4

Air Quality

Brookhaven National Laboratory monitors both radioactive and nonradioactive emissions at several facilities on site to ensure compliance with the requirements of the Clean Air Act. In addition, the Laboratory conducts ambient air monitoring to verify local air quality and assess possible environmental impacts from BNL operations.

During 2003, BNL facilities released a total of 3,725 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.7 percent of the site's radiological air emissions.

With natural gas prices higher than residual fuel prices throughout 2003, the Central Steam Facility relied more on residual fuel to meet the heating and cooling needs of BNL's major facilities than in past years. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably higher in 2003 than in 1999, when natural gas was the predominant fuel used at the Central Steam Facility.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and DOE regulations that govern the release of airborne radioactive material include 40 CFR 61 Subpart H: National Emission Standards for Hazardous Air Pollutants (NESHAPs)—part of the Clean Air Act, and DOE Order 5400.5 (1990): Radiation Protection of the Public and the Environment. Under NESHAPs Subpart H, facilities that have the potential to deliver an annual radiation dose of greater than 0.1 mrem or 1μSv to a member of the public must be continuously monitored for emissions. Facilities capable of delivering radiation doses below that limit require periodic, confirmatory monitoring. BNL has one facility that requires continuous monitoring, the Brookhaven Linac Isotope Producer (BLIP), and three active facilities where periodic monitoring is conducted. Figure 4-1 indicates the locations of the monitored facilities for radiological emissions, and Table 4-1 presents the airborne release data from each of these facilities during 2003. Annual emissions from monitored facilities are discussed in the following sections of this chapter. A fourth inactive facility (the Evaporator Facility) that was periodically monitored in past years is also discussed. The associated radiation dose calculations are presented in Chapter 8.

4.1.1 Brookhaven Medical Research Reactor

In August 2000, DOE announced that the Brookhaven Medical Research Reactor (BMRR) would be permanently shut down due to a reduction of research funding. Until it stopped operating in late December 2000, the BMRR was fueled with enriched uranium, moderated and cooled by "light" (ordinary) water, and was operated intermittently at power levels up to 3 MW, thermal. Air from the interior of the containment building was used to cool the neutron reflector surrounding the core of the reactor vessel. As air was drawn through the reflector, it was exposed to a neutron field, resulting in activation of the argon fraction of the air. This produced argon-41 (Ar-41), an inert, radioactive gas with a half-life of 1.8 hours. After passage through the reflector, the air was routed through a roughing filter and a high-efficiency particu-

Figure 4-1. Air Emission Release Points Subject to Continuous Monitoring.

late air (HEPA) filter to remove any particulate matter. Charcoal filters also were used to remove radioiodines produced during the fission process. Following filtration, the air was exhausted to the atmosphere through a 150-ft stack adjacent to the reactor containment building. This air was continuously monitored for Ar-41 emissions.

After the BMRR stopped operating, continuous Ar-41 monitoring was reduced to periodic, semi-annual monitoring to confirm that radionuclide concentrations remain below detection limits. In 2003, sampling showed there were no detectable emissions of Ar-41 or other argon radionuclides at zero power level with building ventilation on.

In January 2003, the remaining fuel was removed from the BMRR reactor vessel, eliminating the last significant source for radionuclide emissions to the environment. The sole remaining emission source is evaporation of the cooling water, which was tritiated by neutron activation when the BMRR operated. In 2003, the release of tritium as tritiated water vapor (HTO) was estimated at 76.3 mCi, based on the concentration of tritium and measured decreases in the volume of water.

4.1.2 High Flux Beam Reactor

Following the discovery of an underground plume of tritiated groundwater emanating from a

leak in the spent fuel storage pool, the High Flux Beam Reactor (HFBR) was kept in a standby mode. This lasted from January 1997 until November 1999, when DOE announced that the HFBR would be permanently shut down. The storage pool had been drained in December 1997 to prevent additional leakage, as well as to facilitate repairs and double lining of the pool to conform to Suffolk County Article 12, which regulates storage tanks. When the HFBR operated, it used "heavy" water as a neutron moderator and fuel coolant. Heavy water, or D_2O, is water composed of a nonradioactive isotope of hydrogen known as deuterium. When exposed to the neutron fields generated inside the reactor vessel, the deuterium became activated, producing radioactive tritium (half-life: 12.3 years). Although the heavy water has been removed from the vessel, residual tritium still remains in the vessel and cooling loops. Tritiated water vapor is released from the vessel and associated piping systems to building air (via diffusion at valve seals and other system penetrations), where it is routed to the facility's 328-ft stack. Concentrations of HTO in air are assessed using a silica gel absorbent material. In 2003, 8.99 Ci of tritium as airborne HTO were released from the HFBR. This is an increase from the 1.93 Ci of tritium released in 2002. The increased emissions are believed to be the due to evaporative losses during the pump-out of the remaining water from the reactor core to a tanker trailer in July. Figure 4-2 illustrates the declining trend of tritium emissions from the HFBR since 1994. In 2003, sampling frequency continued at 1 week per month.

Table 4-1. Airborne Radionuclide Releases from Monitored Facilities.

Facility	Nuclide	Half-life	Ci Released
BMRR	Argon-41	1.8 hours	None
	Tritium	12.3 years	7.63E-02*
HFBR	Tritium	12.3 years	8.99E+00
BLIP	Carbon-11	20.4 minutes	9.43E+02
	Oxygen-15	122 seconds	2.78E+03
	Tritium	12.3 years	1.76E-02
Target Processing Laboratory	Germanium-68	288 days	4.82E-09
	Germanium-69	1.6 days	4.52E-11
	Iodine-131	8.0 days	4.36E-08
	Selenium-75	119.8 days	2.64E-11
Total			**3.73E+03**

Notes:
Ci = 3.7E10 Bq.
BLIP = Brookhaven Linac Isotope Producer
BMRR = Brookhaven Medical Research Reactor (operations were terminated in December 2000)
HFBR = High Flux Beam Reactor (operations were terminated in November 1999)
* Estimated release (see Section 4.1.1 for details)

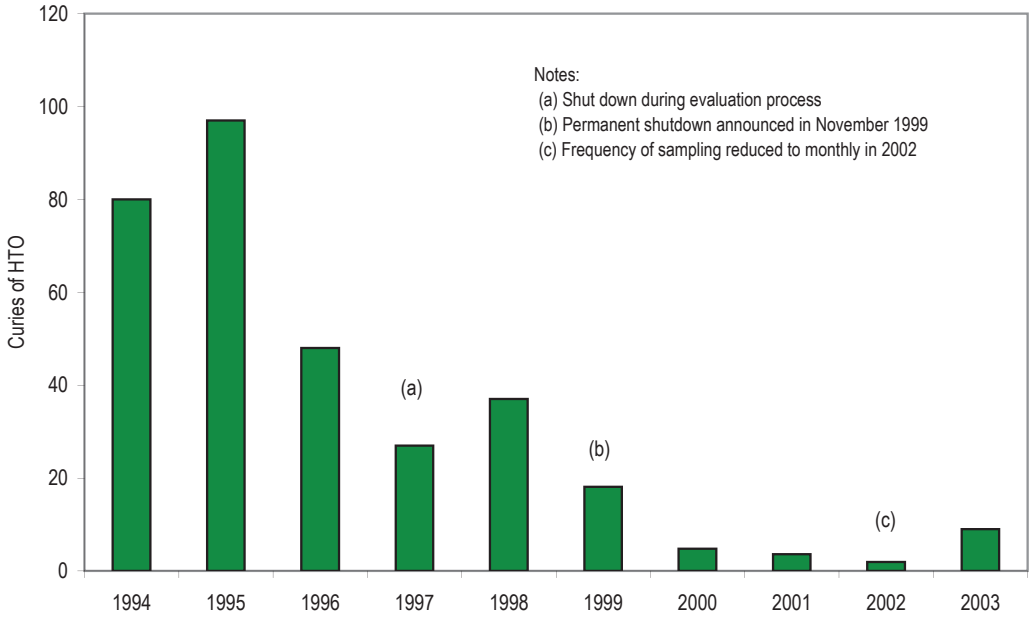

Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1994 – 2003).

4.1.3 Brookhaven Linac Isotope Producer

Protons from the Linear Accelerator (Linac) are sent via an underground beam tunnel to the BLIP, where they strike various metal targets. The proton beam activates these metal targets to produce new radionuclides for diagnostic use. The activated metal targets are transferred to the Target Processing Laboratory (TPL) in Building 801 for separation and later shipment to various radiopharmaceutical research laboratories. During irradiation, the targets become hot and are cooled by a continuously recirculating water system. The cooling water also becomes activated during the process, producing secondary radionuclides. The most significant of these are oxygen-15 (O-15) and carbon-11 (C-11), radionuclides with half-lives of 122 seconds and 20.48 minutes, respectively. Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-ft stack.

In 2003, the BLIP operated over a period of 16 weeks. During this period, 943 Ci of C-11 and 2,782 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 1.76E-02 Ci. Emissions of C-11 and O-15 declined by more than 33 percent from 2002, primarily due to a reduced period of operation (16 weeks in 2003 compared to 21 weeks in 2002). The tritium release also was less than in 2002.

4.1.4 Evaporator Facility

In the past, liquid waste generated on site that contained residual radioactivity was accumulated at the Waste Concentration Facility (WCF) in Building 811. At the WCF, reverse osmosis was used to remove suspended solids and a high percentage of radionuclides from the liquid. However, because tritium is an isotope of hydrogen, it could not be removed from aqueous wastes. The tritiated water that remained following waste concentration was transferred to the Evaporator Facility in Building 802B, where it was converted to steam and released as an airborne emission. The Evaporator Facility was constructed primarily to reduce the amount of tritiated water released to the Peconic River through the BNL Sewage Treatment Plant. Emissions from the Evaporator Facility were directed to the same stack used by the HFBR to exhaust building air. This method was preferable to release via surface water because there was virtually no potential for the airborne emissions to influence groundwater (the primary drinking water source on Long Island), and the potential for the released tritium to contribute to an off-site dose was minimized by atmospheric dispersion.

No aqueous waste has been processed at the WCF since 2001. As a result, the Evaporator Facility has not been used and there have been no emissions of tritiated water vapor from it. Because generation rates of aqueous wastes containing residual radioactivity are expected to remain low, it is no longer economical to process the waste in the same manner. As a result, plans are to decommission the WCF reverse osmosis process and the Evaporator Facility.

4.1.5 Target Processing Laboratory

As mentioned in Section 4.1.3, the metal targets irradiated at the BLIP are transported to the TPL in Building 801, where isotopes are chemically extracted for radiopharmaceutical production. Airborne radionuclides that are released during the extraction process are drawn through multistage HEPA and charcoal filters and then vented to the HFBR stack. The types of radionuclides that are released depend on the isotopes chemically extracted from the irradiated metal targets, which can change from year to year. Annual radionuclide quantities released from this facility are very small, typically in the μCi to mCi range. In 2003, the total release from the TPL was 0.049 μCi. See Table 4-1 for details on which radionuclides were released in 2003.

4.1.6 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves very small quantities of radioactive materials (in the μCi to mCi range). The work done using fume hoods typically involves transferring material between containers, using pipettes, and labeling chemical compounds. Due to the use of HEPA filters, the nature of the work conducted, and the small quantities involved, these operations have

a very low potential for atmospheric releases of any significant quantities of radioactive materials. Compliance with NESHAPs Subpart H is demonstrated through the use of an inventory system that allows an upper estimate of potential releases to be calculated. Facilities that demonstrate compliance in this way include Buildings 463, 490, 490A, 510, 535, 555, 725, and 801, where research is conducted in the fields of biology, medicine, high energy physics, chemistry, applied and materials science, and advanced technology. See Table 8-4 in Chapter 8 for the calculated dose from these facility emissions.

4.1.7 Uncharacterized Radiological Emission Sources

Uncharacterized radiological emissions (diffuse or area sources) were evaluated in 2003 for compliance with NESHAPs, Subpart H. The EPA-approved CAP88-PC dose modeling program was used to calculate the dose to members of the public from planned research, environmental restoration, and waste management activities (see Chapter 8 for more details). These evaluations determined whether NESHAPs permitting and continuous monitoring requirements were applicable, or whether periodic confirmatory sampling was needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of the research, environmental restoration, and waste management activities that occurred in 2003.

One of the projects evaluated was the removal of filters and liners for belowground ducts (BGD) associated with the former Brookhaven Graphite Research Reactor (BGRR). This removal was accomplished using two Brokk Model Remote System machines fitted with a variety of remotely operated tools that enabled the operator to demolish the filter material into pieces small enough to be carried through a vacuum hose to a cyclone separator. All demolition was carried out in a temporary structure called the Duct Service Building (DSB), erected on a concrete slab. The structure was maintained at negative pressure with a separate 6,000-ft^3 (cfm) HEPA-filtered ventilation system. The results of airborne particulate and charcoal samples collected from the DSB's HEPA-filtered exhaust opening during demolition were evaluated using the CAP88-PC modeling program. The potential effective dose equivalent (EDE) estimated by the modeling program was 1.50E-05 mrem in a year to the maximally exposed individual (MEI). This value is well below the annual 0.1 mrem threshold that triggers the NESHAPs Subpart H requirements for continuous monitoring. Chapter 8 discusses this and other activities that were evaluated under NESHAPs Subpart H.

4.2 FACILITY MONITORING

In the past, potential sources of radioactive particulate emissions that have been monitored included the BMRR, the HFBR, the Evaporator Facility, the TPL (Building 801), and the BLIP. Since the BMRR and HFBR are permanently shut down and the Evaporator Facility did not process any aqueous wastes in 2003, no particulate sampling was conducted at these facilities.

The samplers in the exhaust duct for the TPL and the exhaust stack for the BLIP are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-3 for locations). The filters are collected and analyzed weekly for gross alpha and beta activity. Particulate filter analytical results for gross alpha and beta activity are reported in Table 4-2. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0007 and 0.0126 pCi/m^3, respectively. The annual average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were -0.0001 and 0.1302 pCi/m^3, respectively. For a discussion of negative values associated with radioactivity monitoring, see Appendix B.

4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, an array of air monitoring stations is in place around the perimeter of BNL. Samplers are housed within six blockhouse stations (see Figure 4-3 for locations). The blockhouses are fenced to control access and protect costly sampling equipment. In the past, 16 pole-mounted, battery-powered silica-gel samplers,

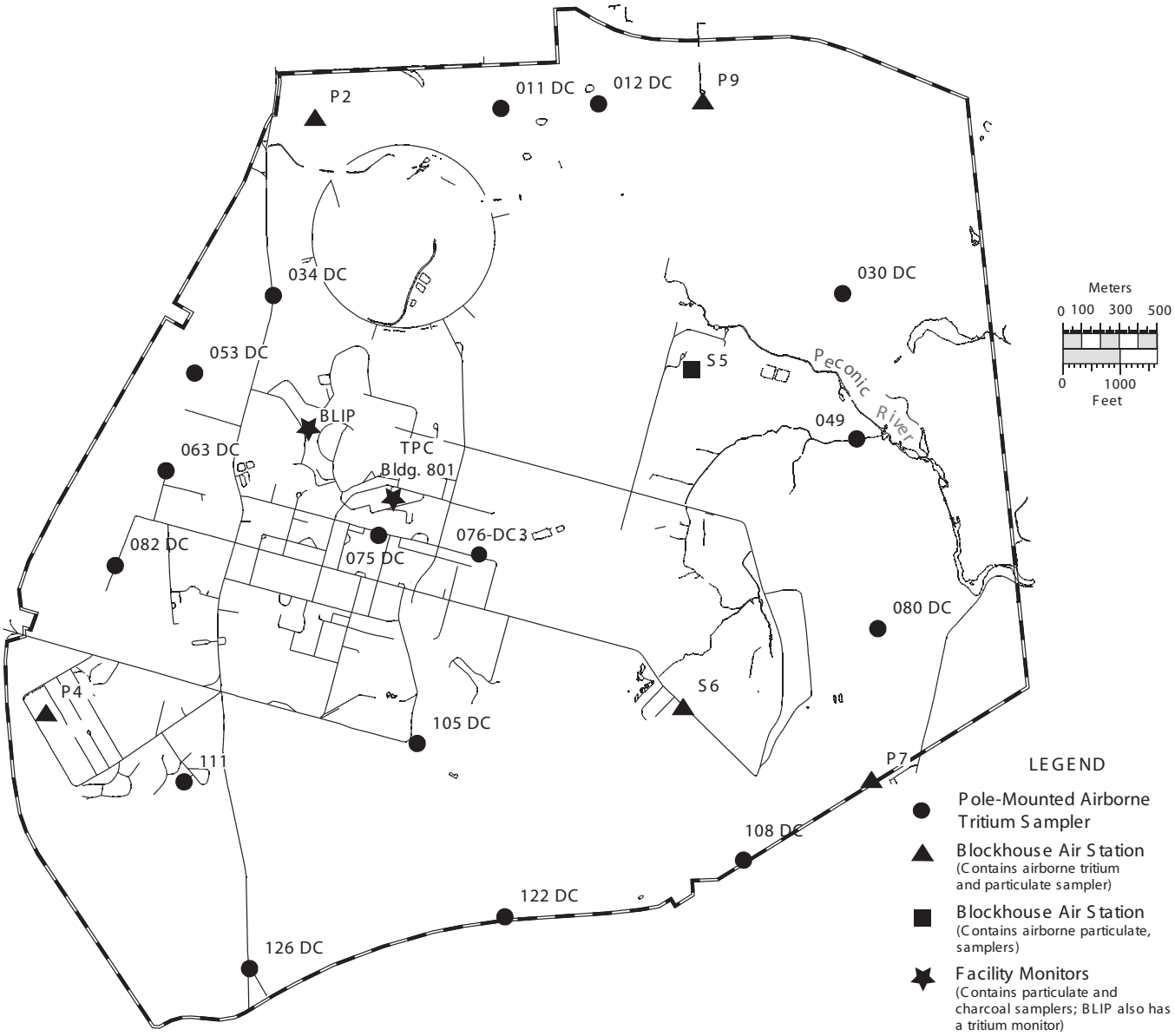

Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.

located throughout the site, had been used for tritium monitoring. Examination of historical air surveillance data after the shutdown of the HFBR and the BMRR revealed that at most of the sampling stations, the tritium concentrations were below minimum detection limits (MDL) obtained on the day of analysis, which ranged from 1.0 to 6.0 pCi/m^3. As a result, it was determined that the number of battery-powered silica-gel tritium samplers could be reduced from 16 to 3, to eliminate redundant sampling. This reduction did not affect the purpose of the monitoring, which is to assess the potential health and environmental impacts of the remaining tritium emission sources on site.

At each blockhouse, particulate matter is captured on a glass-fiber filter, and water vapor for tritium analysis is collected on silica-gel absorbent material. Note that Station S5 does not contain a tritium sampler. Particulate filters are collected weekly and are analyzed for gross alpha and beta activity using a gas-flow propor-

Table 4-2. Gross Activity in Facility Air Particulate Filters.

Facility Monitor		Gross Alpha (pCi/m³)	Gross Beta (pCi/m³)
BLIP	N	46	46
	Max.	0.1610 ± 0.1200	0.9990 ± 0.3480
	Avg.	-0.0001 ± 0.0224	0.1302 ± 0.0397
	MDL	0.200	0.549
TPL - Bldg. 801	N	51	51
	Max.	0.0025 ± 0.0020	0.0480 ± 0.0070
	Avg.	0.0007 ± 0.0003	0.0126 ± 0.0006
	MDL	0.003	0.009

Notes:
See Figure 4-3 for sample monitoring stations.
All values shown with a 95% confidence interval.
Negative values occur when the measured value is less than background. (See Appendix B for description.)
N = Number of validated samples collected
MDL = Average Minimum Detection Limit
TPL = Target Processing Laboratory

Table 4-3. Gross Activity Detected in Ambient Air Monitoring Particulate Filters.

Sample Station		Gross Alpha (pCi/m³)	Gross Beta (pCi/m³)
P2	N	52	52
	Max	0.0021 ± 0.0007	0.0233 ± 0.0021
	Avg.	0.0006 ± 0.0001	0.0126 ± 0.0002
	MDL	0.001	0.002
P4	N	50	50
	Max	0.0027 ± 0.0037	0.4230 ± 0.0236
	Avg.	0.0006 ± 0.0002	0.0199 ± 0.0010
	MDL	0.001	0.002
P7	N	52	52
	Max	0.0022 ± 0.0007	0.0212 ± 0.0025
	Avg.	0.0009 ± 0.0001	0.0123 ± 0.0002
	MDL	0.001	0.002
P9	N	52	52
	Max	0.0015 ± 0.0005	0.0216 ± 0.0023
	Avg.	0.0006 ± 0.0001	0.0109 ± 0.0004
	MDL	0.001	0.002
S5	N	52	52
	Max	0.0019 ± 0.0011	0.0259 ± 0.0025
	Avg.	0.0007 ± 0.0001	0.0122 ± 0.0004
	MDL	0.001	0.002
S6	N	52	52
	Max	0.0018 ± 0.0007	0.0246 ± 0.0024
	Avg.	0.0009 ± 0.0001	0.0144 ± 0.0002
	MDL	0.001	0.002
Grand Average		**0.0007 ± 0.0001**	**0.0137 ± 0.0027**

Notes:
See Figure 4-3 for sample monitoring stations.
All values shown with a 95% confidence interval.
N = Number of validated samples collected
MDL = Average Minimum Detection Limit

tional counter. In 2003, silica-gel samples were collected for processing by liquid scintillation analysis biweekly, which was an increase over the 2002 frequency of one week per month.

4.3.1 Gross Alpha and Beta Airborne Activity

Particulate filter analytical results for gross alpha and beta airborne activity are reported in Table 4-3. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., sample air volumes were not acceptable). The annual average gross alpha and beta airborne activity levels for the six monitoring stations were 0.0007 and 0.0137 pCi/m^3, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-4. The results at this location are typical for the site. The trend shows seasonal variation in activity within a range that is representative of natural background levels. The gross alpha activity is not plotted because most results were below the MDL.

The New York State Department of Health (NYSDOH) received duplicate filter samples that were collected at Station P7 using a sampler they provided. These samples were collected weekly and analyzed by the NYSDOH laboratory for gross beta activity only. The analytical results received were comparable to the Station P7 samples analyzed by the BNL Analytical Services Laboratory. Analytical results for gross beta activity reported by the NYSDOH laboratory were between 0.0066 and 0.0249 pCi/m^3, with an average concentration of 0.0161 pCi/m^3, whereas the BNL results ranged from -0.0012 to 0.0212 pCi/m^3, with an

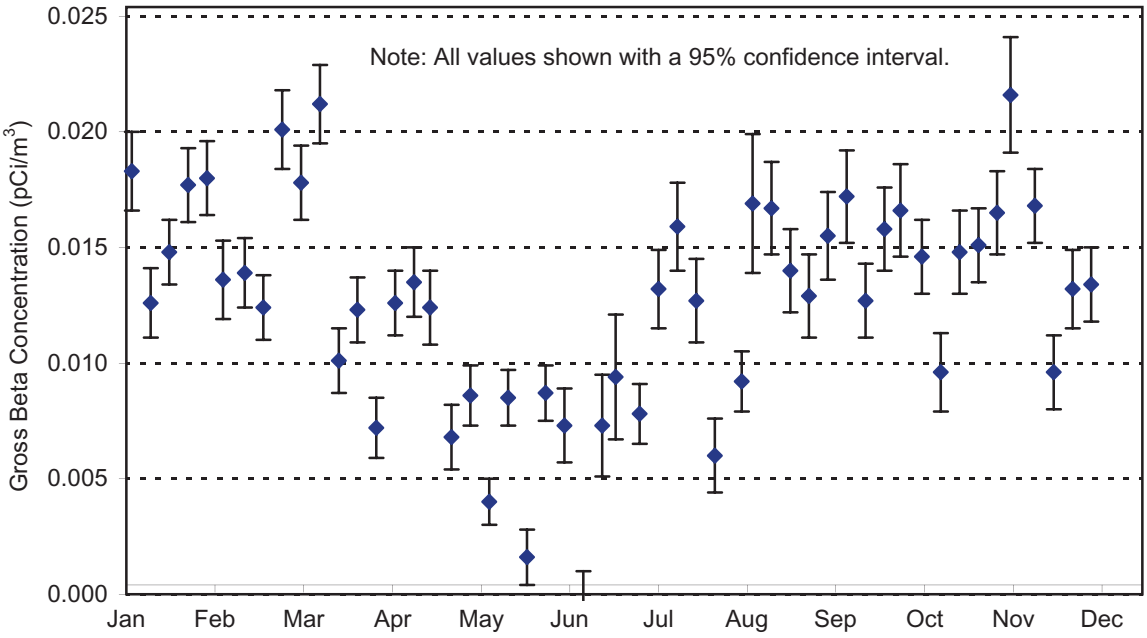

Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.

average concentration of 0.0123 pCi/m^3. As part of a statewide monitoring program, NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions. In 2003, NYSDOH reported that airborne gross beta activity at that location varied between 0.0031 and 0.048 pCi/m^3. The average concentration at this control location was 0.0125 pCi/m^3. Sample results measured at BNL generally fell within this range, demonstrating that on-site radiological air quality was consistent with that observed at locations in New York State not located near radiological facilities.

4.3.2 Airborne Tritium

Airborne tritium in the form of HTO is monitored throughout the BNL site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors used for tritium sampling are located at or near the property boundary (see Figure 4-3 for locations). Airborne tritium is collected by using a pump to draw air through a column of silica gel, a water-absorbent medium. The absorbed HTO is recovered by distillation and analyzed using liquid scintillation counting techniques, described in Appendix D.

Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concentration. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., a battery failure in the sampler, frozen or super-saturated silica gel, or the loss of sample during laboratory preparation). With the exception of Station 049, where biweekly sampling commenced on March 14, airborne tritium samples were collected biweekly from each sampling station during 2003. The average tritium concentrations at all of the sampling locations were less than the typical MDL, which ranged from 1.0 to 6.0 pCi/m^3. The collected data demonstrate that there were no significant differences in ambient tritium concentrations on site or at the site boundary. Observed concentrations of tritium at the sampling stations in 2003 were comparable to concentrations observed in 2002, with the exception of Station S6, where the average concentration dropped from 45.6 to 0.8 pCi/m^3, consistent with background levels. Previous investigations into the elevated concentration of prior years had revealed no obvious source.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emission monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that requires monitoring for nonradiological emissions. BNL has several other emission sources subject to state and federal regulatory requirements that do not require emission monitoring (see Chapter 3 for more details). The CSF supplies steam for heating and cooling to major facilities at BNL through an underground steam distribution and condensate grid. The location of the CSF is shown in Figure 4-1. The combustion units at the CSF are designated as Boilers 1A, 5, 6, and 7. Boiler 1A, which was installed in 1962, has a heat input of 16.4 MW (56.7 MMBtu/hr). Boiler 5, installed in 1965, has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers 6 and 7, were installed in 1984 and 1996, respectively. Each of these boilers has a heat input of 42.6 MW (147 MMBtu/hr). For perspective, Keyspan's Northport, New York power station has four utility-sized turbine/generator boilers, each with a maximum rated heat input of 1,004 MW (3,435 MMBtu/hr).

Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are subject to Title 6 of the New York Code, Rules, and Regulations (NYCRR) Part 227-2, and the Federal New Source Performance Standard (40 CFR 60 Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Boilers). Therefore, these boilers are equipped with continuous emission monitors to measure nitrogen oxides (NO_X). Boiler 7 emissions are also continuously monitored for opacity. To measure combustion efficiency, both boilers are also monitored for carbon dioxide (CO_2). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation (NYSDEC).

From May 1 to September 15 (the peak ozone period), compliance with the 0.30 lbs/MMBtu (129 ng/J) NO_x emission standard for No. 6 oil and the 0.20 lbs./MMBtu (86ng/J) NO_x emission standard for No. 2 oil and natural gas is demonstrated by calculating the 24-hour average emission rate from continuous emission monitoring system readings and comparing the value to the emission standard. The remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Boiler 7 opacity levels are recorded as 6-minute averages. Measured opacity levels cannot exceed 20 percent opacity, except for one 6-minute period per hour of not more than 27 percent opacity. In 2003, there were no measured exceedances of the NO_x emission standards for either boiler. During the year, all but one of the Boiler 7 opacity measurements that exceeded the limit occurred during opacity monitoring system calibrations, boiler start-ups, or routine boiler tube soot blowing operations. While there are no regulatory requirements to continuously monitor opacity for Boilers 1A, 5, and 6, surveillance monitoring of visible stack emissions is a condition of BNL's Title V operating permit. Daily observations of stack gases recorded by CSF personnel throughout the year showed no visible emissions with opacity levels

Table 4-4. Ambient Airborne Tritium Measurements in 2003.

Sample Station	Wind Sector	Validated Samples	Maximum	Average
			(pCi/m^3)	
049	E	18	9.0 ± 4.7	1.2 ± 1.1
053	NW	23	6.9 ± 3.3	0.6 ± 0.7
122	SSE	20	6.6 ± 3.0	0.9 ± 0.7
P2	NNW	25	4.3 ± 2.9	0.6 ± 0.5
P4	WSW	25	<3.9	0.7 ± 0.4
P7	ESE	25	4.9 ± 3.0	0.2 ± 0.6
P9	NE	25	6.5 ± 2.9	0.8 ± 0.6
S6	SE	25	5.6 ± 3.2	0.8 ± 0.5
Grand Average				0.7 ± 0.2

Notes:
See Figure 4-3 for sample monitoring stations.
Wind sector is the downwind direction of the sample station from the HFBR stack.
All values reported with a 95% confidence interval.
Typical minimum detection limit for tritium is between 1.0 and 6.0 pCi/m^3.
DOE Order 5400.5 Air Derived Concentration Guide is 100,000 pCi/m^3.

Table 4-5. Central Steam Facility Fuel Use and Emissions (1996 – 2003).

	Annual Fuel Use and Fuel Heating Values						Emissions			
Year	No. 6 Oil (10^3 gals)	Heating Value (MMBtu)	No. 2 Oil (10^3 gals)	Heating Value (MMBtu)	Natural Gas (10^6 ft^3)	Heating Value (MMBtu)	TSP (tons)	NO_x (tons)	SO_2 (tons)	VOCs (tons)
1996	4,782.55	703,991	52.77	7,388	0.00	0	14.0	104.9	109.0	0.7
1997	3,303.43	484,613	10.23	1,432	190.65	194,463	13.7	83.5	75.1	1.0
1998	354.28	52,283	9.44	1,322	596.17	608,093	2.7	75.1	8.9	1.7
1999	682.76	78,335	2.77	388	614.98	627,280	5.1	53.5	16.7	1.8
2000	2,097.32	309,317	0.82	115	342.40	349,248	9.5	81.6	45.0	1.2
2001	3,645.10	538,847	3.40	476	103.96	106,039	17.5	80.4	77.8	0.8
2002	2,785.04	407,518	0.29	41	220.62	225,030	15.4	62.4	53.8	1.0
2003	4,290.95	628,765	402.06	56,288	0.98	1,000	22.8	75.3	107.1	0.6

Notes:
NO_x = Nitrogen oxides
SO_2 = Sulphur dioxide
TSP = Total Suspended Particulates
VOCs = Volatile Organic Compounds

exceeding the regulatory limits established for these boilers.

In the spring of 1997, the Long Island Lighting Company completed work extending a natural gas main into the CSF. To accommodate the combustion of natural gas, new gas rings were added to the burners of Boiler 5, and natural gas trains were installed to connect the gas main to Boilers 5 and 7. In 1998, existing steam-atomized oil burners on Boiler No. 6 were replaced with two dual-fuel low-NO_x burners, and a natural gas train was added to connect the boiler to the gas main.

Throughout 2003, natural gas prices exceeded those for residual fuel oil. As a result, residual fuel supplied 99 percent of the heating and cooling needs of BNL's major facilities in 2003, while the combustion of natural gas accounted for less than one percent of these heating and cooling needs. By comparison, in 1999 natural gas satisfied more than 88 percent of the major facility heating and cooling needs, and in 2002, 36 percent. Consequently, 2003 emissions of particulates, NO_x, and SO_2 were 17.7, 21.8, and 90.4 tons higher than the respective totals for 1999 and were 7.4, 12.9, and 53.3 tons higher than the respective emission totals for 2002. Table 4-5 shows fuel use and emissions since 1996.

REFERENCES AND BIBLIOGRAPHY

40 CFR 60 Subpart Db. Standards of Performance for Industrial-Commercial-Institutional Steam Boilers. 52 FR 47842, Dec. 16, 1987, as amended 66 FR 49834, Oct. 1, 2001.

40 CFR 61 Subpart H. National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities. 54 FR 51695, Dec. 15, 1989, as amended at 67 FR 57166, Sept. 9, 2002.

DOE Order 5400.5. 1990. Radiation Protection of the Public and the Environment. U.S. Department of Energy, Washington, DC. Change 2: 1-7-93.

NYCRR Part 227-2. Title 6. Reasonably Available Control Technology for Oxides of Nitrogen. New York State Department of Environmental Conservation, Albany, NY. Amended 2-11-04.

Shlein, Bernard, et al., eds. 1998. Handbook of Health Physics and Radiological Health, Third Edition. Williams and Wilkins, Baltimore, MD.