Chapter 5

AIRBORNE EFFLUENTS

5.1 Airborne Effluent Emissions - Radioactive

The following sections describe the radioactive effluents released to the atmosphere in 1997 and the facilities and operations which produced them. Locations of facilities within the BNL site which release airborne radionuclides are shown in Figure 5-1. Chapter 9 contains a discussion of projected radiological doses which would have been received by a member of the public residing at the BNL site boundary .

5.1.1 BMRR

The Brookhaven Medical Research Reactor (BMRR) is the first nuclear reactor built exclusively for medical research. It produces neutrons in an optimal energy range for a promising experimental treatment for a type of brain cancer known as *glioblastoma multiforme*. The BMRR is fueled with enriched uranium, moderated and cooled by light water, and is operated intermittently at power levels up to 3 MW (thermal).

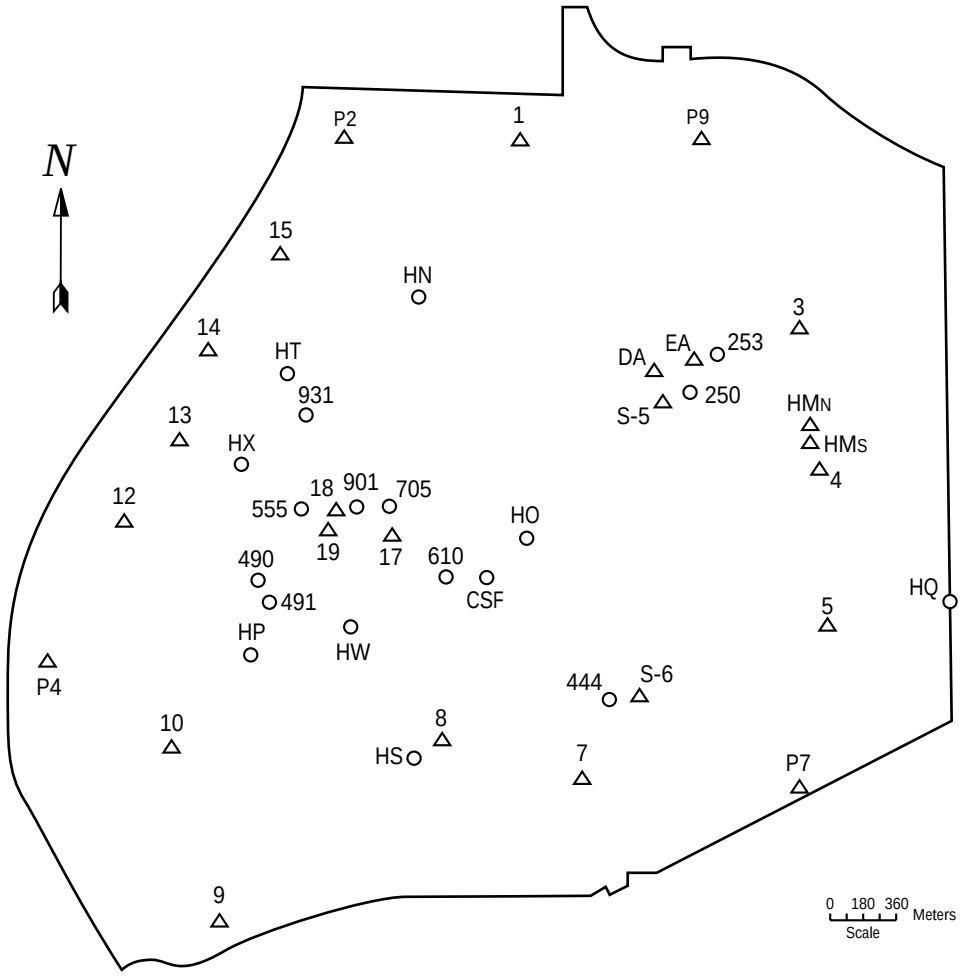
To cool the neutron reflector surrounding the core of the BMRR reactor vessel, air from the interior of the containment building is used. When air is drawn through the reflector, it is exposed to a neutron field which causes the argon component of the air to become radioactive. This radioactive form is known as argon-41. It is a chemically inert gas with a short half-life of 1.8 hours. After passage through the reflector, the air is routed through a roughing filter, a high efficiency particulate air (HEPA) filter to remove any particulate matter, and finally, a charcoal filter to remove radioiodines. The air is then exhausted to a 150 ft. (46 meter) stack adjacent to the containment building.

A real time monitor is in place to monitor argon-41 in the effluent, while passive filter media are used to collect and quantify radioparticulates. Data from this monitor are used to confirm expected release rates and maintain annual radionuclide release inventories. Though the list of radionuclides released from this facility (see Table 5-1) is longer than what was reported in the past, this does not reflect an increase in emissions, but rather an increased level of monitoring initiated in 1996 for very small radionuclide quantities. These non-argon isotopes are of negligible dosimetric importance (<< 0.1 mrem/yr) because of their short half-life and extremely low total activity. In 1997, the BMRR released 2,219 Ci (82 TBq) of argon-41 as an airborne effluent.

5.1.2 HFBR

The High Flux Beam Reactor (HFBR) is one of the premier neutron physics research facilities in the world. Neutron beams produced at the HFBR are used to investigate the molecular structure of materials which aid in drug design and materials development, as well as expanding the current knowledge base of physics, chemistry and biology. This reactor is capable of operating at power levels ranging from 30 to 60 MW (thermal). The HFBR has been shutdown since January, 1997 following the discovery of an underground plume of tritium emanating from beneath the facility.

The HFBR uses heavy water to cool the reactor fuel and moderate neutrons used in the fission process. (Heavy water, or D_2O, is water which is composed of a nonradioactive isotope of hydrogen known as deuterium.) Heavy water flowing in the core is exposed to a dense neutron field which activates the deuterium atoms in the water to produce tritium (half-life = 12.3 years). The rate at which the tritium concentration builds in the primary cooling water depends on the reactor power level and the amount of time elapsed since the last reactor shutdown or coolant



△ Environmental Monitoring Stations

Air

1 thru 16 Perimeter Stations
S-6 Waste Management Area
S-5 Sewage Treatment Plant
17, 18, 19 Center of Site

Water

DA Sewage Treatment Plant Influent
EA Sewage Treatment Plant Effluent
HM Peconic River, 0.5 mi. Downstream From Treatment Plant
HQ Peconic River, Site Boundary

○ Designation	Effluent Release Point
250	Sand filter Beds
253	Peconic R. Stream Bed
491	BMRR
555	Chemistry Bldg.
705	HFBR
931	BLIP
444	Waste Management Incinerator
610	Steam Plant
CSF	Storm Water Outfall
HN	Recharge Basin
HO	Recharge Basin
HP	Recharge Basin
HS	Recharge Basin
HT	Recharge Basin
HX	Recharge Basin
HW	Recharge Basin

Figure 5-1.
Brookhaven National Laboratory
Effluent Release Points and On-site Environmental Monitoring Stations

Table 5-1
BNL Site Environmental Report for Calendar Year 1997
Airborne Radionuclide Releases from Monitored Facilities

Facility	Nuclide	Half-life	Ci* Released
BMRR	Ar-41	1.8 h	2.22E+03
	Al-26	7.2E5 y	1.21E-08
	As-76	26 h	4.70E-04
	Ba-128	2.4 d	1.86E-04
	Ba-140	12.8 d	1.56E-04
	Br-82	35 h	8.61E-03
	Ce-141	32 d	1.82E-07
	Ce-144	284 d	1.42E-06
	Co-60	5.2 y	2.65E-06
	Fe-59	44 d	3.85E-06
	Hg-203	46 d	5.90E-05
	I-124	4.2 d	1.89E-05
	I-131	8 d	3.33E-05
	I-133	21 h	3.63E-04
	La-140	40 h	8.25E-04
	Mo-99	66 h	1.54E-07
	Na-24	15 h	2.30E-04
	Sb-122	2.7 d	4.81E-07
	Sc-46	84 d	2.15E-08
	Se-75	119 d	2.04E-07
	Sr-91	9.5 h	3.32E-04
	Tc-99m	6.0 h	5.86E-05
	Ti-44	47 y	1.29E-04
	Xe-133	5.2 d	1.02E-04
	Xe-135	9.1 h	1.07E-03
	Zn-65	244 d	1.95E-05
	Zn-69m	13.7 h	1.44E-06
Bldg. 801	Br-77	57 h	5.53E-06
	Cs-137	30 y	2.65E-06
	I-131	8 d	1.89E-06
	Rb-86	18.6 d	1.84E-03
HFBR	Co-60	5.2 y	5.75E-08
	Cs-137	30 y	1.93E-08
	Fe-52	8.3 h	6.49E-08
	Rb-84	33 d	8.80E-08
	H-3	12.3 y	2.70E+01
BLIP	Be-7	53 d	2.43E-05
	Ge-69	36 h	3.41E-05
	Rb-86	18.6 d	4.21E-06
	Sr-85	64.8 d	5.75E-06
	O-15	2 m	3.24E+01
	H-3	12.3 y	2.80E-03
Evaporator Facility	Be-7	53 d	7.12E-05
	Co-56	79 d	2.81E-05
	Co-57	271 d	8.42E-05
	Co-58	71 d	8.55E-05
	Co-60	5.2 y	3.61E-06
	Cs-137	30 y	3.02E-05
	Mn-54	312 d	1.52E-05
	Na-22	2.6 y	9.32E-07
	Rb-83	86 d	1.18E-04
	Rb-84	33 d	1.17E-05
	Zn-65	244 d	8.83E-05
	H-3	12.3 y	5.52E+00
Incinerator	*Not in service in 1997.*		

Half-life: m = minutes, h = hours, d = days, y = years

* 1 Ci = 3.7E+10 Bq.

change out. This, in turn, determines the amount of tritium which may eventually be released as an airborne effluent. The primary mechanism by which tritium is transferred from the interior coolant system to the building atmosphere is depressurization of the reactor vessel and evaporative losses during maintenance and refueling. Diffusion at valve seals and other fittings also occurs. Tritiated water vapor is thus released from reactor systems to the building air exhaust where it is routed to the facility's 320 ft. (98 meter) stack. Concentrations of tritiated water vapor (abbreviated "HTO") in the air effluent are determined by the use of a silica gel absorbent as it is released.

Though the HFBR did not operate in CY 1997 due to the tritium plume source investigations, the reactor vessel remained filled with heavy water coolant which contains significant amounts of tritium. This tritium is still a source of radioactivity which may be released to the atmosphere via

the mechanisms described above. In 1997, 27 Ci (1 TBq) of airborne HTO was released from the HFBR (Table 5-1). Figure 5-2 illustrates the trend for emissions over the last ten years. While this constitutes the second largest source of total airborne activity released from the BNL site, tritium is a very minor contributor to off-site dose (i.e., << 0.1 mrem/yr).

Other radionuclides are also released from the HFBR in very small quantities, typically in the millicurie to microcurie range, annually. These nuclides are primarily released during the purge of the helium "cover gas" present above the surface of the reactor vessel's cooling water. Any fission products which have been transferred from the cooling water to the cover gas may be released during a routine depressurization purge. They are passed through charcoal and HEPA filters to remove the greatest fraction possible before atmospheric release.

5.1.3 BLIP

The Brookhaven LINAC Isotope Producer (BLIP) is designed to produce radionuclides for medical applications. It is one of the key production facilities in the nation for radioisotopes which are crucial to clinical nuclear medicine. It also supports research at BNL on new diagnostic and therapeutic radiopharmaceuticals.

Protons from the LINAC are sent via an underground beam tunnel to the BLIP Facility where they strike various target metals. These metals, which become activated by the proton beam, are then processed at Building 801 for use in radiopharmaceutical production. The targets are cooled by a continuously recirculating water system. During irradiation, several radioisotopes are produced in this cooling water, the most significant of which is gaseous oxygen-15, a radionuclide with a very short half-life of 123 seconds. This isotope is released as an airborne effluent.

The BLIP facility underwent significant upgrades between 1994 and 1996 in support of the Brookhaven Isotope Research Center (BIRC) program. In an effort to determine any possible changes in the airborne effluent emission rates that these changes may have caused, measurements were conducted in 1996. They indicated a smaller oxygen-15 production rate than measurements made before the BIRC upgrades. As a result, the calculated annual source term release for this facility has decreased compared to previous years. A total of 32 Ci (1.2 TBq) of oxygen-15 was released as an airborne effluent in 1997 (see Table 5-1).

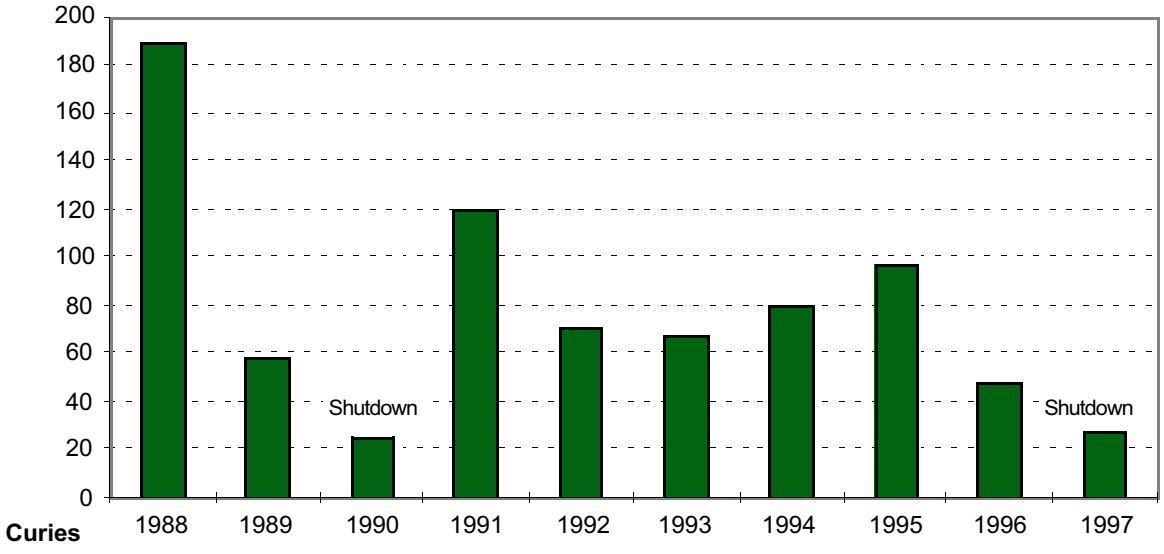


Figure 5-2. HFBR Airborne Tritium Emissions, 10 Year Trend

5.1.4 Tritium Evaporator Facility

First proposed in 1985, the Tritium Evaporator Facility was constructed to reduce the total amount of tritiated water released to the Peconic River. Since the proposal followed the promulgation of NESHAPs, the facility was evaluated for compliance with the Rule prior to its construction. Following submission of an application to construct the facility, formal approval from the EPA Region II was awarded (Approval No. BNL-288-01). The facility became operational in 1995.

Liquid waste generated on-site which contains residual radioactive material is processed at the Building 811 Waste Concentration Facility. At the WCF, suspended solids are removed from the liquid along with a high percentage of radionuclides using a reverse osmosis process. However, because of its chemical properties, tritium is not removed during this process. The tritiated water which remains following waste concentration is delivered to the Evaporator where it is converted to steam and released as an airborne effluent. This method is preferable to release via surface water because (1) there is virtually no potential to influence the underlying aquifer, and (2) the potential for this tritium to contribute to an off-site dose is reduced by atmospheric dispersion. The effluent is directed to the same 98 meter stack used by the HFBR for building air exhaust. In 1997, 5.5 Ci (204 GBq) of HTO were released as an airborne effluent from the evaporator facility.

Since the waste concentration process does not completely remove all other radionuclides, nuclides other than tritium are released at much lower activity levels (see Table 5-1 for a listing). The activity values are estimated ones since facility emissions are tracked by an inventory system in place of in-line monitoring. Liquid shipments to the Evaporator are sampled and analyzed before delivery to determine radionuclide concentrations. The total emissions for a water tanker delivery are calculated by computing the product of the concentration and total volume evaporated. This method is very conservative and airborne releases and projected doses from this facility are likely to be overestimated.

5.1.5 Building 801

Airborne radionuclides are also released from Building 801 (see Table 5-1 for isotopes and quantities). These quantities are very small, typically in the millicurie to microcurie range, annually. This facility serves as a laboratory for chemical separation procedures employed in the routine extraction of radioisotopes from targets irradiated at the BLIP facility.

5.1.6 New Sources Evaluated in 1997

5.1.6.1 Removal Action V Recharge Basin

In 1997, an interim pump-and-recharge system was constructed to control the leading edge of the plume of tritium from the spent fuel storage pool at the HFBR. Three extraction wells pump groundwater containing both tritium and volatile organic compounds (from a source unrelated to the HFBR) from approximately 150 feet below ground surface to carbon filtration units, and ultimately, to the Removal Action V recharge basin, located 3,000 ft. to the north. By recharging this water to a northern, upgradient area, groundwater containing tritium will take an additional 19 years to reach BNL's southern boundary, thus allowing for additional dilution and radioactive decay. Potential air emissions from this source were evaluated before the system became operational.

The tritium concentrations of the groundwater reaching the recharge basin were expected to be in the range of 3,500 pCi/L (130 Bq/L) or less. However, for purposes of assessing air emissions, more conservative assumptions were employed; it was assumed that the water would contain up to 20,000 pCi/L (740 Bq/L) of tritium, the drinking water standard. Also, assuming year round summer time evaporation rates, a total annual airborne tritium source term of 100 mCi (3.7 GBq) was estimated.

Following the start of pumping operations, analysis of the water entering the Recharge Basin showed that tritium was rarely present above detectable levels. These data verified that the initial source calculations used in evaluating the air emissions were overly conservative.

5.1.6.2 Building 830 Kinetic Mixer

The Kinetic Mixer, located in Bldg. 830, was designed to evaluate mixing thermoplastic polymers with waste materials as a viable method for the encapsulation of wastes. The viability of kinetic mixing was demonstrated by processing actual wastes. The polyethylene microencapsulation process used waste samples including: (1) clean BNL soil; (2) BNL soil from the former Hazardous Waste Management Facility; (3) surrogate of DOE Fernald Site silo waste; and (4) mixed waste samples from the Fernald Site. Total estimated atmospheric release of radium, uranium, and thorium decay products from this process was less than 1 mCi (0.04 MBq).

5.1.6.3 HFBR Spent Fuel Pool Dewatering Operation

This operation removed water from the HFBR spent fuel pool (SFP). The SFP is the source of the tritium plume detected in groundwater to the south of the HFBR. Plans were developed to pump the water out of the SFP and into liquid waste storage tanks at the Building 811 WCF after removing all spent fuel elements. The water was pumped via a double-walled underground line constructed with leak detection equipment. The volume pumped was approximately 60,000 gallons.

As water entered one of four waste receiving tanks, any radionuclides made airborne inside a tank as a result of agitation could have been forced out of the air vents by volume displacement. (There were no forced ventilation fans or emissions controls at these tank vents.) Given its physical properties as water vapor, the radionuclide evaluated for off-site dose potential from this operation was tritium. In this scenario, the maximum amount of airborne tritium that could have been generated was estimated to be 2.5 Ci (93 GBq).

5.1.6.4 BGRR Deep Drain Sump Pumping Operation

The BGRR is a research reactor facility which last operated in 1969. During a visual inspection of the facility in 1997, standing water was observed in what is known as the Deep Drain Sump. The source of this standing water is an underground air exhaust duct which had accumulated water through rain intrusion and air cooler water leaks. Analysis showed this water to contain radioactive materials, including tritium. To remove this water as a potential source of groundwater contamination, it was pumped out of the sump and into mobile tankers within the reactor building. The water was then moved to a temporary on-site storage facility while treatment and disposal options are evaluated.

The possibility was considered that radioactive material could become airborne from agitation caused by pumping the water from the underground duct into the mobile tanker through hoses. Given its physical properties as water vapor, tritium was evaluated for off-site dose potential. The maximum amount of airborne tritium generated was estimated to have been 1 mCi (37 MBq).

5.1.7 Fugitive Emissions

The potential fugitive emission sources evaluated in CY 1997 were the Removal Action V Recharge Basin (described above) and the STP holding ponds.

During 1997, the STP holding ponds contained only trace quantities of tritiated water. However, since these ponds provide the opportunity for airborne radionuclide generation through evaporation, they are considered fugitive sources. The maximum inventory within the ponds at any time during CY1997 was approximately 30 mCi (1 GBq). The total quantity of airborne activity was estimated to be 3 mCi (111 MBq).

5.1.8 Additional Minor Sources

Several Departments within BNL conduct research involving very small quantities of radioactive materials (in the microcurie to millicurie range). This material is often used in fume hoods designated for use with radioactive materials. Operations such as transferring material between containers, pipetting, and chemical compound labeling are typical of this work. Due to exhaust filters, the type of work conducted and the small quantities involved, these operations have a very low potential for atmospheric release of any environmentally significant quantity of radioactive material. Compliance with 40 CFR 61 Subpart H is demonstrated through the use of an inventory system which allows an upper estimate of potential releases to be calculated. Facilities which demonstrate compliance in this way include the Biology Dept. (Bldg. 463), the Chemistry Dept., (Bldg. 555), the Dept. of Applied Science (Bldgs. 318 and 490A), the Medical Dept. (Bldg. 490), and the Dept. of Advanced Technology (Bldg. 703).

5.2 Airborne Effluent Emissions - Nonradioactive

Nonradioactive emissions are generated from a variety of processes at BNL. Boilers at the Central Steam Facility (CSF) account for most of the nonradioactive air emissions at the Laboratory. Since potential emissions of NO_x and SO_2 from the CSF boilers exceed the major facility thresholds of 25 tons and 100 tons, respectively, BNL is required to submit a Title V operating permit application to the NYSDEC by December 9, 1998 pursuant to 6 NYCRR Part 201 provisions. One of the goals of the Title V operating permit program is to consolidate all emission sources and all federal and state regulatory requirements applicable to the sources at major facilities into a document known as the Title V permit. To ensure that all potential emission sources are included in BNL's Title V permit application, BNL conducted walk through inspections of most on-site buildings beginning in April 1997. More than 1800 emission sources were identified. Most were classified as *exempt* or *trivial* sources in accordance with provisions of Part 201, and include processes such as welding/soldering, degreasing, sandblasting, machining, aerosol painting and parts cleaning. Aside from the boilers at the CSF, other significant sources subject to applicable state and/or federal regulatory include the Asbestos Test Facility, the Building 458 paint booth, and the on-site gasoline refueling facilities.

5.2.1 Central Steam Facility (CSF)

The CSF is located along the eastern perimeter of the developed portion of the BNL site. The CSF supplies steam for heating and cooling to all major facilities through the underground steam distribution and condensate grid. The combustion units at the CSF are designated as Boiler Nos. 1A, 5, 6 and 7. Boiler 1A is a Babcock and Wilcox FM unit that was installed in 1962, and has a heat input of 56.7 MMBtu/hr. Boiler 5 is a Combustion Engineering VU-60 unit installed in 1965 that has a heat input of 225 MMBtu/hr. Boiler No. 6 is a Combustion Engineering 28-A-14 unit, installed in 1984, with a heat input of 147 MMBtu/hr. Boiler No. 7 is a new Babcock & Wilcox FM-117-8-97 unit with a heat input of 147 MMBtu/hr installed in 1996. Boiler Nos. 6 and 7 are subject to the New Source Performance Standard, 40 CFR Subpart Db, and are equipped with continuous emissions monitors for NO_x. Boiler No. 7 emissions are also continuously monitored for opacity in accordance with Subpart Db requirements. All four boilers are monitored for O_2 and CO_2. Emissions from these boilers are reported quarterly to the NYSDEC.

In the spring of 1997, LILCO completed work to extend 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 Boiler Nos. 5 and 7. Plans to upgrade Boiler No. 6, which included replacing existing steam atomized oil burners with two Peabody-Hamworthy DFL low NO_x burners, and the adding a natural gas train connection to the gas main are expected to be completed in 1998. Upgrades to carry the gas from the gas main to each of the boilers and new burners were installed. Before the upgrades proceeded, BNL entered into an agreement with LILCO, whereby the Laboratory is required to burn at least 1.8 million dekatherms over three years. During this period, LILCO can interrupt gas flow to the site when

ambient temperatures fall below 30° F. After shakedown testing of the boilers was completed, Boiler Nos. 5 and 7 started burning natural gas in November and September 1997, respectively. Because natural gas was used, annual emissions of NO_x and SO_2 at the CSF in 1997 declined by 34 tons and 21 tons, respectively, from totals recorded in 1996. On an equivalent heat input basis, NO_x emissions at the CSF dropped by 17 tons while SO_2 emissions fell 28 tons.

5.2.2 Asbestos Test Facility

Since August 1995, the Department of Applied Sciences (DAS) has used the former Inhalation Toxicology Facility in Building 490 to fabricate GVF-12.7 fireproofing test panels as part of a Cooperative Research and Development Agreement with a private company. The primary goal was to develop a process to treat fire proofing products with a conversion agent which would chemically convert the asbestos containing material to a non-regulated asbestos-free product that retains its fire proofing properties. The work is conducted in three stages in three separate enclosures (i.e., hoods). The exhaust systems for all three enclosure have their own pollution control systems to remove potential releases of asbestos fibers; the third enclosure is equipped with a wet scrubber system to control caustic and acidic aerosols generated in applying conversion agents to fabricated asbestos test samples. The exhaust systems for each of the project's three hoods were designed to exceed pollution control requirements established by NESHAPs Subpart M. Exhaust from each processing step pass through a series of fabric pre-filters and two HEPA filters before their release to the atmosphere. To satisfy Subpart M monitoring requirements, each process hood exhaust is visually monitored on a daily basis for evidence of visible emissions of asbestos. In addition, the pre-filters and HEPA filters associated with each hood are inspected at least once per week to ensure that they are functioning properly. This is accomplished by visually inspecting the clean side of pre-filters, recording the pressure drop readings across each filter and comparing these readings with the manufacturer's recommendations. Since panel fabrication and testing began, DAS has prepared quarterly reports documenting the inspections of emission filter devices and the monitoring of exhausts for visible emissions; none were observed in 1997.

5.2.3 Spray Paint Booth

The spray paint booth located in Building 458 paint shop is used primarily to apply both protective and decorative coatings to miscellaneous metal parts and metal and wood room furnishings. The coatings have VOC contents that comply with the VOC limitations described in 6 NYCRR Part 228. To ensure compliance with the VOC requirements, Paint Shop personnel keep a running log of the substrates coated and the coating products applied during the year. Paint overspray is controlled by a bank of disposal fabric cartridges. This is a low volume shop that typically applies less than 200 gallons of coating annually.

5.2.4 Gasoline Refueling Facilities

In 1989, BNL replaced the existing single wall steel underground storage tanks at the fleet vehicle refueling facility at Building 423 and the contractor operated facility at Building 630 with double walled underground storage tanks to comply with Suffolk County Article 12 requirements. The two 8,000 gallon tanks installed at Building 423 and the three 8,000 gallon tanks installed at Building 630 were each equipped with stage I fill connections, submerged fill drop tubes and with NYSDEC approved stage II vapor recovery systems. The stage I collection system consists of a vapor-tight return line connected from the gasoline delivery tanker to the tank fill pipe during filling operations. Displaced vapors are returned to the gasoline delivery tanker through the vapor return line as gasoline is pumped into the tanks. The stage II recovery systems are designed to recover more than 90 percent by weight of the gasoline vapors displaced from a motor vehicle gas tank during refueling. Both stage I and stage II systems were installed to comply with 6 NYCRR Part 230 requirements. In 1997 the combined annual throughput of gasoline for the two facilities was 430,354 gallons. Using EPA AP-42 emission factors, the combined VOC emissions from the two facilities for 1997 were estimated to be less than 1,800 pounds.