was also some accumulation of ^{90}Sr from BNL effluents in these fish, since this nuclide is concentrated in the inedible bone, the resulting dose appears to have been small by comparison.

Although not directly relatable to BNL liquid effluents during 1974, a small concentration of ^{90}Sr was found in an off-site surveillance well, about 1,000 ft. east of the BNL site boundary at the Peconic. Using dose commitment factors published by Shleien[25], a potential individual 50 year bone dose commitment of 19 mrem for infants and 16 mrem for adults may be calculated for a small number of people living in the adjacent area. This is about 0.2% of the Radiation Protection Standard. This calculation is based on the assumption that during 1974, all of their drinking water was obtained from shallow water supply wells, containing ^{90}Sr in a concentration comparable to that of the surveillance well. It is estimated that not more than twenty-five people reside in this locality and thus that the total dose commitement did not exceed 0.475 person-rems. Their dose from natural background (including internal radiation) would have been about 2.5 person-rems during 1974.

Doses Due to the Gamma Forest ^{137}Cs Source

A ~~6,660~~ 6,450 curie* ^{137}Cs source is located in the northeast part of the BNL site, 1,010 meters (3,310 ft; 0.628 miles) from the north boundary. The dose rate at this boundary during ~~1974~~ 1971, as determined by the BNL Environmental Monitoring Group, was ~~6.3~~ 4.7 mR/yr, or 1.3% of the Radiation Protection Standard.

Dose rates at more distant off-site locations are too low to be measured directly, but can be computed by application of appropriate analytical methods described by Cowan and Meinhold [26], based on the work of Berger [27].

The propagation of gamma radiation in this case is described by the following equation:

$$D = D_o\ (S/r^2)\, e^{-\mu_o r}\, BK$$

where

D = dose rate at distance r;

D_o = dose rate at unit distance;

S = source strength;

r = distance from source;

μ_o = narrow-beam absorption coefficient;

B = dose buildup factor;

K = ground correction factor.

Since D_o and S remain constant, the drop-off of dose rate beyond the site boundary is controlled by the four factors $1/r^2$, $e^{-\mu_o r}$, B, and K. For ^{137}Cs, $\mu_o = 9.58 \times 10^{-5}\ cm^{-1}$ for average atmospheric pressure and temperature. Values of dose rate vs. distance due to the BNL gamma-forest source are given below. The product of $e^{-\mu_o r}$, B, and K is tabulated as transmission factor.

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*As of 1/1/74.

Distance from source, miles	Inverse-square factor	Transmission factor	Dose rate, mR/yr
0.628	1	1	~~6.3~~ 4.7
0.878	0.511	5.01×10^{-2}	~~0.163~~ 0.122
1.128	0.310	2.46×10^{-3}	~~0.00480~~ 3.58×10^{-3}
1.378	0.208	1.205×10^{-4}	1.18 ~~1.58~~ $\times 10^{-4}$
1.628	0.149	5.81×10^{-6}	4.07 ~~5.45~~ $\times 10^{-6}$
1.878	0.112	2.82×10^{-7}	1.49 ~~2.00~~ $\times 10^{-7}$
2.128	0.087	1.38×10^{-8}	5.04 ~~7.56~~ $\times 10^{-9}$
2.378	0.070	7.00×10^{-10}	2.31 ~~3.10~~ $\times 10^{-10}$
2.628	0.057	3.39×10^{-11}	9.18 $1.23 \times$ ~~10^{-11}~~ 10^{-12}

Population doses beyond the site boundary due to this source have been computed using a population count by segments centered on the HFBR stack. Average dose rates for each population segment and for each distance from the source are given in Table XXIX.

Since the dose rate from this source decreases very rapidly with distance, only population segments located <3 miles from the source need be considered. The total off-site dose is 0.10 person-rem/yr, and appreciable contributions are found only in the NNE and NE sectors.

Doses Due to Alternating Gradient Synchrotron

The Alternating Gradient Synchrotron (AGS) is a 33-GeV proton synchrotron located 1,180 meters from the nearest site boundary. Although the machine is heavily shielded, some neutrons do escape through it or from areas where experiments are in progress. Some of these neutrons reach off-site areas either directly, or in most cases, by scattering from the air, which is called skyshine.

The dose rates due to AGS skyshine have been measured at a distance of 850 meters from the machine, and the relationship between these dose rates and values of the AGS circulating beam intensity has been established. From this

relationship and machine operating records, the dose due to AGS operation during ~~1974~~ at a distance of 850 meters is estimated as ~~2.0 ± 50%~~ 11 ± 13 mrem.

The decrease in dose rate at distances >850 meters is due to an inverse-square factor and exponential absorption by the air. Measurements of dose rate previously made at various distances out to 900 meters by the AGS Health Physics Research Group indicate that the dose rate decreases with a relaxation length of 600 meters. Values of dose rate beyond the site boundary can be computed by using the following equation:

$$\text{mrem/yr} = 2.0(854/r)^2 e^{-(r-854)/600}$$

where r = distance in meters from the AGS centroid.

Values of dose rate in mrem/year for a selection of distances from the AGS are shown in the following table:

r, km	$(854/r)^2$	$(r-854)/600$	$e^{-(r-854)/600}$	mrem/yr
1	0.73	0.243	0.784	~~1.05~~ 0.78
2	0.182	1.91	0.148	0.0540 0.297
3	0.0811	3.58	0.0279	0.00453 0.0249
4	0.0455	5.25	0.00525	0.000476 0.00262
4.5	0.0360	6.08	0.00229	0.000165 0.000907
5	0.0291	6.90	0.00101	0.0000589 0.000324

At the site boundary nearest to the AGS, about 1.0 Km to the northwest, the dose rate was about ~~1.1~~ 5.8 mrem/yr, or ~~0.2%~~ 1.2% of the radiation protection standard.

Population doses beyond the site boundary due to this source have been computed, with use of an available population count with relation to the HFBR stack. Average dose rates for each population segment and for each distance from the source are also given in Table XXIX.

Since the dose rate from this source decreases rapidly with distance, only population segments with radii of 1 to 2 and 2 to 3 miles need be considered. The total off-site dose was 0.045 person-rem/yr, and appreciable contributions were found only in the NW and NNW sectors.

Total Population Dose

The total population dose beyond the site boundary due to BNL operations during 1974 is the sum of the values due to the five components discussed above, as shown below:

	Person-Rem
Airborne effluents	6.70
Liquid effluents	0.49
Gamma-forest source	0.10
AGS skyshine	0.05
Total	7.34

The total annual dose, due to external radiation from natural background, to the population within a 50-mile radius of BNL amounts to about 400,000 person-rems, to which about 127,000 person-rems should be added for internal radioactivity from natural sources.

APPENDIX A

QUALITY CONTROL

The accuracy of the reported measurements of radioactivity is established by the use of standards supplied by the National Bureau of Standards (NBS), U. S. Department of Commerce. These are generally available within an uncertainty range of 1 - 5%. Alternatively, for nuclides not available from NBS, standards within a similar uncertainty are obtained from Amersham/Searle. Daily checks of counter and/or gamma system performance are made using point sources of ^{36}Cl, ^{60}Co, ^{137}Cs and ^{239}Pu.

The Analytical Laboratory of the Health Physics and Safety Division also participates in intercomparisons of radioactivity in samples of air filters, water and other media distributed by the International Atomic Energy Agency.

Procedures for nonradioactive contaminants are those presented in Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971. 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.

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TABLE I

1974 BNL ENVIRONMENTAL MONITORING
BACKGROUND AND SOURCE RADIATION LEVELS
(mrem/wk)*

Month	P-2	P-4	P-7	Northeast Perimeter (Source)*	Northeast Perimeter (Total)	All Stations** (Background)
January	1.27	1.33	1.38	0.08 E	1.41 E	1.33
February	1.34	1.45	1.44	0.08 E	1.49 E	1.41
March	1.33	1.60	1.54	0.09 E	1.61 E	1.50
April	1.60	1.63	1.53	0.10 E	1.69 E	1.59
May	1.60	1.63	1.53	0.06	1.65	1.59
June	1.52	1.48	1.67	0.12	1.68	1.56
July	1.51	1.43	1.54	0.20	1.69	1.49
August	1.36	1.38	1.46	0.17	1.57	1.40
September	1.53	1.48	1.51	0.17	1.68	1.51
October	1.36	1.41	1.43	0.10	1.50	1.40
November	1.60	1.63	1.64	0.14	1.76	1.62
December	1.71	N.A.	1.68	0.10 E	1.80 E	1.70
Average	1.46	1.48	1.53	0.12	1.63	1.51
Error (2 S.D.)	±0.22	±0.15	±0.15	±0.07	±0.07	±0.18
Total (mrem/yr)	76.0	77.0	79.5	6.3	84.8	78.5
Radiation Protection Std. for Uncontrolled Areas (4)	-	-	-	500	-	-

*Source level derived by subtracting average background at other stations from total measured level at northeast perimeter. Values estimated 1/74 - 4/74 and 12/74 from source level derived for station 800 meters south of perimeter.

**Average of P-2, P-4 and P-7, unaffected by BNL on-site radiations or effluents.

E Estimated by assuming ratio of measured 1974 May - November data to previous years data for these months also applicable to January - April and December 1974, for which TLD data not obtained.

TABLE II

1974 BNL ENVIRONMENTAL MONITORING
BNL GASEOUS EFFLUENT RELEASE LOCATIONS
AND ON-LINE MONITORING AND SAMPLING DEVICES

Building	Facility and release point Radioactive Effluents	Release Height (ft)	Principal Nuclide(s)	On-Line Monitoring	Sampling Devices
490	Medical Research Center Roof Stack	45	Tritium (vapor)	None	Dessicant for tritium vapor
491	Medical Research Reactor Stack	150	Argon-41	Moving tape for radioparticulates; charcoal for radioiodines	None
555	Chemistry Building Roof Stack	55	Tritium (vapor)	None	Dessicant for tritium vapor
705	High Flux Beam Reactor/ Hot Laboratory Stack	320	Tritium (vapor)	Beta scintillator for radioactive gases; Kanne chamber for tritium (gas + vapor)	Dessicant for tritium vapor; particulate filter for gross beta; charcoal cartridge for radioiodines
901	Van de Graaff Accelerator Roof	60	Tritium (gas + vapor)	Kanne chamber for tritium (gas + vapor)	Dessicant for tritium vapor *
931	Linac Isotope Facility	60	Tritium (vapor) Oxygen-15	G-M detector for radiogases	Dessicant for tritium vapor
Steam Plant Effluents					
610	Central Steam Plant Stack	65	Particulates; SO_2; NO_x	None	None

* Tritium gas releases are derived from the total tritium releases, as established by the Kanne Chamber.

TABLE III

1974 BNL ENVIRONMENTAL MONITORING
AIRBORNE EFFLUENT DATA

Radioactive Effluents

Building	Facility & Release Point	Elevation*	Nuclide	Amount (Ci)
491	Medical Research Reactor Stack	150'	^{41}Ar	450.4**
490	Medical Research Center Stack	45'	^{3}H (vapor)	4.3
555	Chemistry Building Stack	55'	^{3}H (vapor)	94.7
705	High Flux Beam Reactor/Hot Laboratory Stack	320'	^{3}H (vapor)	305.7
			Gross beta (particulate)	9.1×10^{-5}
901	Van de Graaff Accelerator Stack	60'	^{3}H (gas)	697.3
			^{3}H (vapor)	15.2
931	Linac Isotope Producution Facility	60'	^{3}H (vapor)	8.7×10^{-2}
			^{15}O	22,750***

*Above ground level.

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

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

TABLE IV

1974 BNL ENVIRONMENTAL MONITORING
EMISSION OF SO_2, NO_x, AND PARTICULATES
FROM CENTRAL STEAM PLANT (Bldg. 610)

	Total Kg	Calculated Stack Conc.	Average Boundary Conc.**	EPA Primary Air Quality Standard (5)
SO_2	2.54×10^5*	201 ppm	0.0002 ppm	0.03 ppm
NO_x	2.05×10^5	222 ppm	0.0002 ppm	0.05 ppm
Particulates	2.27×10^5	0.50 $\mu g/m^3$***	0.4 $\mu g/m^3$	75 $\mu g/m^3$

*Based on average 0.60% sulfur content.

**Based on average X/Q of $2.4 \times 10^{-7} \frac{sec}{m^3}$ calculated by BNL Meteorology Group.

***Based on measured average value during 2/74 stack sampling conducted on main stream boiler unit.

TABLE V

1974 BNL ENVIRONMENTAL MONITORING MONTHLY AVERAGE GROSS ALPHA AND GROSS BETA CONCENTRATIONS, AIR PARTICULATE FILTERS (pCi/m^3 or 10^{-12} $\mu Ci/ml$)

		Gross Alpha				Gross Beta			
Month	Location	No.	Average	Maximum	Minimum	No.	Average	Maximum	Minimum
Jan.	Waste Packaging	17	.0010	.0023	.0002	17	.1473	.5410	.0319
	S.W. Perimeter					4	.0713	.0954	.0425
	N.E. Perimeter					4	.0874	.1040	.0695
Feb.	Waste Packaging	19	.0009	.0015	.0002	19	.1416	.2740	.0724
	S.W. Perimeter					4	.0917	.1440	.0631
	N.E. Perimeter					4	.1266	.1750	.1060
March	Waste Packaging	25	.0008	.0020	.0002	25	.2433	.4930	.1370
	S.W. Perimeter					5	.1660	.2080	.1090
	N.E. Perimeter					5	.2159	.2710	.1590
April	Waste Packaging	20	.0009	.0021	.0001	20	.3539	.7010	.0906
	S.W. Perimeter					4	.2513	.3460	.1950
	N.E. Perimeter					4	.3243	.4260	.2240
May	Waste Packaging	18	.0007	.0028	.0001	18	.3803	1.1000	.0522
	S.W. Perimeter					4	.2885	.5330	.1030
	N.E. Perimeter					4	.3611	.5850	.2440
June	Waste Packaging	24	.0006	.0035	.0000	26	.2079	.7030	.0203
	S.W. Perimeter					6	.2162	.3410	.1000
	N.E. Perimeter					5	.2064	.3670	.0852
July	Waste Packaging	20	.0010	.0044	.0001	20	.1999	.3220	.0752
	S.W. Perimeter					4	.1788	.1890	.1650
	N.E. Perimeter					4	.1916	.2310	.1680
August	Waste Packaging	20	.0007	.0016	.0001	19	.1245	.2030	.0589
	S.W. Perimeter					4	.1182	.1780	.0275
	N.E. Perimeter					4	.1322	.1520	.1160
Sept.	Waste Packaging	21	.0008	.0015	.0001	21	.1061	.1840	.0434
	S.W. Perimeter					5	.0982	.1350	.0759
	N.E. Perimeter					5	.0988	.1130	.0877
Oct.	Waste Packaging	20	.0015	.0188	.0001	20	.0831	.2990	.0226
	S.W. Perimeter					4	.0508	.0724	.0314
	N.E. Perimeter					4	.0656	.0697	.0620
Nov.	Waste Packaging	19	.0006	.0017	.0001	19	.0903	.2230	.0295
	S.W. Perimeter					4	.0873	.1010	.0780
	N.E. Perimeter					4	.0589	.0898	.0033
Dec.	Waste Packaging	23	.0007	.0018	.0001	23	.0750	.2070	.0297
	S.W. Perimeter					5	.0655	.0781	.0505
	N.E. Perimeter					5	.0765	.1240	.0016
Average	Waste Packaging	246	.0008	.0188	.0000	247	.1791	1.1000	.0203
	S.W. Perimeter					53	.1444	.5330	.0275
	N.E. Perimeter					52	.1608	.5850	.0016
Est. % Error of Individual Sample			± 25%				± 10%		
Radiation Concentration Guide[4] for Unidentified Mixtures			0.100				100		

TABLE VI

1974 BNL ENVIRONMENTAL MONITORING
AVERAGE TRITIUM VAPOR CONCENTRATIONS IN AIR
(pCi/m^3 or 10^{-12} $\mu Ci/ml$)

Period	Waste Management Area	S.W. Perimeter	N.E. Perimeter	Background*
12/3/73-2/7/74	9.3	10.1	24.7	2.5
2/7 - 4/3	11.9	9.3	10.4	
4/3 - 5/1	Samples lost due to process malfunction			2.4
5/1 - 6/3	17.5	< 5.5	6.1	
6/3 - 7/1	45.6	22.8	23.1	
7/1 - 7/29	192.0	19.1	28.4	1.0
7/29 - 8/26	43.8	7.2	5.4	
8/26 - 9/30	48.4	12.7	19.3	
9/30 - 12/10	34.7	39.2	22.0	N.A.
Average	63.9	34.6	34.6	2.0
Radiation Concentration Guide (4)	2×10^5	2×10^5	2×10^5	

*Calculated from concentration of tritium in precipitation collected off-site.

TABLE VII

1974 BNL ENVIRONMENTAL MONITORING
MONTHLY AVERAGE CONCENTRATIONS OF GROSS BETA ACTIVITY
AND OF GAMMA-EMITTING NUCLIDES IN MONTHLY COMPOSITE
AIR PARTICULATE FILTERS AND CHARCOAL FILTERS

(pCi/m^3 or $10^{-12}\mu Ci/ml$)

Month	Average $G\beta$*	^{7}Be	^{65}Zn	^{95}Zr-Nb	^{106}Ru	^{131}I**	^{137}Cs	^{144}Ce
January	0.103	0.152	0.152	0.014	0.001	<0.0002	0.001	0.007
February	0.120	0.158	0.159	0.032	0.007	<0.0002	0.001	0.014
March	0.212	0.207	0.207	0.053	0.014	<0.0002	0.002	0.028
April	0.310	0.201	0.201	0.082	0.027	<0.0002	0.005	0.042
May	0.340	0.168	0.168	0.077	0.032	<0.0002	0.006	0.047
June	0.211	0.131	0.131	0.047	0.027	<0.0002	0.005	0.035
July	0.189	0.138	0.138	0.023	0.022	0.0002	0.005	0.034
August	0.125	0.129	0.129	0.017	0.013	<0.0002	0.003	0.022
September	0.100	0.127	0.127	0.019	0.007	<0.0002	0.001	0.016
October	0.067	0.093	0.093	0.012	0.010	<0.0002	0.001	0.007
November	0.078	0.114	0.114	0.026	0.009	<0.0002	0.001	0.011
December	0.073	0.099	0.099	0.020	0.005	<0.0002	0.001	0.011
Average	0.161	0.143	0.143	0.035	0.014	<0.0002	<0.001	0.023
Estimated Error of Individual Sample %	±10	±25	±25	±25	±25	±100	±50	±50
Radiation Concentration Guide (4)	100	$4x10^4$	$2x10^3$	$1x10^3$	200	100	500	200

*All stations.

**Charcoal filter collections, all other nuclides collected on particulate filters.

TABLE VIII

1974 BNL ENVIRONMENTAL MONITORING
MONTHLY AVERAGE GROSS BETA CONCENTRATION
TOTAL GROSS BETA ACTIVITY AND INDIVIDUAL NUCLIDE
ACTIVITY IN PRECIPITATION

Month	Amount (cm)	Avg. GB Conc. (pCi/l or $10^{-9}\mu Ci/ml$)	Nuclide Activity (nCi/m^2 or $10^{-3}\ \mu Ci/m^2$)										
			^{7}Be	^{22}Na	^{54}Mn	^{65}Zn	^{90}Sr	^{95}Zr-Nb	^{125}Sb	^{131}I	^{137}Cs	^{140}Ba-La	^{144}Ce	GB
Jan.	9.65	32.1												3.10
Feb.	4.86	57.6												2.80
March	10.58	70.3	18.36	0.46	0.11	0.34	0.16	4.95	<.10	<.10	0.28	<.10	1.34	7.44
April	9.45	70.4												6.60
May	7.23	72.9												5.27
June	6.41	65.5	66.27	1.37	<.10	1.48	0.20	12.73	1.03	<.10	2.34	<.10	3.45	4.20
July	2.11	44.1												.93
August	3.00	10.3												.31
Sept.	16.09	11.2	7.47	0.14	<.10	0.21	0.06	0.63	<.10	<.10	<.10	.08	<.10	1.80
Oct.	5.49	9.8												.54
Nov.	3.91	14.6												.57
Dec.	13.21	17.6	10.35	0.18	<.10	0.12	0.10	1.54	<.10	<.10	.22	<.10	.95	2.32
Total:	91.99		~~102.45~~	~~2.15~~	<0.41	~~2.15~~	0.52	~~19.85~~	<1.33	<0.40	~~2.89~~	<0.38	~~5.84~~	35.88
Average:		39.0	42.7	0.92		0.92		8.40	<0.40		0.78		2.74	
Radiation Conc.* Guide (4)		$3x10^3$												

*For release to uncontrolled areas of mixture of radionuclides containing <10% ^{90}Sr, $^{125\text{-}133}I$, or longer lived alpha-emitting nuclides.

TABLE IX

1974 BNL ENVIRONMENTAL MONITORING
MONTHLY AVERAGE TRITIUM CONCENTRATION
AND ACTIVITY IN PRECIPITATION

Concentration (pCi/l or 10^{-9} μCi/ml)

Month	Location P-2	P-4	P-7	P-9	BNL Sewage Treatment Plant	Off-Site
January - March	117	106	127	96	188	99
April - June	268	254	172	270	257	207
July - September	211	203	106	176	201	137
October - December	233	N.A.	N.A.	895	549	140
Yearly Average*	204	155	134	365	549	144
Estimated Error	±41	31	27	73	110	29
Radiation Conc. Guide (4)**	3×10^6	3×10^6	3×10^6	3×10^6	3×10^6	3×10^6

Deposition (nCi/m^2 or 10^{-3} μCi/m^2)

Total***	1,876	1,424	1,231	4,184	2,784	1,324

*Quarterly concentrations weighted on basis of amount of precipitation collected on-site in the calculation of yearly average.

**For tritium in water released to the off-site environment.

***Calculated for other locations on the basis of measured volume of precipitation at sewage treatment plant.

TABLE X

1974 ENVIRONMENTAL MONITORING
TOTAL ACTIVITIES AND AVERAGE CONCENTRATIONS OF IDENTIFIABLE NUCLIDES IN LIQUID EFFLUENTS

CLARIFIER (mCi)

Month	Flow x 10^{10} cm^3	^3H (THO)	^7Be	^{22}Na	^{24}Na*	^{51}Cr	^{54}Mn	^{57}Co	^{58}Co	^{60}Co	^{65}Zn	^{90}Sr	^{95}Zr-Nb	^{125}Sb	^{127}Cs	^{131}I	^{132}Cs	^{134}Cs	^{137}Cs	^{144}Ce	GS**
January	8.66	918	13.51	0.31	15.03	1.53	0.52	0.18	0.63	<0.02	0.23	0.09	<0.03	<0.01	<0.05	2.00	<0.05	0.07	0.09	<0.40	37.40
February	9.58	1,513	12.03	0.12	10.70	1.17	0.14	0.05	0.14	<0.02	0.08	0.08	<0.03	<0.01	<0.05	1.84	<0.05	0.07	0.50	<0.29	28.92
March	12.86	3,528	62.60	0.34	50.60	2.82	0.29	0.06	0.35	0.23	<0.05	0.17	0.05	<0.01	<0.05	2.67	<0.05	0.04	2.16	0.37	130.89
April	11.25	894	58.00	0.41	41.60	2.36	0.34	0.14	0.45	<0.02	0.21	0.10	<0.03	<0.01	<0.05	3.10	<0.05	0.10	0.63	<0.60	118.92
May	12.68	1,228	52.50	0.44	34.60	0.55	0.68	0.37	1.37	0.22	0.73	0.06	<0.03	<0.01	<0.05	0.58	<0.05	<0.03	0.66	<0.48	104.28
June	16.31	612	24.05	0.09	10.28	0.82	0.43	0.29	0.61	0.19	0.38	0.06	<0.03	<0.01	<0.05	0.49	<0.05	<0.03	0.17	<0.25	41.06
July	14.40	1,141	6.45	0.08	2.88	0.76	0.27	0.13	0.18	0.08	0.21	0.05	<0.03	<0.01	<0.05	1.11	<0.05	0.04	1.05	<0.26	14.42
August	14.87	1,509	15.58	0.23	19.30	0.42	0.18	0.06	<0.05	<0.02	0.15	0.09	0.06	<0.01	<0.05	1.21	<0.05	0.19	0.50	<0.30	41.04
September	18.57	2,560	27.10	1.13	20.50	1.57	0.30	<0.05	<0.05	0.34	<0.05	0.14	0.29	0.66	4.52	3.28	8.19	0.37	0.76	0.11	68.37
October	12.94	435	9.65	0.13	0.58	1.49	0.04	<0.05	0.19	0.59	0.95	0.06	<0.03	<0.01	<0.05	2.17	<0.05	0.01	0.25	<0.41	19.06
November	12.09	711	7.29	0.51	<0.10	<0.10	0.16	0.14	<0.05	0.15	<0.05	0.84	0.16	<0.01	<0.05	1.71	20.68	1.18	2.21	<0.10	38.19
December	13.55	1,870	2.93	0.19	<0.10	0.64	0.63	<0.05	<0.05	0.43	0.13	4.86	<0.03	0.16	<0.05	0.83	<0.05	1.30	21.49	<0.73	69.78
Total	157.76	16,919	291.69	3.98	206.17	14.18	3.98	1.50	4.02	2.27	3.15	6.60	<0.80	<0.92	<5.07	21.09	<29.37	3.40	30.47	<3.12	712.33
Avg. Conc. (pCi/l or 10^{-9} µCi/ml)		10,750	184.0	2.5	130.1	9.0	2.5	1.0	2.5	1.5	2.0	4.2	<0.5	<0.6	<3.2	1.34	<18.6	2.2	19.4	<2.0	452.0
% of Total			41	1	29	2	1	<1	1	<1	<1	1	<1	<1	<1	3	<4	<1	4	<1	100

CHLORINE HOUSE (mCi)

January	6.94	692	0.51	0.09	3.03	0.32	0.03	0.03	0.08	0.01	0.03	0.06	<0.02	<0.01	<0.05	0.34	<0.02	0.03	0.48	<0.07	4.73
February	7.24	1,270	0.40	0.04	4.55	0.36	0.01	<0.01	<0.01	<0.01	0.03	0.08	<0.02	<0.01	<0.05	0.33	<0.02	0.02	0.50	0.09	6.94
March	8.66	2,918	1.01	0.05	14.25	0.50	0.04	<0.01	<0.01	0.05	<0.03	0.18	<0.02	<0.01	<0.05	0.53	<0.02	<0.02	0.36	<0.15	18.03
April	7.30	621	1.20	0.09	11.42	0.34	0.03	0.02	<0.01	0.04	<0.03	0.10	<0.02	<0.01	<0.05	0.22	<0.02	0.05	0.41	<0.08	15.43
May	9.31	907	1.39	0.28	15.23	0.14	0.07	0.03	0.05	0.02	0.17	0.07	<0.02	<0.01	<0.05	0.21	<0.02	<0.02	0.43	<0.17	19.48
June	10.38	441	1.28	0.11	2.62	0.25	0.04	0.04	0.07	<0.01	0.11	0.07	<0.02	<0.01	<0.05	0.09	<0.02	<0.02	0.57	<0.07	6.56
July	9.30	667	0.23	0.04	1.27	0.27	0.03	0.01	0.02	0.05	0.09	0.07	<0.02	<0.01	<0.05	0.28	<0.02	0.02	0.47	0.08	3.17
August	10.18	1,166	0.41	0.03	5.03	0.14	0.02	0.02	<0.01	0.02	0.06	0.07	<0.02	<0.01	<0.05	0.33	<0.02	0.02	0.35	0.05	7.17
September	12.51	1,710	0.74	0.57	4.32	<0.10	0.03	<0.01	<0.01	0.04	<0.03	0.08	0.04	<0.01	<0.05	0.11	0.08	<0.01	0.39	0.14	7.72
October	5.56	122	0.28	0.25	0.37	<0.10	<0.01	<0.01	<0.01	<0.01	<0.03	0.05	0.02	<0.01	<0.05	0.02	<0.02	<0.02	0.35	<0.13	1.71
November	7.69	384	0.54	0.17	<0.10	<0.10	0.01	<0.01	<0.01	<0.01	<0.03	0.10	0.02	<0.01	<0.05	0.03	<0.02	0.05	0.43	<0.10	2.91
December	10.64	1,390	0.37	0.24	<0.10	<0.10	0.03	<0.01	<0.01	0.03	<0.03	0.95	0.03	<0.01	<0.05	0.05	<0.02	0.04	0.61	<0.15	8.99
Total	105.71	12,288	8.36	1.96	62.19	2.52	0.35	0.18	<0.30	0.28	0.58	1.88	<0.27	<0.12	<0.60	2.54	<0.30	0.28	5.35	<1.28	102.84
Avg. Conc. (pCi/l or 10^{-9} µCi/ml)	5325	11,600	7.9	1.9	58.0	2.4	0.3	0.2	<0.3	0.3	0.6	1.8	<0.3	<0.2	<0.6	2.4	<0.3	0.3	5.1	<1.2	97.3
% of Total	5327 4678		8	2	61	2	<1	<1	<1	<1	1	2	<1	<1	<1	2	<1	<1	5	<1	100

*Estimated from otherwise unaccounted for activity and occasional daily sample analysis.

**Includes γ-only emitters, does not include ^3H.

TABLE X (Cont'd.)

GROUND WATER (Sand Filter Beds) (mCi)

	Flow $\times 10^{10}$ cm^3	(HTO)	^{7}Be	^{22}Na	^{24}Na*	^{51}Cr	^{54}Mn	^{57}Co	^{58}Co	^{60}Co	^{65}Zn	^{90}Sr	^{95}Zr-Nb	^{125}Sb	^{127}Cs	^{131}I	^{132}Cs	^{134}Cs	^{137}Cs	^{144}Ce	GB*
Total	47.76	5,550	3.77	0.89	29.04	1.14	0.16	0.08	<0.13	0.13	0.26	0.85	<0.12	<0.09	<0.28	1.15	<0.13	0.13	2.42	<0.58	46.45
Avg. Conc. (pCi/l or 10^{-9} µCi/ml)		11,600	7.9	1.9	58.8	2.48	0.3	0.2	<0.3	0.3	0.6	1.8	<0.3	<0.2	<0.6	2.4	<0.3	0.3	5.1	<1.2	97.3
% of Total		-	8	2	61	2	<1	<1	<1	<1	1	2	<1	<1	<1	2	<1	<1	5	<1	100
									UPLAND RECHARGE (mCi)												
Total	5.27	348	5.96	0.08	2.80	0.29	0.08	0.03	0.08	0.03	0.07	0.17	<0.02	<0.01	<0.03	0.44	<0.06	0.07	0.64	<0.07	10.97
Avg. Conc. (pCi/l or 10^{-9}µCi/ml)		10,750	18.44	2.52	4.82	9.0	2.5	0.96	2.54	0.96	2.00	4.2	<0.51	<0.2	<0.6	13.39	<1.86	2.16	19.35	<1.98	20.80
% of Total		-	54		25	3	1	<1	1	<1	1	2	<1	<1	<1	4	<1	1	6	<1	100
Radiation Conc.** Guide (pCi/l or 10^{-9} µCi/ml) (4)		3×10^{6}	2×10^{6}	4×10^{4}	2×10^{5}	2×10^{6}	1×10^{5}	5×10^{5}	1×10^{5}	5×10^{4}	1×10^{5}	300	6×10^{4}	1×10^{5}	4×10^{6}	300	1×10^{5}	9×10^{3}	2×10^{4}	1×10^{4}	3×10^{3}**

*Includes γ-only emitters; does not include ^{3}H.

**For mixtures of radionuclides containing <10% ^{90}Sr, $^{125\text{-}133}I$, or long-lived alpha-emitters.

TABLE XI

1974 BNL ENVIRONMENTAL MONITORING
TOTAL ACTIVITIES AND AVERAGE CONCENTRATIONS OF IDENTIFIABLE NUCLIDES IN LIQUID EFFLUENTS

FORMER PERIMETER - (mCi)

Month	Flow $\times 10^{10}$ cm^3	HTO	^{7}Be	^{22}Na	^{24}Na	^{51}Cr	^{54}Mn	^{57}Co	^{58}Co	^{60}Co	^{65}Zn	^{90}Sr	^{95}Zr-Nb	^{131}I	^{132}Cs	^{134}Cs	^{137}Cs	^{144}Ce	GB*
January	14.26	650	0.30	0.06	2.75	0.28	0.03	0.01	0.05	0.02	<0.02	0.12*	<0.01	0.29	<0.01	0.02	0.23	0.06	5.50
February	15.50	1,270	0.15	0.02	2.05	0.12	0.01	0.01	<0.01	<0.01	<0.02	0.13*	<0.04	0.06	<0.01	0.05	0.18	<0.05	3.14
March	20.60	2,920	0.78	0.06	7.41	0.45	0.03	<0.01	<0.01	0.03	<0.02	0.17*	0.05	0.38	<0.01	0.02	0.36	<0.05	10.08
April	22.00	622	0.89	0.09	9.10	0.25	0.02	0.02	<0.01	0.02	<0.02	0.13	0.05	0.17	<0.01	0.05	0.32	<0.05	11.69
May	22.00	859	0.61	0.15	11.50	0.17	0.02	0.02	0.02	0.02	0.04	0.12	0.02	0.12	<0.01	0.02	0.21	<0.07	14.56
June	19.13	368	0.80	0.09	2.46	0.14	0.02	0.03	0.03	<0.01	0.06	0.12	<0.01	<0.05	<0.01	0.02	0.52	<0.05	4.74
July	11.06	612	0.13	0.04	1.20	0.16	0.01	<0.01	<0.01	0.01	0.03	0.07	<0.01	0.14	<0.01	0.01	0.29	0.06	2.55
August	8.54	1,332	0.31	0.04	2.34	0.16	0.01	<0.01	<0.01	0.02	0.04	0.06	0.01	0.06	<0.01	0.03	0.31	0.07	3.45
September	9.55	1,310	0.32	0.59	2.86	<0.10	<0.01	<0.01	<0.01	<0.01	<0.02	0.07	0.04	<0.05	0.05	<0.01	0.37	<0.05	4.86
October	6.05	124	0.31	0.19	0.29	<0.10	<0.01	<0.01	<0.01	<0.01	<0.02	0.05**	0.02	0.13	<0.01	0.03	0.30	<0.05	1.75
November	7.15	277	0.29	0.13	<0.10	<0.10	0.01	<0.01	<0.01	0.02	<0.02	0.10**	<0.01	0.11	<0.01	0.05	0.33	<0.05	2.32
December	10.36	1,273	0.03	0.42	<0.10	<0.10	0.02	<0.01	<0.01	0.03	<0.02	0.82*	0.05	<0.05	<0.01	0.02	0.54	<0.05	5.54
Total	166.20	11,617	5.19	1.88	42.06	1.93	0.19	<0.16	<0.19	0.19	<0.03	1.96	0.27	1.54	<0.16	0.33	3.96	<0.63	69.78
Avg. Conc. (pCi/l or 10^{-9} μCi/ml)		7,000	3.1	1.1	24.4	1.2	0.1	<0.1	<0.1	0.1	<0.2	1.2	0.2	0.9	<0.1	0.2	2.4	<0.4	42.3
% of Total			7	3	58	3	<1	<1	<1	<1	<1	3	<1	2	<1	<1	6	<1	100

SITE BOUNDARY

January	14.86	534	0.33	0.04	1.09	0.18	0.01	0.01	<0.01	0.01	<0.02	0.16*	0.01	0.10	<0.01	0.03	0.25	<0.03	2.51
February	18.07	1,178	0.12	0.02	1.57	0.09	0.01	0.01	<0.01	<0.01	<0.02	0.20*	<0.01	0.05	<0.01	0.01	0.20	<0.03	2.76
March	20.68	1,529	0.26	0.03	3.04	0.12	0.01	<0.01	<0.01	0.01	<0.02	0.23*	0.03	0.11	<0.01	0.01	0.19	0.05	4.20
April	27.63	809	0.32	0.03	3.53	0.11	0.01	<0.01	<0.01	0.01	<0.02	0.26	0.03	<0.01	<0.01	0.02	0.18	<0.03	5.60
May	26.76	707	0.45	0.05	4.85	0.05	<0.01	<0.01	<0.01	0.03	<0.02	0.25	0.01	<0.01	<0.01	0.03	0.19	<0.03	7.13
June	19.35	371	0.21	0.03	1.64	0.08	0.01	0.01	<0.01	0.01	<0.02	0.19	0.01	<0.01	<0.01	0.01	0.13	<0.03	3.27
July	9.45	344	0.06	<0.01	0.40	<0.05	<0.01	<0.01	<0.01	0.01	<0.02	0.16	<0.01	<0.01	<0.01	<0.01	0.11	<0.03	1.41
August	4.12	390	0.06	0.01	0.30	0.09	0.04	<0.01	<0.01	0.01	<0.02	0.07	<0.01	<0.01	<0.01	0.02	0.10	<0.05	0.87
September	5.53	677	0.19	0.06	0.33	0.05	<0.01	<0.01	<0.01	0.02	<0.02	0.09	<0.01	<0.01	0.02	<0.01	0.14	<0.03	1.17
October	0.34	10	0.02	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.13
November	0.14	6	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.04
December	5.74	566	0.08	0.23	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.02	0.25	0.04	<0.01	<0.01	0.02	0.18	<0.03	2.58
Total	152.67	7,121	2.11	0.53	16.79	0.83	<0.15	<0.12	<0.12	0.13	<0.22	1.88	0.17	<0.35	<0.13	0.17	1.69	<0.36	31.67
Avg. Conc. (pCi/l or 10^{-9} μCi/ml)		4,600	1.4	0.3	11.0	0.5	<0.1	<0.1	<0.1	0.1	<0.2	1.2	0.1	<0.2	<0.1	0.1	1.1	<0.2	20.6
% of Total			7	2	53	3	<1	<1	<1	<1	<1	6	1	<1	<1	1	5	<1	100

GROUND WATER (Stream Bed)

	27.39	2,560	0.87	0.74	3.54	0.27	0.03	<0.03	<0.03	0.05	<0.07	0.56	0.07	0.26	<0.04	0.08	1.12	<0.17	1.70
Avg. Conc. (pCi.l)		9,350	3.15	2.68	12.90	0.99	0.116	<0.12	<0.12	0.17	<0.25	2.03	0.25	0.93	<0.153	0.285	4.06	<0.63	38.9
% of Total			8	7	33	3	<1	<1	<1	<1	<1	5	1	2	<1	1	11	<2	
Radiation Conc. Guide** (pCi/l) (4)		3×10^6	2×10^6	4×10^4	2×10^5	2×10^6	1×10^5	5×10^5	1×10^5	5×10^4	1×10^5	300	6×10^4	300	1×10^5	9×10^3	2×10^4	1×10^4	3×10^{3}**

* Includes gamma-only emitters; does not include tritium.

** For mistures of radionuclides containing <10% ^{90}Sr, $^{125\text{-}133}$I, or long-lived alpha emitters.

TABLE XII -A

1974 BNL ENVIRONMENTAL MONITORING
LIQUID EFFLUENT QUALITY AND PURITY

	Sample	BOD[a] (ppm)	Chlorides (ppm)	Chromium (Hexavalent) (ppm)	Chlorine (Residual) (ppm)	Coliform Total (#/100ml)	Coliform Fecal (#/100ml)	Dissolved Oxygen (ppm)	Dissolved Solids (ppm)	Nitrate Nitrogen	Total Phosphorus	pH	Temp °C
	No.	42	-	12	-	-	-	-	-	-	44	251	248
CLARIFIER	Average	31.8	-	<0.01	b	-	-	-	-	-	1.21	6.7	20.1
EFFLUENT	Maximum	64.8	-	<0.01	-	-	-	-	-	-	2.10	7.5	25
	Minimum	13.2	-	<0.01	-	-	-	-	-	-	0.76	5.5	15
	No.	35	52	12	247	199	189	247	16	52*	52*	247	247
SAND FILTER[d]	Average	1.2	31.4	<0.01	1.2[c]	<6	≤1	8.7	121	2.68	0.75	6.0	15.2
BED EFFLUENT	Maximum	4.0	44.5	<0.01	1.8	(44)	2	12.0	160	4.70	0.98	6.6	25
	Minimum	<0.1	24.7	<0.01	0.0	(<1)	<1	4.8	94	0.70	0.52	5.4	4
	No.		89	-	-	86	74	89	13	89	89	89	89
UPSTREAM OF	Average		8.1	-	-	1,312	44	7.0	46	<0.23	<0.07	5.8	10.7
OUTFALL	Maximum		(12.7)	-	-	(2,542)	(150)	12.4	74	(0.65)	0.10	6.5	22.0
	Minimum		(5.8)	-	-	(338)	(<1)	3.2	35	(<0.10)	<0.05	4.7	1.0
FORMER	No.		52*	-	153	122	118	153	13	52*	52*	153	153
PERIMETER	Average		22.2	-	<0.1	1,030	75	9.3	89	167	0.56	6.2	13.3
(0.5 mi.	Maximum		52.3	-		(2,330)	(330)	12.2	117	3.60	0.98	6.6	25
Downstream)	Minimum		9.2	-		(29)	(<1)	5.0	62	0.40	0.25	5.6	2
BNL	No.		52*	-	-	120	115	143	13	52*	52*	143	143
PERIMETER	Average		22.1	-	-	2,120	62	7.0	95	0.68	0.50	6.5	11.8
(1.6 mi.	Maximum		61.7	-	-	(5,875)	(224)	124	133	2.50	0.81	7.1	25
downstream)	Minimum		11.6	-	-	(268)	(<1)	0.8	68	<0.10	0.25	53	0
WATER[e] QUALITY STANDARD(14,15)	ppm	-	-	-	-	-	-	≥4.0	-	-	-	6.5-8.5	ΔT (16) < + 2.8 T max < 30

* Weekly composite samples.
a Biological oxygen demand.
b 8,381 gal. NaClO added to maintain ~ 0.5 ppm Cl residual in Clarifier outflow.
c 3,204 lb. Cl added.
d Samples obtained in Peconic River after mixing, 150 ft. below Chlorine House.
e Standard for Class "C" waters, which also prohibit other substances injurious to fish life or other substances.

TABLE XII-B

1974 BNL ENVIRONMENTAL MONITORING
CONCENTRATIONS OF METALS IN FILTER BED
EFFLUENT AND IN PECONIC RIVER*

Metal	Upstream		Filter Bed Effluent			0.5 mi. Downstream			Site Boundary			Water Quality Standard**(14,15)
	No.	Conc. ppb	No.		Conc. ppb	No.		Conc. ppb	No.		Conc. ppb	Conc. ppb
Ag	1	<1	4	Avg	<31	4	Avg	97	4	Avg	47	
				Max	70		Max	135		Max	80	
				Min	4		Min	7		Min	2	
Be	1	<1	1		<1	1		<1	1		<1	-
Cd	1	<1	1		1	1		<1	1		<1	
Cr	1	<1	3	Avg	<8	1		2	1		4	
				Max	<12							
				Min	2							
Cu	1	<8	4	Avg	<93	4	Avg	96	4	Avg	<39	
				Max	120		Max	140		Max	50	
				Min	52		Min	42		Min	<30	
Fe	-	-	1		85			-	-		-	-
Hg	1	1	1		<1	1		<1	1		<1	-
Mn	1	9	3	Avg	<19	4	Avg	<34	4	Avg	83	-
				Max	<30		Max	150		Max	60	
				Min	10		Min	2		Min	12	
Pb	1	1	3	Avg	<44	1		4	1		2	-
				Max	<100							
				Min	2							
Zn	1	<8	3	Avg	140	4	Avg	53	4	Avg	40	300
				Max	280		Max	80		Max	50	
				Min	74		Min	30		Min	30	

*Analyses performed by Suffolk Department of Environmental Conservation and by BNL Chemistry Department.

**Standards are applicable to Class "C" waters, which also prohibit other substances injurious to fish life or other best usages within this class.

TABLE XIII

1974 BNL ENVIRONMENTAL MONITORING
GROSS BETA, ^{3}H (HTO) AND ^{90}Sr IN EFFLUENT
APPLIED TO UPLAND RECHARGE EXPERIMENTAL PLOTS

Plot		Flow (m^3)	Gross Beta* Concentration (pCi/l or 10^{-9} µCi/ml)	Gross Beta* Amount (µCi)	^{3}H (HTO) Concentration (nCi/l or 10^{-6} µCi/ml)	^{3}H (HTO) Amount (mCi)	^{90}Sr Concentration (pCi/l or 10^{-9} µCi/ml)	^{90}Sr Amount (µCi)
Pine Forest	- Primary	6,101	69	420	6.0	36.71	4.2	25.6
	- Secondary	6,123	72	439	6.9	41.95	4.2	25.7
Pine Oak Forest	- Primary	4,193	69	290	6.1	25.63	4.2	17.6
	- Secondary	3,820	78	299	7.2	27.66	4.2	11.7
Old Field	- Primary	7,468	71	533	6.0	44.67	4.2	18.8
	- Secondary	7,459	73	547	7.2	53.54	4.2	22.5
Agricultural Field	- Primary	9,701	75	725	6.0	58.62	4.2	24.6
	- Secondary	7,860	78	614	7.4	57.95	4.2	24.3
Total		52,725		3,867		346.73		170.8
Average		4.3x10⁹	73		6.6	28.8	4.2	
Radiation Concentration** Guide (4)			3,000		3,000		300	

*Less HTO, does not include γ-only emitters.

**For mixture of radionuclides containing < 10% ^{90}Sr, $^{125\text{-}133}I$, or long lived alpha emitters.

TABLE XIV

1974 UPLAND RECHARGE PROJECT
PRIMARY AND SECONDARY QUALITY AND PURITY

	No. Samples	Primary Average* (ppm)	No. Samples	Secondary Average* (ppm)	Water Quality Standard (14)
MBAS	50	0.51±0.30	48	0.23±0.24	1.5
BOD	47	3.03±2.81	45	1.08±.80	-
COD	47	10.32±18.47	45	3.26±2.58	-
Total Solids	46	8.41±8.54	45	3.59±2.02	-
Dissolved Solids	46	2.79±5.60	45	1.42±.55	500
Volatile Dissolved Solids	42	1.81±5.77	43	.50±.39	-
Total Volatile Solids	47	5.56±6.66	44	2.10±1.45	-
N in Solids**	37	23.3±1.5	35	8.81±7.19	-
NH_3 - N	52	8.08±4.94	52	4.82±3.85	-
NO_2 - N	52	0.04±0.24	52	0.03±0.23	-
NO_3 - N	52	0.59±1.19	52	0.59±0.60	20.0
PO_4 - P	52	3.02±1.05	52	1.51±0.91	-
SO_4 - S	52	12.6±3.7	52	9.89±2.19	-
Cl	52	32.6±3.6	52	29.4±3.8	500
Mg^{+2}	52	3.92±0.60	52	3.24±0.37	-
Ca^{+2}	52	19.1±5.9	52	13.4±3.2	-
K^{+}	52	6.56±1.83	52	4.20±1.11	-
Na^{+}	52	29.4±4.2	52	24.5±4.1	-
Cu	49	0.76±0.41	48	0.33±0.20	0.4
Fe	53	3.81±2.01	48	1.67±0.93	0.6
Mn	50	0.12±0.06	47	0.05±0.03	0.6
Zn	50	1.93±0.85	47	0.88±0.52	0.6

*The indicated error is one standard deviation.

**N-determination made on suspended solids fraction.

TABLE XV

1974 BNL ENVIRONMENTAL MONITORING
DOWNSTREAM AND CONTROL WATER SAMPLES

GROSS BETA (pCi/l or 10^{-9} μCi/ml)

	Downstream Locations					Control Locations		
Month	A	B	C	D	R**	E	F	H
January	5.6	13.5	4.8	5.7	-	-	4.6	4.6
February								
March	6.7	5.2	4.6	4.3	-	-	4.1	2.9
April	-	-	-	-	6.7	-	-	-
May	9.4	7.2	6.6	7.5	13.0	-	4.3	3.8
June	-	-	-	-	9.4	-	-	-
July	7.5	5.5	4.7	5.5	10.3	2.1	2.2	2.8
August	-	-	-	-	12.6	-	-	-
September	3.0	2.6	3.4	3.6	8.2	4.6	5.4	2.8
October	-	-	-	-	9.2	-	-	-
November	3.4	1.6	3.1	2.6	8.2	5.7	3.3	2.0
December	-	-	-	-	-	-	-	-
Average	5.9 ±2.5	5.9 ±4.2	4.5 ±1.3	4.9 ±1.8	9.7 ±2.2	4.1 ±1.2	4.0 ±1.1	3.1 ±0.9

TRITIUM (HTO) (nCi/l or 10^{-6} μCi/ml)

January	3.3	1.5	<0.6	<0.6	-	-	<0.6	<0.6
February								
March	2.1	2.2	1.3	0.9	-	-	<0.7	<0.7
April								
May	0.8	0.6	<1.0	<1.0	0.5	-	<1.2	<1.2
June								
July	<0.6	0.8	<0.6	<0.6	0.5	<0.6	<0.6	<0.6
August								
September	<0.7	<0.7	<0.7	<0.7		<0.7	<0.7	<0.7
October								
November	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
December								
Average	1.3 ±1.1	1.0 ± 0.8	<0.8	<0.7	0.5	<0.6	<0.7	<0.7

Flow

Radiation Concentration Guide (4): Gross Beta: 3,000 pCi/l**, HTO 3,000 nCi/l, ^{90}Sr 300 pCi/l.

†Riverhead - ^{90}Sr: 4/73-6/73 0.6 pCi/l, 7/73 - 9/73 1.1 pCi/l, 10/73 - 11/73 <1.0.

*Average of weekly composite samples (April - November).

**For mixture of radionuclides containing <10% ^{90}Sr, $^{125-133}$I, and long-lived alpha emitters.

TABLE XVI

1974 BNL ENVIRONMENTAL MONITORING
CONCENTRATIONS OF SELECTED GAMMA-EMITTING
NUCLIDES IN PECONIC RIVER SEDIMENTS

(pCi/~~l~~ or 10^{-9} μCi/~~ml~~ Wet weight)
kg gr

Peconic River Location	No. Samples	^{60}Co	^{65}Zn	^{134}Cs	^{137}Cs	^{144}Ce	K gm/kg
K	2	63	82	74	479	1,759	7.6
L	1	152	112	127	614	1,164	7.6
M	1	28	53	71	308	587	9.0
Q	1	<40	66	88	382	728	9.5
A	1	44	53	117	679	<127	<7.5
B	1	<49	92	107	175	1,168	9.5
C	1	<40	49	47	340	689	7.4
D	1	<40	<36	33	37	353	7.9
R	1	<40	57	<25	87	<143	10.0
Reference							
E Upstream Peconic	2	28	-	131	865	1,047	<7.5
I Artist Lake	1	<40	-	114	108	1,169	8.1
Estimated Error at 95% Confidence Level		±50% or 40	±50% or 25	±25% or 25	±10% or 25	±50%	±50% or 25

TABLE XVII

1974 ENVIRONMENTAL MONITORING
CONCENTRATIONS OF SELECTED GAMMA-EMITTING
NUCLIDES IN PECONIC RIVER VEGETATION*

Station Peconic	No. of Samples	Sample Type	^{7}Be	^{22}Na	^{60}Co	^{65}Zn	^{95}Zr-Nb	^{134}Cs	^{137}Cs	^{144}Ce	K (gm/kg)
			(pCi/kg or 10^{-9} μCi/gm)								
K	1	Grass (unidentified)	2,462	48	108	148	379	43	292	2,477	0.5
L	1	Grass "	3,397	117	143	102	456	<35	832	<1,000	1.1
M	2	Grass "	1,846	52	116	52	340	<25	367	⩽1,000	2.8
A	1	Callatrichae	1,345	110	160	<50	642	<35	269	4,303	1.0
A	1	Carax	526	<50	<30	<50	182	<35	454	2,486	1.6
B	1	Callatrichae	1,567	<50	160	⩽50	616	343	454	⩽1,000	<0.5
B	1	Carax	551	<50	<31	<50	160	76	583	<1,000	0.8
C	1	Ceratuphyllum	862	84	409	<50	390	159	220	<1,000	3.57
D	1	Vallisnaria	760	22	<22	<35	24	34	90	<1,000	3.9
R	1	Vallisnaria	<179	<50	⩽41	<58	37	<20	84	<1,000	4.9
Reference											
E Upstream		Carax	326	<50	⩽27	<150	<158	<15	169	1,534	<0.8
Artist Lake		Carax	198	<50	<15	<11	88	9	37	547	1.5
Estimated Error at 90% Confidence Level			±25% or 100	±50% or 50	±50% or 30	±50% or 50	±50% or 25	±50 or 25	±25% or 25	±50% or 500	±25% or 0.5

*Wet weight. Analyses were made on dried samples and these data adjusted on the basis of an assumed 90% moisture content.

TABLE XVIII

1974 BNL ENVIRONMENTAL MONITORING
CONCENTRATIONS OF γ-EMITTING NUCLIDES
IN ANIMALS OBTAINED FROM PECONIC RIVER

(pCi/kg or 10^{-9} μCi/gm)

Location	No. Samples	Type	^{7}Be	^{22}Na	^{60}Co	^{137}Cs	K gm/kg	Remarks
M	1	Bullhead	162	<25	<25	88	1.1	Composite several whole fish samples
Q	2	Bass	<100	<25	<25	815	2.6	Composite several whole fish samples
Q	1	Bullhead	<100	36	29	279	<1.0	Composite several whole fish samples
C	1	Bullhead	<100	<25	<25	497	2.3	Composite several whole fish samples
C	1	Turtle	<100	<25	<25	445	0.4	Three whole turtles
Estimated Error at 90% Confidence Level			±50% or 100	±50% or 25	±50% or 25	±10% or 50	±25% or 0.5	
Radiation Concentration Guide (4) *			$9x10^{7}$	$2x10^{6}$	$2x10^{6}$	$9x10^{5}$	-	

*Assumed intake of 50 gms/day.

TABLE XIX

1974 BNL ENVIRONMENTAL MONITORING
GROSS BETA AND TRITIUM CONCENTRATIONS
IN POTABLE WATER SUPPLY WELLS

GROSS BETA (pCi/l or 10^{-9} μCi/ml)

Well	1	2	3	4	5	6	7	101	102	103	104	105	W&R
February	1.1	0.9	3.3	1.5	2.1	2.8	1.8	1.1	1.5	1.6	4.6	-	3.9
April	0.8	2.9	5.9	1.6	1.2	3.9	1.1	1.5	1.8	1.8	3.2	2.5	<0.8
June	1.6	2.4	-	1.5	1.4	3.3	1.1	2.1	1.1	2.3	1.9	3.5	1.4
August	3.5	1.9	5.1	1.2	1.1	1.9	1.0	0.8	0.9	1.5	1.8	1.0	<0.7
October	1.0	2.0	3.1	2.3	1.3	2.3	0.7	<0.9	1.8	<1.0	0.7	2.1	<0.9
December	1.6	2.4	4.5	5.1	7.5	3.5	<1.0	1.6	3.0	-	-	-	<1.0
Average	1.6±1.6	2.1±1.1	4.4±1.9	2.2±2.4	2.4+4.1 -2.4	2.4±2.4	1.0+1.6 -1.0	1.3+1.5 -1.3	1.7±1.3	1.5±1.1	2.6±2.1	2.3±1.7	0.2±2.3

Radiation Concentration Guide: 3,000 pCi/l or 3.0×10^{-6} μCi/ml (for unidentified nuclides in the absence of ^{90}Sr, ^{226}R, ^{228}Ra or ^{129}I).

^{3}H (nCi/l or 10^{-6} μCi/ml)

February	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	<0.5
April	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
June	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
August	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
October	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
December	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Average	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6

Radiation Concentration Guide: 3,000 nCi/l or 3.0×10^{-3} μCi/ml.

TABLE XX-A

1974 BNL ENVIRONMENTAL MONITORING
MONTHLY SUMP SAMPLES
GROSS BETA AND ^{3}H CONCENTRATIONS

GROSS BETA (pCi/l or 10^{-9} μCi/ml)

	N North of AGS		O East of HIRDL		P Medical	
Month	No. of Samples	Conc.	No. of Samples	Conc.	No. of Samples	Conc.
January	2	5.5	2	1.3	1	<0.5
February	2	11.4	2	2.0	2	2.1
March	5	6.0	5	4.7	2	2.8
April	4	6.0	4	3.1	3	4.1
May	3	16.8	3	5.6	3	2.8
June	4	3.8	4	3.3	4	2.3
July	3	3.5	3	2.4	3	1.7
August	4	6.6	4	3.2	4	1.9
September	4	4.6	4	3.7	3	2.2
October	5	4.5	5	2.1	5	1.9
November	4	7.6	4	2.7	4	1.8
December	3	7.8	3	5.3	3	3.4
Total:	43		43		37	
Average:		6.6±1.6*		3.3±1.3		2.3±1.4

*± 90% Confidence error

Radiation Concentration Guide[4]: 3,000 pCi/l or 3 x 10^{-6} μCi/ml if $^{125\text{-}133}I$, ^{90}Sr and alpha-emitters absent.

TRITIUM (nCi/l or 10^{-6} μCi/ml)

January	2	<0,5	2	<0.5	2	0.5
February	2	<0.7	2	<0.3	3	<0.5
March	5	<0.7	5	<0.7	4	<0.5
April	4	<0.7	4	<0.7	3	0.6
May	3	<1.0	3	<1.0	3	<0.5
June	4	<0.6	4	<0.6	3	<0.5
July	3	<0.7	3	<0.7	5	<0.6
August	4	<0.6	4	<0.6	5	<0.7
September	4	<0.6	4	<0.6	3	<0.6
October	5	<0.6	5	<0.6	2	<0.7
November	4	<0.5	4	<0.5	4	0.5
December	3	<0.5	3	<0.5	2	<0.5
Total	43		43		39	
Weighted Average		<0.6		<0.6		<0.6

Radiation Concentration Guide[4]: 3,000 nCi/l or 3 x 10^{-3} μCi/ml.

TABLE XX-B

1974 BNL ENVIRONMENTAL MONITORING
RECHARGE BASIN WATER QUALITY AND PURITY

Basin	Sample	Chlorides (ppm)	Coliform (#/100 ml)	DO ppm	Dissolved Solids	Nitrate Nitrogen	Total P	pH	Temp °C
N (N of AGS)	No.	18	13	29	17	19	20	31	36
	Average	18.3	156	9.1	87	0.37	0.37	6.9	18
	Maximum	22	620	10.4	149	0.55	0.81	7.6	24
	Minimum	13	16	7.2	71	0.10	0.15	6.6	11
O (East of HFBR)	No.	17	13	32	15	17	15	31	31
	Average	19	148	8.7	83	0.36	1.61	6.6	19
	Maximum	26	670	10.4	101	0.65	2.59	6.7	27
	Minimum	15	30	7.2	71	0.10	0.71	6.3	13
P (South of MRR)	No.	16	13	30	14	14	15	29	31
	Average	31.1	48	6.1	131	142	0.09	6.1	16
	Maximum	41	180	8.8	159	1.90	0.37	6.6	20
	Minimum	17	0	4.6	111	0.40	<0.05	6.0	12
Water Quality Standard[14]		500	-	-	1,000	20.0	-	6.5-8.5	-

TABLE XXI

1974 BNL ENVIRONMENTAL MONITORING
SAND FILTER BED, PECONIC RIVER AREA, AND MISCELLANEOUS ON-SITE SURVEILLANCE WELLS
GROSS ALPHA, GROSS BETA, TRITIUM, ^{90}Sr AND ^{137}Cs AVERAGE CONCENTRATIONS

Well	Sample No.	Gross α (pCi/l or $10^{-9}\mu Ci/ml$)	Gross β (pCi/l or $10^{-9}\mu Ci/ml$)	HTO* (nCi/l or $10^{-6}\mu Ci/ml$)	^{90}Sr** (pCi/l or $10^{-9}\mu Ci/ml$)	^{137}Cs (pCi/l or $10^{-9}\mu Ci/ml$)
			Sand Filter Bed and Peconic River Area			
XA	6	0.3 ± 0.3	13.3 ± 1.3	16.2 ± 1.0	-	-
XB	6	0.3 ± 0.3	1.8 ± 0.8	≤0.5	<0.1	≤1.0
XC	6	0.6 ± 0.3	5.0 ± 0.9	0.4 ± 0.1	2.0 ± 0.2	<1.0
XD	6	≤0.2	1.1 ± 0.6	1.8 ± 0.6	0.1 ± 0.1	<1.0
XE	8	0.4 ± 0.3	3.7 ± 1.6	<0.8	-	-
XF	1	<0.1	0.7 ± 0.5	<0.7	-	-
XG	8	0.4 ± 0.3	5.6 ± 1.6	2.3 ± 0.8	0.4 ± 0.1	<1.0
XH	6	<0.2	1.1 ± 0.7	≤0.7	≤0.1	<1.0
XI	2	0.3 ± 0.3	2.4 ± 1.0	<0.6	1.0 ± 0.1	<1.0
XJ	2	0.3 ± 0.3	5.6 ± 0.9	<0.8	1.2 ± 0.1	<1.0
XK	9	0.8 ± 0.6	11.9 ± 1.8	6.3 ± 0.9	3.4 ± 0.4	<1.0
XL	6	1.3 ± 0.5	25.3 ± 1.8	5.1 ± 0.7	9.1 ± 0.9	≤1.0
XM	6	6.1 ± 3.8	40.1 ± 2.1	8.8 ± 0.9	33.5 ± 3.4	-
XN	6	1.7 ± 0.5	8.7 ± 1.0	0.1 ± 0.1	1.9 ± 0.2	<1.0
XO	6	0.7 ± 0.3	22.2 ± 1.3	0.3 ± 0.1	2.4 ± 0.2	≤1.0
XQ	5	0.2 ± 0.2	5.8 ± 1.0	4.2 ± 0.8	0.3 ± 0.1	≤1.0
XR	2	0.6 ± 0.3	2.6 ± 0.7	<0.5	1.4 ± 0.2	<1.0
XS	2	1.4 ± 0.6	18.3 ± 1.6	0.2 ± 0.1	4.3 ± 0.4	<1.0
XT	7	<0.3	1.7 ± 1.3	<0.4	≤0.7	≤1.0
XU	3	0.5 ± 0.3	5.0 ± 0.9	≤0.4	2.7 ± 0.3	<1.0
XV	3	0.5 ± 0.4	56.3 ± 2.3	0.3 ± 0.1	≤0.1	≤1.0
XW	2	0.4 ± 0.3	2.4 ± 0.8	<0.6	0.8 ± 0.1	<1.0
XX	6	<0.2	10.8 ± 1.2	3.2 ± 0.9	3.5 ± 0.4	<1.0
XY	6	<0.3	14.5 ± 1.4	3.2 ± 0.4	7.4 ± 0.7	<1.0
XZ	6	≤0.2	2.6 ± 0.7	1.6 ± 0.2	0.2 ± 0.1	≤1.0
X-1	6	<0.2	1.6 ± 0.6	<0.5	0.1 ± 0.1	<1.0
X-2	6	<0.2	1.8 ± 0.7	1.7 ± 0.7	0.2 ± 0.1	<1.0
			Miscellaneous On-Site			
SA	2	<0.2	1.5 ± 0.6	≤0.7	0.2	<1.0
SB	1	<0.2	0.6 ± 0.6	<0.5	0.2	≤1.0
SC	2	<0.1	<0.6	<0.7	0.2	≤1.0
SD	2	≤0.3	1.4 ± 0.8	<0.7	≤0.1	<1.0
SE	2	<0.4	2.4 ± 0.7	0.8 ± 0.1	≤0.1	<1.0
SG	2	<0.2	1.4 ± 0.6	<0.7	-	-
Radiation Conc. Guide (4)		100†	3,000††	3,000	300	2×10^4

*HTO Concentrations less than 1.0 nCi/l established after electrolytic enrichment of one sample

**^{90}Sr and ^{137}Cs Concentrations established from assay of one sample; if total number of samples <6, from assay of two samples of total number of samples > 6.

†If ^{226}Ra and ^{220}Ra <10%

††If $^{125\text{-}133}I$, ^{90}Sr not present

TABLE XXII

1974 BNL ENVIRONMENTAL MONITORING
SOLID WASTE MANAGEMENT AREA, LANDFILL AND DUMP AREA, AND 650 SUMP AREA
GROSS ALPHA, GROSS BETA, TRITIUM, ^{90}Sr AND ^{137}Cs CONCENTRATIONS

Well	Sample No.	Gross Alpha (pCi/l or 10^{-9}µCi/ml)	Gross Beta (pCi/l or 10^{-9}µCi/ml)	HTO* (nCi/l or 10^{-6}µCi/ml)	^{90}Sr** (pCi/l or 10^{-9}µCi/ml)	^{137}Cs (pCi/l or 10^{-9}µCi/ml)
			Solid Waste Management Area			
WB	4	0.5 ± 0.3	79.1 ± 2.7	13.8 ± 0.9	15.9 ± 1.6	<1.0
WC	4	<0.2	22.5 ± 4.6	6.5 ± 0.7	93.3 ± 9.3	<1.0
WD	4	0.7 ± 0.4	34.2 ± 2.0	6.1 ± 0.7	10.6 ± 1.1	<1.0
WE	4	<0.2	6.8 ± 1.0	0.3 ± 0.3	1.7 ± 0.2	<1.0
WI	3	0.4 ± 0.3	6.0 ± 0.9	<0.7	-	-
WJ	3	0.8 ± 0.4	15.7 ± 1.3	0.9 ± 0.5	1.5 ± 0.2	<1.0
WK	4	0.3 ± 0.2	80.1 ± 2.8	1.0 ± 0.6	31.1 ± 3.1	<1.0
WL	4	<0.2	114.2 ± 3.3	<0.6	53.6 ± 5.4	<1.0
WM	1	<0.2	6.1 ± 0.9	0.8 ± 0.5	0.9 ± 0.1	<1.0
W-1	4	<0.2	51.3 ± 2.3	1.7 ± 0.5	18.0 ± 1.8	<1.0
W-2	2	<0.3	8.0 ± 1.1	0.5 ± 0.2	1.7 ± 0.2	<1.0
W-3	2	<0.7	1.2 ± 0.6	0.2 ± 0.2	0.3 ± 0.2	<1.0
W-4	2	<0.2	3.9 ± 0.8	<0.3	0.1 ± 0.1	<1.0
W-5	2	<0.3	3.4 ± 0.8	<0.3	0.1 ± 0.1	<1.0
W-7	2	<0.2	2.0 ± 0.7	0.4 ± 0.1	<0.1	<1.0
W-8	2	0.5 ± 0.3	4.1 ± 0.8	0.4 ± 0.1	0.3 ± 0.2	<1.0
WU	1	<0.2	0.9 ± 0.5	<0.6	0.2 ± 0.1	<1.0
WV	1	<0.2	0.9 ± 0.5	<0.6	<0.1	<1.0
WW	1	<0.2	2.7 ± 0.7	<0.6	<0.1	<1.0
WX	2	<0.2	2.4 ± 0.7	<0.5	0.3 ± 0.2	<1.0
WZ	2	<0.2	2.5 ± 0.8	<0.6	0.1 ± 0.1	<1.0
			Landfill Area			
WF	2	<0.2	1.6 ± 0.7	<0.7	0.2 ± 0.1	<1.0
WG	2	<0.2	1.4 ± 0.7	<0.7	-	-
WR	3	8.8 ± 3.1	84.0 ± 3.8	31.5 ± 1.1	5.3 ± 0.5	0.9 ± 0.5
WT	2	0.7 ± 0.4	1.6 ± 0.7	0.9 ± 0.6	0.3 ± 0.1	<1.0
W-6	2	0.6 ± 0.5	3.8 ± 0.9	0.3 ± 0.1	0.3 ± 0.1	<1.0
W-9	3	6.8 ± 2.9	40.0 ± 2.7	10.8 ± 2.1	7.3 ± 0.7	<1.0
1-K	4	10.7 ± 3.4	43.3 ± 2.5	54.1 ± 5.4	3.8 ± 0.4	<1.0
			Former Dump Area			
WH	1	<0.2	2.4 ± 0.7	<0.6	-	-
WO	2	<0.1	<0.7	<0.7	0.4 ± 0.2	<1.0
WP	2	0.4 ± 0.2	3.4 ± 0.8	4.4 ± 0.8	0.5 ± 0.2	<1.0
WQ	2	<0.2	2.5 ± 0.7	<0.7	<0.1	<1.0
1-I	2	<0.1	<0.7	0.2 ± 0.1	<0.1	<1.0
1-J	3	<0.2	1.9 ± 0.7	6.0 ± 0.8	<0.1	<1.0
1-L	1	15.2 ± 4.5	52.0 ± 3.7	<0.7	0.4 ± 0.2	<1.0
			650 Sump Area			
1-A	2	<0.3	15.5 ± 1.4	0.5 ± 0.2	6.8 ± 0.7	<1.0
1-B	2	<0.1	2.4 ± 0.7	<0.7	0.7 ± 0.1	<1.0
1-C	1	0.3 ± 0.2	2.1 ± 0.6	<0.7	0.5 ± 0.1	3.6
1-D	2	0.2 ± 0.2	1.3 ± 0.6	<0.7	0.4 ± 0.1	<1.0
1-E	2	<0.2	36.6 ± 0.6	<0.6	24.6 ± 2.5	<1.0
1-F	1	<0.2	<1.2	<1.0	0.3 ± 0.1	<1.0
1-G	2	<0.1	2.3 ± 0.7	<0.6	0.2 ± 0.1	<1.0
1-H	2	<0.2	160.4 ± 4.6	<0.6	56.6 ± 5.7	<1.0
Radiation Concentration Guide (4)		100†	3,000††	3,000	300	$2x10^4$

*HTO concentrations less than 1.0 nCi/l established by electrolytic enrichment of one sample

**^{90}Sr and ^{137}Cs concentrations established from assay of one sample.

†If ^{226}Ra and ^{220}Ra absent

††If $^{125\text{-}133}I$ and ^{90}Sr absent

TABLE XXIII

1973 BNL ENVIRONMENTAL MONITORING
UPLAND RECHARGE PROJECT SURVEILLANCE WELLS
GROSS ALPHA, GROSS BETA AND TRITIUM CONCENTRATIONS

Well	No. Samples	Gross α (pCi/l or 10^{-9} μCi/ml)	Gross β (pCi/l or 10^{-9} μCi/ml)	HTO (nCi/l or 10^{-9} μCi/ml)
1M	10	<1.0	7.4 ± 3.3	<0.5
1N	11	<0.6	<1.0	<0.5
1O	11	<0.7	5.0 ± 3.1	3.8 ± 0.9
1P	10	<0.7	3.5 ± 3.1	4.0 ± 0.8
1Q	11	<0.7	10.0 ± 3.5	<0.5
1R	11	<0.5	<3.1	<0.5
1S	11	<0.7	10.7 ± 3.8	<0.5
1T	11	<1.1	7.3 ± 3.4	3.3 ± 0.7
1U	11	3.5 ± 1.6	7.9 ± 4.0	<0.5
1V	8	<0.9	<4.2	<0.5
1W	10	<0.6	<3.4	<0.7
1X	11	<0.8	<3.1	1.0 ± 0.6
1Y	11	<0.6	<9.9	4.3 ± 0.8
1Z	9	<0.5	<3.1	<0.5
1-1	10	<0.7	<3.0	3.2 ± 0.6
1-2	11	<0.6	<3.1	4.6 ± 0.8
1-3	6	<0.6	4.7 ± 2.5	<0.5
1-4	6	<0.6	<2.3	4.0 ± 0.8
1-5	6	<0.6	2.9 ± 1.9	3.8 ± 0.8
Radiation Concentration Guide (4)		100*	3,000**	3,000

*If long-lived alpha emitters not present

**If ^{90}Sr, $^{125-133}I$ not present

TABLE XXIV-A

1974 BNL ENVIRONMENTAL MONITORING
SAND FILTER BEDS, PECONIC RIVER AND MISCELLANEOUS ON-SITE GROUND WATER
SURVEILLANCE WELLS, WATER QUALITY AND PURITY

Well	No. Samples	pH	Chlorides	Coliforms	DO	Dissolved Solids	Nitrate Nitrogen	Total P	Temp °C
				Sand Filter Bed and Peconic River Area					
XA	4	5.6	25	-	5.8	127	4.80	<0.05	17
XB	5	6.3	7.0	-	3.1	51	0.20	<0.05	11
XC	4	5.7	7.2	-	3.0	37	0.10	<0.05	11
XD	5	5.8	4.9	-	4.0	33	1.20	<0.05	12
XE	4	5.3	7.5	-	6.9	45	0.30	0.07	12
XG	4	5.7	16	-	1.9	69	0.20	0.08	10
XH	4	6.0	6.1	-	4.8	38	<0.10	<0.05	10
XI	2	5.4	6.6	-	7.1	39	<0.10	<0.05	11
XJ	1	5.3	4.1	-	1.6	27	-	<0.05	13
XK	5	4.9	21	0.5	1.3	114	0.22	0.09	14
XL	5	6.3	19	0.1	1.2	100	0.30	0.07	13
XM	6	5.8	21	0.3	6.7	83	2.73	0.07	14
XN	6	5.1	6.9	0.7	2.6	54	0.43	0.06	9
XQ	6	6.3	21	-	2.5	87	<0.20	<0.07	12
XR	1	5.8	4.1	-	6.0	25	<0.10	<0.05	11
XS	2	5.5	16	-	2.1	102	2.90	<0.05	11
XT	6	6.8	7.3	-	0.8	104	<0.10	0.13	11
XU	-	-	-	-	-	-	-	-	-
XV	-	-	-	-	-	-	-	-	-
XW	1	5.3	49	-	1.0	118	<0.10	<0.05	12
XX	6	5.5	15	-	0.9	51	<0.10	<0.05	12
XY	5	5.1	16	-	1.5	71	<0.10	<0.05	12
XZ	5	5.6	14	-	6.3	30	<0.20	<0.05	11
X-1	6	5.1	4.7	-	5.7	30	<0.20	<0.05	12
X-2	5	5.6	38	-	1.4	85	<0.20	<0.05	11
				Miscellaneous On-Site					
SA	1	5.5	37	-	3.6	75	-	-	14
SB	1	5.7	6.2	-	2.6	41	<0.10	<0.05	11
SC	2	6.4	8.4	-	7.1	38	<0.10	<0.05	10
SD	2	6.4	8.6	-	7.7	56	<0.10	<0.05	10
SE	2	6.4	31	-	8.2	116	1.50	<0.05	14
SG	2	6.2	7.0	-	5.6	54	<0.10	<0.05	13
Est. Error		±0.1	±0.5		±0.3	±10	±0.10	±0.05	±1
Water Quality Standard (14)		6.5-8.5	500	-	-	1,000	20.0	-	-

TABLE XXIV-B

1974 BNL ENVIRONMENTAL MONITORING
SOLID WASTE MANAGEMENT AREA, LANDFILL AND DUMP AREA, AND 650 SUMP AREA
GROUNDWATER WELLS, WATER QUALITY AND PURITY

Well	Sample No.	pH	Chlorides	Coliforms	DO	Dissolved Solids	Nitrate Nitrogen	Total P	Temp. °C
				Solid Waste Management Area					
WB	4	5.3	13	-	7.0	84	1.60	<0.05	14
WC	4	5.3	13	-	6.9	85	1.30	<0.05	13
WD	4	5.4	19	-	7.0	91	1.00	<0.05	13
WE	3	5.7	9.3	-	8.8	37	0.20	<0.05	12
WI	2	5.6	4.2	-	6.0	47	0.10	<0.05	12
WJ	3	5.3	12	-	8.9	52	0.80	<0.05	11
WK	3	5.4	9.2	-	6.6	57	0.50	<0.05	12
WL	3	5.7	5.0	-	9.4	43	0.60	<0.05	12
WM	1	6.3	5.5	-	7.8	104	0.80	<0.05	13
W-1	3	5.8	12	-	9.3	40	0.20	<0.05	11
W-2	2	5.4	7.0	-	8.5	69	0.90	<0.05	11
W-3	2	6.2	9.4	-	8.2	86	1.90	<0.05	11
W-4	2	5.9	5.4	-	9.6	37	<0.10	<0.05	11
W-5	2	5.6	9.9	-	9.8	41	<0.10	<0.05	11
W-7	1	6.1	7.8	-	9.6	54	1.10	<0.05	11
W-8	2	5.8	5.2	-	9.5	38	<0.10	<0.05	11
WU	1	5.7	7.7	-	9.2	44	<0.10	<0.05	10
WV	1	5.7	7.9	-	9.2	38	<0.10	<0.05	11
WW	1	-	13.	-	-	65	0.30	<0.05	10
WX	2	6.2	12.	-	9.1	50	0.10	<0.05	11
WZ	1	5.9	9.9	-	9.4	48	<0.10	<0.05	10
				Landfill Area					
WF	2	5.8	6.6	-	8.6	40	<0.10	<0.05	12
WG	2	5.6	5.4	-	6.3	36	0.40	<0.05	13
WR	3	6.8	28	-	2.2	663	0.60	0.06	14
WS	2	6.5	69	-	2.4	624	0.40	<0.05	12
WT	2	5.8	10	-	2.9	56	<0.10	<0.05	13
W-6	1	7.0	16	-	0.8	196	0.25	<0.05	10
W-9	3	6.8	84	-	2.2	502	0.90	0.35	12
1-K	2	6.3	59	-	1.4	407	0.20	0.06	12
				Former Dump Area					
WH	1	5.3	7.1	-	7.2	49	1.25	<0.05	15
WO	1	6.0	7.8	-	8.4	46	<0.10	<0.05	11
WP	1	5.1	10.9	-	3.0	66	2.80	<0.05	12
1-I	2	5.8	5.8	-	11.8	32	<0.10	<0.05	11
1-J	2	6.5	9.2	-	7.4	50	0.20	<0.05	11
1-L									12
				650 Sump Area					
1-A	2	6.4	22	-	5.9	100	0.40	0.07	17
1-B	1	6.2	19	-	4.6	81	0.40	<0.05	18
1-C	1	6.2	24	-	6.5	87	0.60	<0.05	17
1-D	1	6.2	18	-	4.4	71	<0.10	0.09	18
1-E	1	6.0	6.8	-	6.0	71	0.80	<0.05	16
1-F	1	6.2	20	-	9.5	88	0.40	0.08	16
1-G	1	6.3	20	-	6.8	93	1.20	<0.05	19
1-H	1	5.8	8.6	-	6.6	94	1.20	0.08	18
Water Quality Standard[14]		6.5-8.5	500	-	-	1,000	20.0	-	-

TABLE XXIV-C

1974 BNL ENVIRONMENTAL MONITORING

UPLAND RECHARGE PROJECT, GROUNDWATER SURVEILLANCE WELLS, WATER QUALITY AND PURITY

Plot	Type	Map No.	No. Samples	pH	Chlorides ppm	Conductivity µmho/cm	Nitrate Nitrogen	Total P ppm	Total Coliforms No. Positive Samples	Total Coliforms Avg. MPN/100	BOD No. Positive Samples	BOD Avg. ppm
Boundary	Control	IN	11	5.2	7.2	44	<0.02	0.02	1	9	3	5.3
	Control	IR	11	5.4	5.5	44	<0.02	0.01	1	2	1	7.9
	Control	IQ	11	5.6	21.	262	0.29	0.02	0	-	3	11.8
	Control	IM	11	5.6	14.	98	0.02	0.02	1	9	4	8.3
Pine & Oak Forest	Primary	IT	11	4.9	31.	198	0.02	0.02	2	2	3	5.3
	Secondary	1-4	6	5.6	26.	134	0.02	0.03	4	6	1	4.0
	Control	IW	11	5.6	19.	100	0.02	0.01	1	2	4	6.4
	Control	IZ	11	5.5	8.7	53	0.02	0.01	1	2	4	5.9
	Control	1-3	6	5.0	6.8	44	0.02	0.01	0	-	3	8.0
Pine Forest	Control	IV	11	5.6	6.0	44	0.02	0.02	0	-	4	7.7
	Primary	IY	11	5.7	30.	162	0.02	0.01	2	7	5	13.2
	Secondary	1-2	11	5.5	27.	121	0.02	0.02	4	3	5	11.1
Old Field Spray Area	Control	IU	11	5.6	4.5	55	0.02	0.02	2	7	3	6.6
	Primary	1-5	6	5.7	23.	124	0.02	0.01	6	12	3	10.5
	Secondary	IX	11	5.7	11.	81	0.02	0.01	1	2	2	6.0
	Secondary	1-1	11	5.6	16.	98	0.02	0.04	0	-	1	4.0
Agricultural Spray Fields	Control	IS	11	5.9	16.	136	0.02	0.02	1	38	3	6.6
	Primary	IO	11	5.8	25.	218	0.02	0.05	1	38	3	5.3
	Secondary	IP	11	5.8	18.	151	0.02	0.02	5	25	4	13.7
Estimated Error				±0.1	±0.5	±10	±0.02	±0.01	-	±1		±0.5
Water Quality Standard (14)				6.0-8.5	500	*	20	-		-		-

* Approx. 0.8 x conductivity indicates upper limit of dissolved solids, for which the standard is 1,000 ppm.

TABLE XXIV-D

1974 BNL ENVIRONMENTAL MONITORING

GROUNDWATER SURVEILLANCE WELLS, WATER QUALITY-METALS

Area	Well	No. Samples	Ag	Cd	Cr	Cu	Fe	Pb	Zn
			ppm						
Sand Filter Beds									
	XG	1	<0.01	<0.005	<0.01	<0.01	6.00	<0.03	0.13
	XK	1	<0.01	<0.005	<0.01	0.01	1.75	<0.03	1.60
Peconic Downstream									
	XM	1	<0.01	<0.005	<0.01	0.06	0.41	<0.03	1.12
	XO	1	<0.01	<0.005	<0.01	0.01	0.03	<0.03	0.25
Landfill Area									
	WR	1	<0.01	<0.005	<0.01	0.01	127.	<0.03	0.32
	WS	1	<0.01	<0.005	<0.01	0.01	59.	<0.03	0.18
	WT	1	<0.01	<0.005	<0.01	0.01	0.97	<0.03	1.32
Upland Recharge Project									
Boundary	1N	11	-	-	-	-	<0.05	-	<0.01
	1R	11	-	-	-	-	<0.05	-	<0.01
	1Q	11	-	-	-	-	<0.05	-	<0.01
	1M	11	-	-	-	-	0.23	-	<0.01
Forest	1W	11	-	-	-	-	<0.05	-	<0.01
	1Z	11	-	-	-	-	<0.05	-	<0.01
	1-3	6	-	-	-	-	-	-	<0.01
	1-4	6	-	-	-	-	-	-	<0.01
	1-T	11	-	-	-	-	<0.05	-	<0.01
Pines	1V	11	-	-	-	-	10.25	-	<0.01
	1Y	11	-	-	-	-	<0.05	-	<0.01
	1-2	11	-	-	-	-	<0.05	-	<0.01
Fields	1O	11	-	-	-	-	0.42	-	0.03
	1-5	6	-	-	-	-	-	-	0.08
	1X	11	-	-	-	-	<0.05	-	<0.01
	1-1	11	-	-	-	-	<0.05	-	<0.01
Agricultural	1S	11	-	-	-	-	<0.05	-	<0.01
	1O	11	-	-	-	-	<0.05	-	<0.01
	1P	11	-	-	-	-	<0.05	-	<0.01
Minimum Detectable			0.01	0.005	0.01	0.01	0.01	0.03	0.01
Water Quality Standard (14)			0.	0.02	0.10	0.40	0.60	0.10	0.60

TABLE XXV

1974 BNL ENVIRONMENTAL MONITORING
CONCENTRATIONS OF ^{90}Sr, ^{131}I AND ^{137}Cs IN MILK

Month	Farm C - 10 km SE					Farm H - 40 km E				
	HTO**	^{90}Sr**	^{131}I	^{137}Cs**	K	HTO**	^{90}Sr**	^{131}I	^{137}Cs**	K
	- - - -	pCi/1 or 10^{-9} µCi/ml - - - - -			(gm/1)	- - - -	pCi/1 or 10^{-9} µCi/ml - - - - -			(gm/1)
February	<200	9.5 ± 2.2	<5	<10	1.4 ± 0.1	400 ± 140	6.0 ± 2.2	N.A.	<10	N.A.
April	300 ± 200	11.2 ± 6.2	N.A.	<10	N.A.	266 ± 235	7.4 ± 1.3	N.A.	<10	N.A.
July	200 ± 200	14.5 ± 3.8	<5	12 ± 10	1.6 ± 0.1	<300	6.6 ± 1.8	N.A.	<9	N.A.
October	<300	8.4 ± 1.8	<5	<10	1.3 ± 0.4	<300	8.4 ± 3.3	<5	<10	1.2 ± 0.2
Average	<300	11.2 ± 5.0	<5	<10	1.4 ± 0.2	<300	7.0 ± 1.7	-	<10	-
Radiation Concentration Guide (4)	$3x10^6$	200*	100*	$4x10^4$	-	$3x10^6$	200*	100*	$4x10^4$	-

*Based on Federal Radiation Protection Council Guide[19], Range II upper limit, and on assumed intake of one liter per day.

**Analysis by New York State Department of Environmental Conservation.

TABLE XXVI

1974 BNL ENVIRONMENTAL MONITORING
CONCENTRATIONS OF γ-EMITTING NUCLIDES IN SOIL

Off-Site Locations	Month	No. Samples		^{54}Mn	^{60}Co	^{65}Zn	^{137}Cs	^{144}Ce
				pCi/kg (10^{-9} μCi/gm)				
Farm A - 3 km NW	June	1		<100	<100	<100	839±50	1,340±49
Farm D - 15 km NW	June	1		<100	<100	<100	990±90	2,879±909
Farm H - 40 km E	June	1		<100	<100	<100	830±48	1,335±466
On-Site Locations								
Adjacent High Intensity Radiation Development Lab (~1,000' NE HFBR)	July	18	Avg.	-	750	<100	850	-
			Max.	-	1,500		1,120	-
			Min.	-	110		380	-
Waste Management Area	July	19	Avg.	86,030	7,170	<100	879,000	-
			Max.	1,270,000	97,700		1,900,000	-
			Min.	190	<100		1,000	-

TABLE XXVII

1974 BNL ENVIRONMENTAL MONITORING
CONCENTRATIONS OF γ-EMITTING NUCLIDES IN VEGETATION

Off-Site Locations	Month	No. Samples	^{65}Zn	^{131}I	^{137}Cs	^{144}Ce	K
			(pCi/kg or 10^{-9} μCi/gm)				gm/kg
Farm A - 3 km NW	Sept.	1	158±43	<20	<20	<226	5.0±0.3
Farm D - 15 km NW	June	1	200±117	<18	<22	<360	5.8±7
Farm H - 40 km E	June	1	<236	<176	<54	<1760	6.4±1.2

TABLE XXVIII

INCREMENTAL POPULATION EXPOSURE DUE TO BNL AIRBORNE EFFLUENTS COMPARED WITH BACKGROUND

Distance from HFBR Stack (miles)	X/Q	Dose rate mrem/yr	Population	Annual dose person-rem	Background dose, person-rem
1-2	2.4×10^{-7}	0.08	1,748	0.140	138
2-3	1.04×10^{-7}	0.035	4,464	0.156	353
3-4	5.93×10^{-8}	0.0198	8,240	0.163	651
4-5	3.86×10^{-8}	0.0129	14,420	0.186	1,139
5-10	1.69×10^{-8}	0.0057	193,250	1.102	1,527
10-15	8.0×10^{-9}	0.0027	241,240	0.650	19,058
15-20	5.5×10^{-9}	0.0018	184,250	0.341	14,556
20-30	3.8×10^{-9}	0.0012	994,060	1.192	78,531
30-40	2.7×10^{-9}	0.0009	1,502,900	1.350	118,729
40-50	2.1×10^{-9}	0.0007	1,948,920	1.363	153,965
1-50	-	-	5,093,492	6.70	402,386

TABLE XXIX

OFF-SITE DOSE RATES AND DOSES DUE TO BNL GAMMA FOREST AND AGS

	Gamma Forest					AGS			
Sector	Distance from HFBR Stack (miles)	Distance from Source (miles)	Dose rate (mR/yr)	Pop.	Person-rem	Distance from AGS (km)	Dose rate (mR/yr)	Pop.	Person-Rem
SSW	1-2	-	-	0	-	-	-	0	-
	2-3	>3	$<10^{-12}$	230	$<10^{-13}$	4.4	2.2×10^{-4}	230	5.1×10^{-5}
SW	1-2	-	-	0	-	-	-	0	-
	2-3	>3	$<10^{-12}$	160	$<10^{-13}$	4.3	2.8×10^{-4}	160	4.5×10^{-5}
WSW	1-2	-	-	0	-	-	-	0	-
	2-3	>3	$<10^{-12}$	370	$<10^{-13}$	4.0	5.1×10^{-4}	370	1.9×10^{-4}
W	1-2	2.7	4×10^{-12}	150	$<10^{-11}$	2.5	1.6×10^{-2}	150	2.4×10^{-3}
	2-3	>3	$<10^{-12}$	740	$<10^{-12}$	3.86	7.2×10^{-4}	740	5.3×10^{-4}
WNW	1-2	2.6	3×10^{-11}	190	$<10^{-11}$	2.14	4.0×10^{-2}	190	7.6×10^{-3}
	2-3	>3	$<10^{-12}$	550	$<10^{-12}$	3.64	1.1×10^{-3}	550	6.0×10^{-4}
NW	1-2	2.06	2×10^{-11}	190	$<10^{-11}$	1.96	6.6×10^{-2}	190	1.25×10^{-2}
	2-3	>3	$<10^{-12}$	130	$<10^{-13}$	3.5	1.6×10^{-3}	130	2.1×10^{-4}
NNW	1-2	1.73	2×10^{-6}	150	3×10^{-7}	1.96	6.6×10^{-2}	150	1.0×10^{-2}
	2-3	>3	$<10^{-12}$	64	<10	3.46	1.6×10^{-3}	64	1.0×10^{-4}
N	1-2	1.31	4×10^{-9}	250	1.0×10^{-4}	2.32	2.5×10^{-2}	250	6.25×10^{-3}
	2-3	-	-	0	-	-	-	0	-
NNE	1-2	0.84	0.069	150	0.0106	2.5	1.6×10^{-2}	150	2.4×10^{-3}
	2-3	1.48	4×10^{-5}	370	9.1×10^{-6}	3.64	1.1×10^{-3}	370	6.2×10^{-4}
NE	1-2	0.73	1.21	74	0.0900	2.86	6.8×10^{-3}	74	5.0×10^{-4}
	2-3	1.22	8×10^{-4}	180	1.5×10^{-4}	3.64	1.1×10^{-3}	180	2×10^{-4}
ENE	1-2	-	-	0	-	-	-	0	-
	2-3	-	-	0	-	-	-	0	-
E	1-2	-	-	0	-	-	-	0	-
	2-3	1.72	2×10^{-6}	100	2×10^{-7}	4.05	5×10^{-4}	100	5×10^{-5}
ESE	1-2	-	-	0	-	-	-	0	-
	2-3	2.2	3×10^{-9}	210	$<10^{-9}$	4.35	2.5×10^{-4}	210	5.25×10^{-5}
SE	1-2	-	-	0	-	-	-	0	-
	2-3	-	-	0	-	-	-	0	-
SSE	1-2	2.5	2×10^{-10}	47	$<10^{-11}$	3.4	2×10^{-3}	47	1×10^{-4}
	2-3	>3	$<10^{-12}$	520	$<10^{-12}$	4.5	1.8×10^{-4}	520	$<10^{-4}$
S	1-2	2.7	4×10^{-12}	47	$<10^{-12}$	3.28	2.6×10^{-3}	47	1.2×10^{-4}
	2-3	>3	$<10^{-12}$	640	$<10^{-12}$	4.5	1.8×10^{-4}	640	$<10^{-4}$
Total					0.10				0.045

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