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EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

BROOKHAVEN NATIONAL LABORATORY

1998 Site Environmental Report

September 1999

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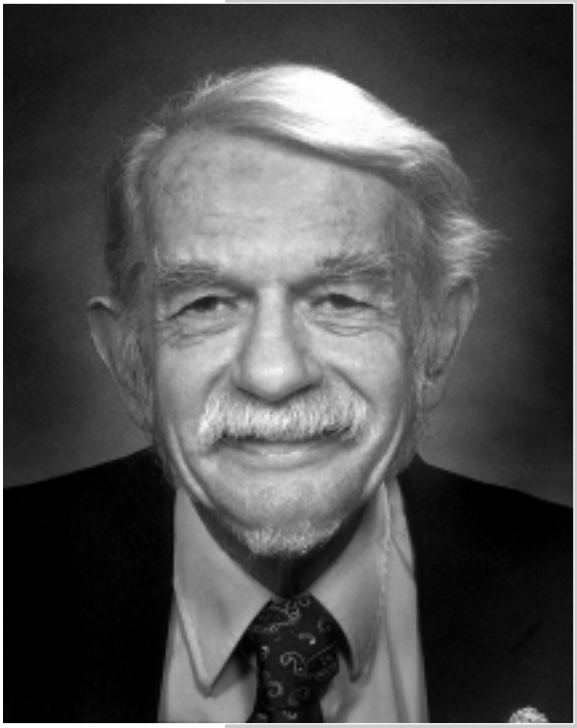

Dedication

Andrew P. Hull, CHP

(1920-1999)

This Site Environmental Report is dedicated to Andrew Hull, who was a Certified Health Physicist at Brookhaven National Laboratory (BNL). Hull was devoted to the environment and the safe use of nuclear physics throughout the world. Born in Bristol, Connecticut, Hull became a health physicist after a career with American Airlines and a tour of duty in the U.S. Air Force during the Korean War. He received his bachelor's degree from Central Connecticut State College in 1956 and, on a fellowship from the Atomic Energy Commission, his master's degree in physics from Vanderbilt University in 1961. For the next 38 years he worked at BNL. From 1962 to 1981, Hull was responsible for the environmental monitoring program and for publishing the site environmental reports.

In addition to his BNL duties, Hull was one of the first health physicists to reach the Three Mile Island nuclear reactor accident in 1979 and was responsible for the analysis and interpretation of the environmental data that estimated population radiation doses. He was also called to the site of the Chernobyl Nuclear Power Plant accident in 1986 and helped determine the health and environmental impacts of that accident for the Department of Energy.

As a source of information, a mentor, and as friend of the environment, Andrew Hull will be missed.

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Executive Summary

For 50 years, the unique, leading-edge facilities at Brookhaven National Laboratory (BNL) have made many valuable scientific contributions possible. Today, BNL continues its research mission while paying close attention to protecting and cleaning up the local environment. The Laboratory's new environmental motto, "Exploring Earth's Mysteries ... Protecting Its Future," reflects a desire to balance world class research with operating in harmony with the natural environment.

ENVIRONMENTAL PROGRAMS AND EFFORTS

This Site Environmental Report is a summary of BNL's environmental performance. It is BNL's policy to integrate environmental stewardship into all facets of the Laboratory's missions. In 1998, BNL strengthened its environmental programs to ensure that it operates in a responsible manner that protects human health and the ecosystem. Major investments were made in four key programs:

* The Upgrade of BNL's Environmental Management System. Improvements include the use of the International Standards Organization (ISO) 14001 standard as a framework, with added emphasis on assuring compliance with environmental requirements.

* The Facility Review Project. This program provides an extensive examination of all previous and current buildings and equipment that have the potential to cause environmental damage, and furnishes remedies for any identified endangerment.

* The Process Evaluation Project. This program is being used to create an integrated database that will be used to identify, track and address all potential or historical environmental concerns and issues related to facility operations.

* The Groundwater Protection Program. Expansion of this program included the efforts in pollution prevention, monitoring, restoration and communications with the public.

Together, the programs provide effective tools for pinpointing and preventing conditions that could harm the environment. They are described in more detail in Chapter 2.

BNL's aggressive Pollution Prevention Program is the keystone for all programs safeguarding the environment. It is being integrated into the planning, decision-making, and implementation phases of all site activities. Pollution prevention initiatives in 1998 resulted in declines of 11 tons of particulate emissions, 8.5 tons of nitrogen oxides, and 66.2 tons of sulfur dioxide; reductions in excess of 500 million liters per year of water used for cooling; elimination of the use of treatment chemicals at two water cooling towers; and other significant accomplishments. Chapter 2 has more information.

COMPLIANCE

BNL is subject to more than 50 sets of federal, state and local environmental regulations, 60 site-specific permits and a number of other binding agreements. BNL is committed to achieving and maintaining full compliance with these environmental requirements and agreements. In 1998, BNL operated in compliance with the majority of applicable regulations. Exceptions include nine minor exceedances of wastewater discharge permit limitations, and noncompliance with administrative provisions of the hazardous waste regulations. Corrective actions have been taken to address any issues noted. In order to meet Article 12 of the Suffolk County Sanitary code that regulates the storage and handling of toxic and hazardous materials, BNL permanently removed 26 storage tanks and retrofitted 31 tanks with containment systems in 1998. Other improvements that enhanced compliance this year (and for future years) include the upgrade of the Sewage Treatment Plant from primary to tertiary treatment facilities and the Spill Prevention Control Plan upgrade. Potable water met all standards. Chapter 3 gives more information about the environmental regulations affecting BNL operations and compliance.

In addition, BNL's operations and environmental protection programs were reviewed and audited extensively by a number of organizations in 1998. The New York State Department of Environmental Conservation and the Suffolk County Department of Health Services conducted compliance inspections; DOE local, regional and headquarters conducted audits and program reviews; and BNL conducted its own assessments. No significant compliance issues were identified.

ENVIRONMENTAL MONITORING AND RESULTS

In addition to groundwater monitoring, BNL's comprehensive monitoring program has hundreds of ambient and emission-point air monitoring stations and river water checkpoints. The monitoring system assesses environmental quality, ensures compliance with regulatory and permit conditions, and provides early detection of any condition requiring corrective action.

Over 5,000 samples of air, drinking water, surface water, groundwater, soil, flora and fauna were collected from hundreds of locations in 1998. Samples were analyzed for radiological parameters and organic and inorganic constituents. Improved wastewater management and reduced maintenance work within the High Flux Beam Reactor resulted in the lowest amount of tritium released to the Peconic River since measurements began in 1966. Analytical results showed that farm-grown vegetation remained unaffected by BNL activities. Due to historical environmental releases, local deer and fish continued to show somewhat elevated levels of BNL-related radionuclides, but at levels that continue to decrease with time. Both total air emissions and radiological air quality met Clean Air Act and DOE standards in 1998. Analytical results from groundwater monitoring wells located near most active facilities indicated that releases from current operations were within regulatory standards. However, groundwater monitoring did identify elevated tritium concentrations near the Brookhaven Linac Isotope Producer. Following this discovery, corrective actions were immediately taken to prevent further impacts to groundwater quality.

Modeling of radioactive air emissions showed that the theoretical maximum public dose from the air exposure pathway was equal to only two percent of the limit established by the EPA's National Emission Standards for Hazardous Air Pollutants. Potential radiological doses from the routine consumption of fish and deer containing BNL-related radionuclides were calculated to be less than eight percent of the annual public dose limit specified by the DOE.

ENVIRONMENTAL RESTORATION

Six significant volatile organic compound (VOC) plumes and six radionuclide plumes exist in the groundwater underneath and downgradient of the BNL site as a result of historical spills and past operations. Efforts to monitor and cleanup the soil and groundwater contamination are managed under the Environmental Restoration Program. As part of BNL's extensive monitoring program carried out in 1998, 470 monitoring wells were sampled for a total of 1,750 individual sampling events, to verify that prevention and restoration activities are effective. During 1998, groundwater restoration activities resulted in the removal of approximately 222 kilograms (490 pounds) of volatile organic compounds (VOCs) and the treatment and return of approximately 2,800 million liters (740 million gallons) of groundwater in the Upper Glacial aquifer. As a whole, no significant change in contaminant concentrations occurred during the year. However, remediation systems are decreasing VOC concentrations located near the southern boundary of the site.

These strides forward reflect BNL's commitment to continually bettering its environmental performance through managerial emphasis as well as compliance efforts.

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The production of the 1998 BNL Site Environmental Report (SER) requires the knowledge, skill, experience, and cooperation of many people and several organizations at the Laboratory. Responsibility for producing the SER lies within the Environmental Services Division, which is managed by Elizabeth A. Flores. The main authors, co-authors and other contributing staff and organizations involved in this year's SER are listed below.

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BROOKHAVEN
NATIONAL LABORATORY

Environmental Stewardship Policy

It is Brookhaven National Laboratory's (BNL's) policy to integrate environmental stewardship into all facets of the Laboratory's missions. We will manage our programs in a manner that protects the ecosystem and public health.

In support of this policy,
BNL makes the following commitments:

♦

We are committed to achieving compliance with applicable environmental requirements.

♦

In consideration of the potential impacts of our activities on the environment, we will integrate pollution prevention/waste minimization, resource conservation, and compliance into all of our planning and decision-making. We will adopt cost-effective practices that eliminate, minimize or mitigate environmental impacts.

♦

We will define, prioritize, and aggressively correct and clean up existing environmental problems.

♦

We will work to continually improve our environmental management system and performance.
We will establish appropriate environmental objectives and performance indicators to guide these efforts and measure our progress.

♦

We will maintain a positive, proactive, and constructive relationship with our neighbors in the community, regulators, DOE, and our other stakeholders. We will openly communicate with stakeholders on our progress and performance.

In addition to my annual review of BNL's progress on environmental goals and adherence to this policy, I invite all interested parties to provide me with input on our performance relative to this policy, and the policy itself.

John H. Marburger

John H. Marburger, Laboratory Director

11/19/98

Date

CHAPTER 1

Introduction

Brookhaven National Laboratory (BNL) is a research facility situated on 21.3 square kilometers (5263 acres) in Brookhaven Township on Long Island, New York. BNL has a comprehensive environmental protection and monitoring program. The Site Environmental Report is prepared annually by BNL to summarize the Laboratory's environmental performance and to describe what impact, if any, BNL operations have on the environment. Key to evaluating the monitoring data used in determining what impact the Laboratory may be having on the environment is the understanding of local site characteristics in terms of human population, geology and hydrology, climatic data and ecological resources.

1.1. PURPOSE OF THE 1998 SITE ENVIRONMENTAL REPORT (SER)

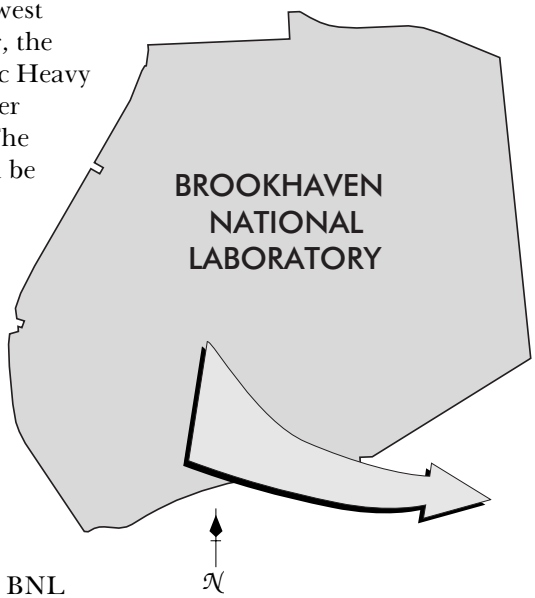
The SER summarizes the efforts, data, and status of BNL's environmental protection, compliance and monitoring programs for calendar year 1998. This report is prepared in accordance with the U.S. Department of Energy (DOE) Order 5400.1, "General Environmental Protection Program." This order sets forth the requirements for environmental protection programs at DOE facilities to ensure that operations fully comply with applicable federal, state, and local environmental laws and regulations, executive orders, and with DOE policies. A condensed version of the SER, referred to as the Summary Report, is also available. The Summary Report, written with a minimum of technical terminology, is used to provide information to visitors, students, and members of the public in support of BNL's educational and community outreach programs.

1.2. THE HISTORY AND MISSION OF BROOKHAVEN NATIONAL LABORATORY

BNL is operated for DOE by Brookhaven Science Associates (BSA), a partnership of Battelle Memorial Institute and the State University of New York at Stony Brook (SUNY). BSA entered into an agreement with the DOE under contract DE-AC02-98CH10886 and began operating BNL on March 1, 1998. Prior to that, BNL was operated by Associated Universities, Incorporated (AUI).

BNL is a world class scientific research laboratory founded in 1947 on the site of the U.S. Army's former Camp Upton. BNL's main mission is basic and applied research in a variety of scientific fields from physics, chemistry and materials science to biology, medicine and forefront technology. In undertaking research, it is BNL's policy to integrate environmental stewardship into all facets of the Laboratory's missions, and to manage programs in a manner that protects the ecosystem and public health. The cover page to this chapter presents BNL's Environmental Stewardship Policy, and affirms this committment. The policy was signed by the Laboratory Director, John H. Marburger, on November 19, 1998.

At the heart of BNL are a number of large and unique research facilities. These sophisticated facilities allow thousands of BNL scientists and visiting researchers from academia and industry to extend the boundaries of knowledge and technology. BNL's scientific history began in 1950 with the operation of the Brookhaven Graphite Research Reactor (BGRR), the first of three research reactors used for peaceful scientific exploration. The BGRR was joined in 1952 by the Cosmotron, the first particle physics accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Nobel Prize-winning discovery in 1957. In 1960, the Alternating Gradient Synchrotron (AGS), a large accelerator, was built to surpass the Cosmotron's capabilities. It has yielded many discoveries on new particles and phenomena for which BNL researchers were awarded Nobel Prizes in physics in 1973, 1980, and 1988. Another accelerator, the Tandem Van de Graaff, began operating in 1970. Today, Brookhaven is looking forward to 1999 when physicists will begin to use the newest accelerator, the Relativistic Heavy Ion Collider (RHIC). The RHIC will be able to recreate a state of matter that was believed to be seen moments after the universe's formation.



Medical research at BNL began in 1950, with the opening of the first hospital devoted to nuclear medicine. It was fueled by a modern Medical Research Center (MRC) in 1958, the Brookhaven Medical Research Reactor (BMRR) in 1959, and the Brookhaven Linac Isotope Producer (BLIP) in 1973. Chemists and physicians teamed up to view the inner workings of the brain in 1977 with the advent of Positron Emission Tomography (PET) cameras. Two more imaging techniques were added to PET to form the Center for Imaging and Neuroscience in 1996.

A range of research from solid-state physics to art history was made possible starting in 1965, when the High Flux Beam Reactor (HFBR) began providing neutrons to researchers of all disciplines. In 1982, the National Synchrotron Light Source (NSLS) began operation. The NSLS guides charged particles in an orbit. As the electrons whirl around inside a hollow donut-shaped tube called an "electron storage ring," they give off light called "synchrotron light." This light, which can be detected by specialized instruments, is used to study the properties of matter.

The Laboratory's treatment of the environment did not measure up to its world class status in science. Historical waste management practices led to releases of chemicals and radioactive materials which resulted in soil and groundwater contamination. In 1989, BNL joined a number of Long Island sites added to the federal Superfund National Priorities List. Remediation of soil, groundwater and other waste disposal areas is proceeding. The year 1997 was an eventful one at BNL, with many environmental issues coming to light; the most noteworthy of which prompted the shut down of the HFBR (See Section 1.4 for more details). In the year the Laboratory celebrated its 50th anniversary, DOE terminated the AUI operating contract for poor environmental performance.

After a competitive bidding process that began in 1997, BSA was selected to succeed AUI in managing BNL. BSA is committed to guiding BNL into the 21st century, with a combination of excellent science, environmental protection and community involvement.

1.3. SITE LOCATION AND LOCAL POPULATION

Brookhaven National Laboratory is located near the geographical center of Suffolk County, Long Island, about 97 kilometers (km), or 60 miles (mi), east of New York City (Figure 1-1). About a third of the 1.36 million people that reside in Suffolk County live in Brookhaven Township where the Laboratory is situated (LIPA, 1998). Approximately eight

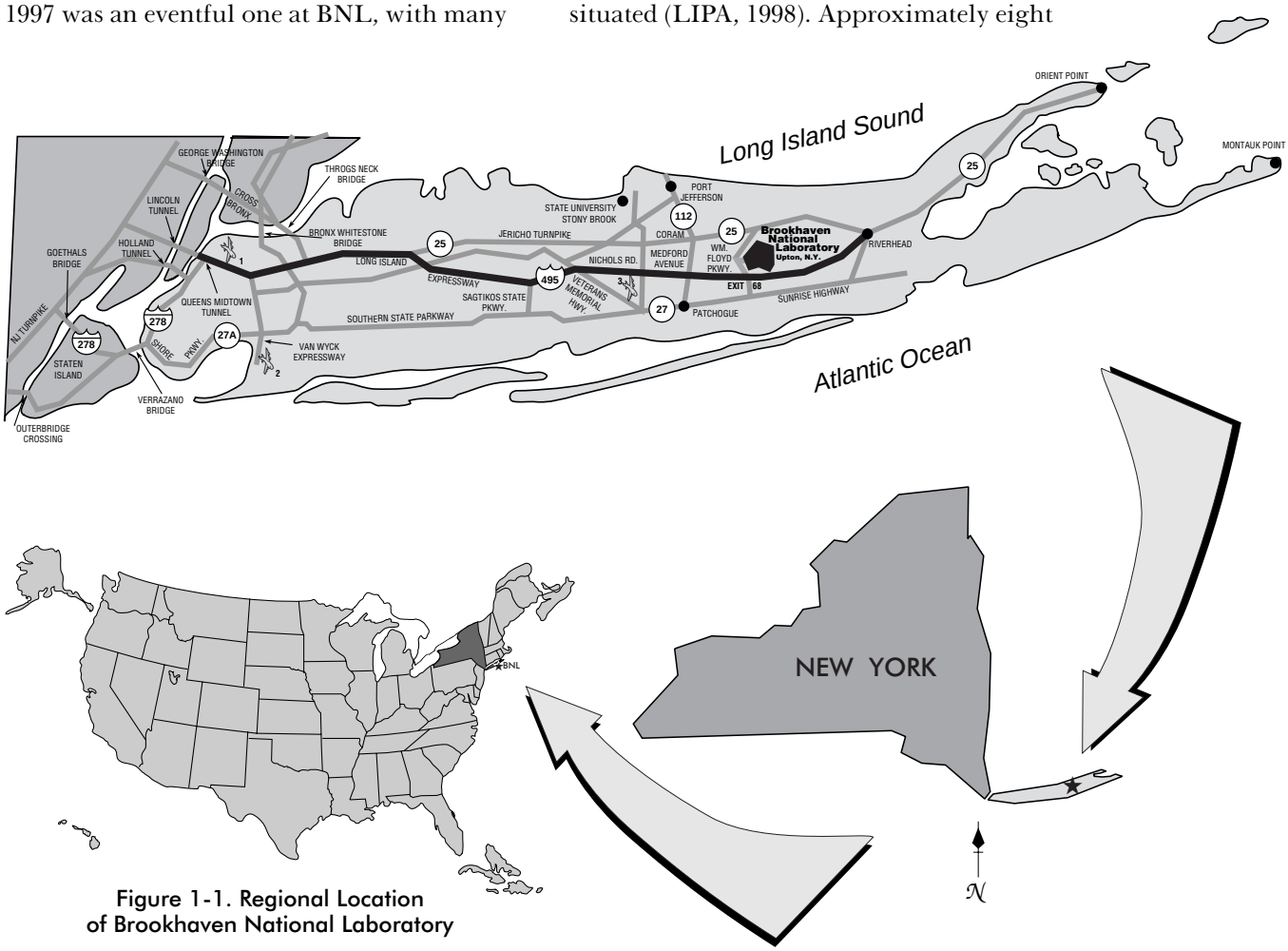


Figure 1-1. Regional Location of Brookhaven National Laboratory

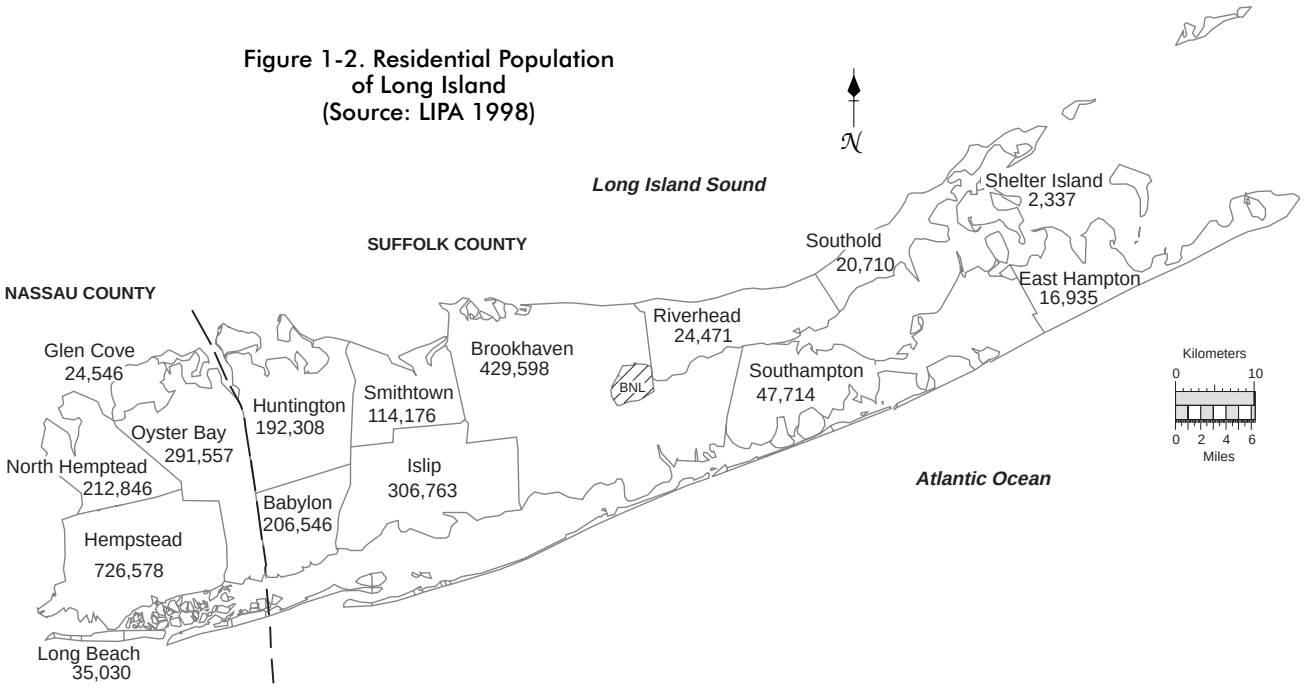


Figure 1-2. Residential Population of Long Island (Source: LIPA 1998)

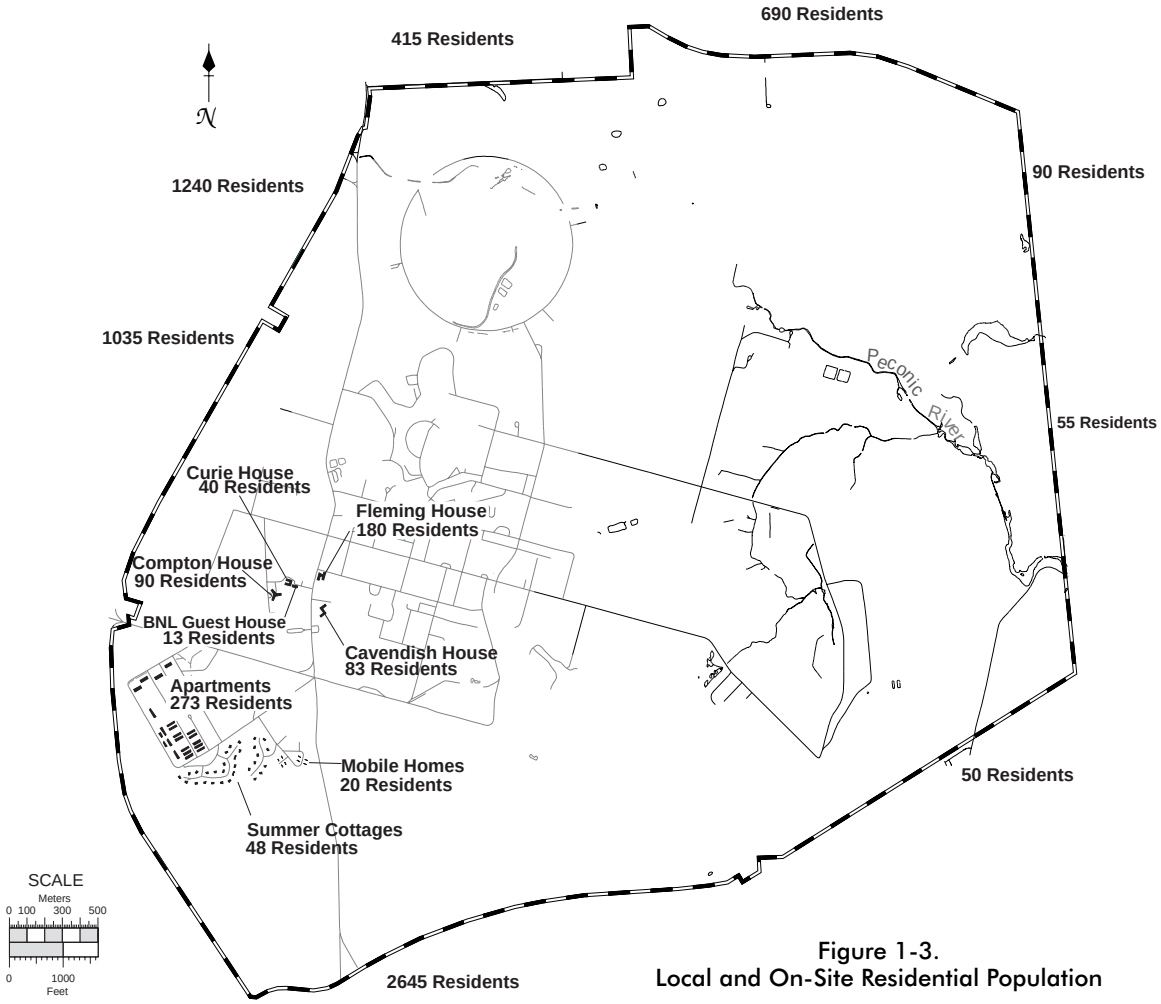


Figure 1-3. Local and On-Site Residential Population

thousand people live within a one-half km (0.3 mi) of the Laboratory's boundaries. Figure 1-2 shows the distribution of the resident population on Long Island. Figure 1-3 shows the onsite and resident population surrounding the site within a one-half km (0.3 mi). Although much of the land area within a 16 km (9.9 mi) radius of BNL is either forested or cultivated, there has been an increase in residential housing in recent years, a trend that is expected to continue.

BNL has over 3,000 employees. As shown in Figure 1-4, more than 75 percent of BNL's employees live within a 15-mile radius of the laboratory. In addition, more than 4,000 visiting scientists come from all over the world each year to conduct research at the laboratory. While conducting their research, these visiting scientists either live on or offsite. Adding to our onsite staff and visiting scientists, more than 10,000 student visitors and other members of the public visited the laboratory in 1998 to participate in education and public outreach activities. See Chapter 2 for more information.

1.4. FACILITY DESCRIPTION

BNL's site consists of 21.3 sq-km (5263 acres). Most principal facilities are located near the center of the site. The developed area is approximately 6.7 sq-km (1,656 acres), of which about 2.02 sq-km (500 acres) were originally developed by the Army (as part of Camp Upton), and about 0.81 sq-km (200 acres) are occupied by various large, specialized research facilities. Outlying facilities occupy about 2.22 sq-km (549 acres); these include the Sewage Treatment Plant (STP), research agricultural fields, housing, and fire breaks. The balance of the site is largely wooded.

The major scientific facilities are pictured and briefly described in Figure 1-5. The High Flux Beam Reactor is pictured in Figure 1-6.

Additional radiological programs for scientific investigations are carried out at other BNL facilities including those of the Medical Research Center, Biology, Chemistry, and Applied Technology programs.

In addition to the scientific facilities, there are numerous other major facilities, which provide support to BNL's science and technology mission. Among these are:

- Sewage Treatment Plant (STP) - The STP, shown in Figure 1-7, has a design capacity of 11.3 million liters per day (MLD) [3.0 million gallons per day (MGD)] and receives sanitary and certain process waste

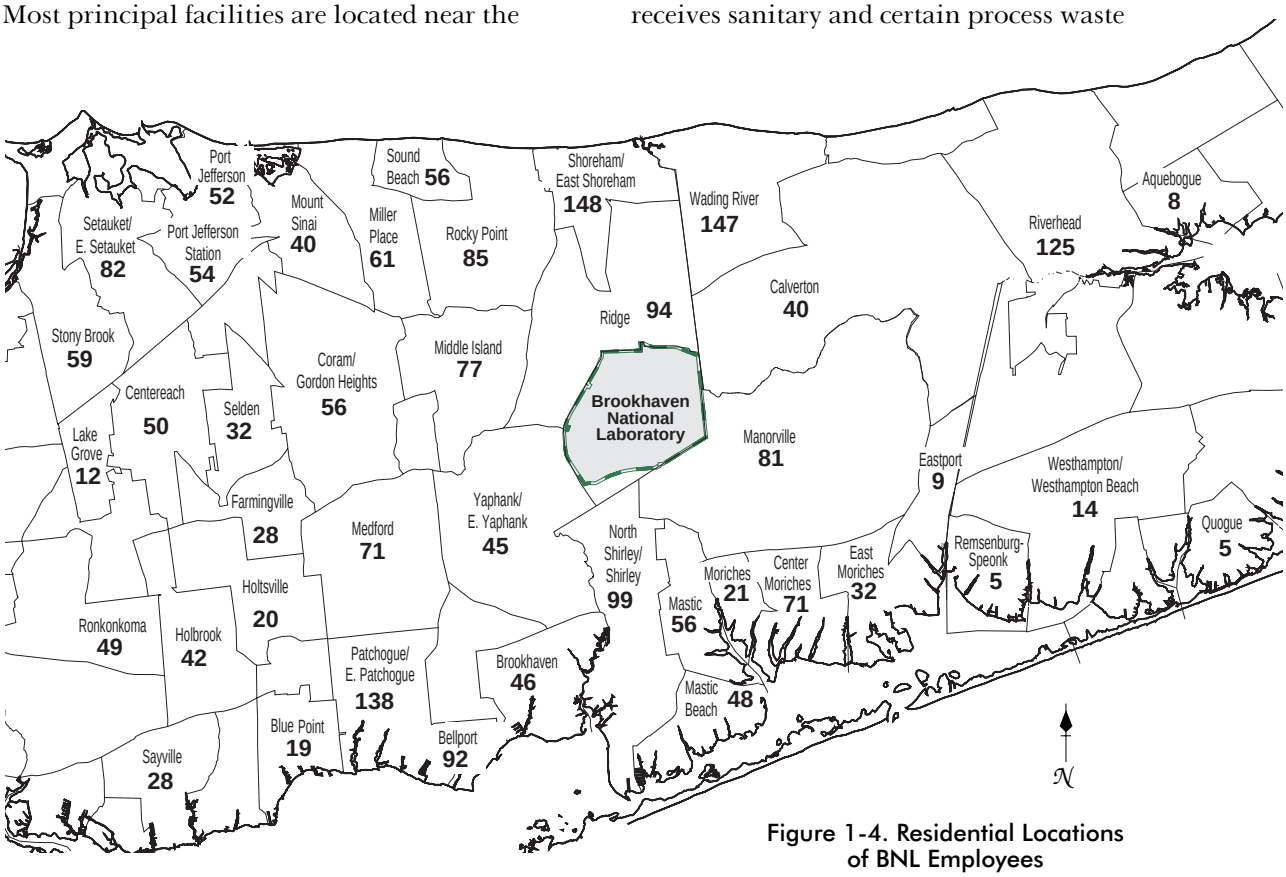


Figure 1-4. Residential Locations of BNL Employees

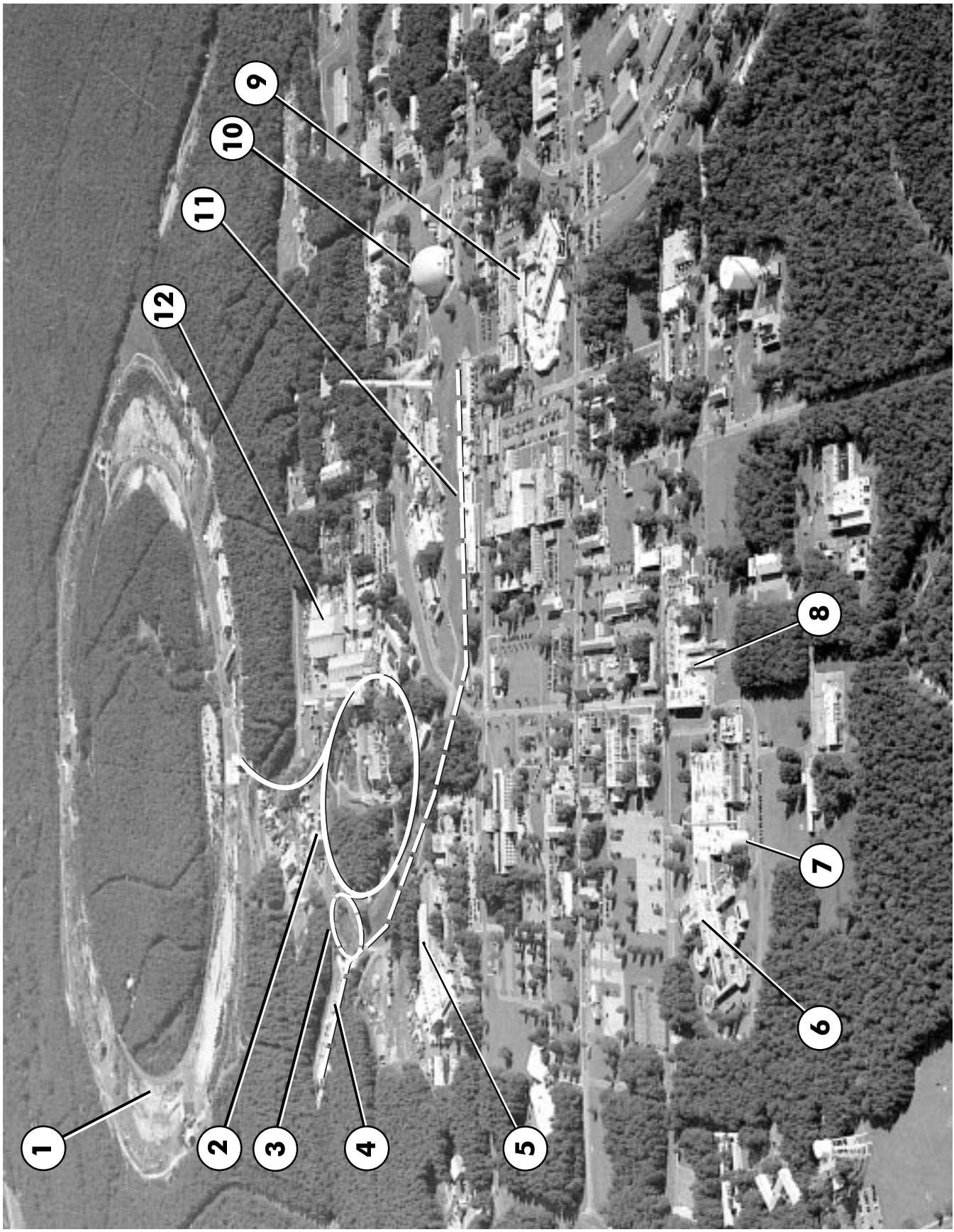

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Figure 1-5. Major Scientific Facilities

1. RELATIVISTIC HEAVY ION COLLIDER (RHIC)
Now under construction, RHIC will soon be one of the world's largest and most powerful accelerators. RHIC's main physics mission is to study particles smaller than atoms.

2. ALTERNATING GRADIENT SYNCHROTRON (AGS)
The AGS is used for high-energy physics research and accelerates protons to energies up to 30 GeV, and heavy-ion beams to 15 GeV. A 200 MeV Linear Accelerator, described below, serves as a proton injector for the AGS and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven Linac Isotope Producer (BLIP) facility.

3. AGS BOOSTER
The AGS Booster is a circular accelerator, 200 meters in circumference, that receives either a proton beam from the Linac, or heavy ions from the Tandem Van de Graaff. The Booster accelerates proton particles and heavy ions before injecting them into the AGS ring. This facility became operational in 1992.

4. LINEAR ACCELERATOR (Linac) AND BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP)
The Linac makes beams of polarized protons for the AGS and, when it becomes operational, for the Relativistic Heavy Ion Collider (RHIC). BLIP utilizes the excess beam capacity of the Linac to produce radioisotopes used in research and medical imaging. 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.

5. HEAVY ION TRANSFER LINE (HITL)
The HITL connects the Tandem Van de Graaff and the AGS. This interconnection permits ions of intermediate mass to be injected into the AGS where they can be accelerated to an energy of 15 GeV/amu. These ions then are extracted and sent to the AGS experimental area for physics research.

6. RADIATION THERAPY FACILITY (RTF)
Part of the Medical Research Center (MRC), the RTF is a high-energy dual X-ray mode linear accelerator for radiation therapy of cancer patients. This accelerator delivers therapeutically useful beams of X-rays and electrons for conventional and advanced medical radiotherapy techniques.

7. BROOKHAVEN MEDICAL RESEARCH REACTOR (BMRR)
The Brookhaven Medical Research Reactor (BMRR) was the world's first nuclear reactor built exclusively for medical research applications. 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 an integral part of the MRC.

8. SCANNING TRANSMISSION ELECTRON MICROSCOPE (STEM)
This facility actually includes two microscopes, STEM 1 and STEM 3, used for biological research. Both powerful devices allow scientists to see the intricate details of living things, from bacteria to human tissue.

9. NATIONAL SYNCHROTRON LIGHT SOURCE (NSLS)
The NSLS utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings which operate at energies of 750 MeV vacuum ultraviolet (VUV), and 2.5 GeV (x-ray). The synchrotron radiation produced by the stored electrons is used for VUV spectroscopy and for x-ray diffraction studies.

10. HIGH FLUX BEAM REACTOR (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 pharmaceutical design and materials development, as well as expanding the current knowledge base of physics, chemistry and biology. Due to a leak in the fuel storage pool which was discovered in 1997. Since that time, the HFBR has not been in operation.

11. TANDEM VAN DE GRAAFF AND CYCLOTRON
These two facilities are used in medium-energy physics investigations, and for producing special nuclides. The heavy ions from the Tandem Van de Graaff also can be injected into the AGS for physics experiments.

12. BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)
No longer in operation, the BGRR was used to research cancer therapy methods, such as boron neutron capture therapy.

Figure 1-6. High Flux Beam Reactor. (HFBR)

Figure 1-7. Aerial photograph of Sewage Treatment Plant

waters from BNL facilities for treatment prior to discharge into the Peconic River. The discharge, which is called effluent, is carefully monitored and controlled under a permit issued by the New York State Department of Environmental Conservation (NYSDEC). See Chapter 2 for additional information on this facility and environmental permits.

- Water Treatment Plant (WTP) - The WTP is a potable water treatment facility with a capacity of 19 MLD (5 MGD). During the treatment process, potable water obtained from three wells located along the western boundary of the developed site is treated with a lime-softening process to remove naturally occurring iron. The WTP is also equipped with dual air-stripping towers to ensure that volatile organic compounds are at or below New York State Drinking Water Standards.
- Central Steam Facility (CSF) - The CSF provides high-pressure steam used for both facility and process heating. Steam is conveyed to the user facilities through a series of underground piping. Condensate is collected and returned to the CSF for reuse as a water and energy conservation measure. See Chapter 2 for more information about Pollution Prevention initiatives at the CSF.
- Major Petroleum Facility (MPF) - The MPF provides the petroleum reserve needed for operating the CSF. This facility has a total capacity of 8.7 million liters (2.3 million gallons) for storing predominately fuel oil No. 6. The recent installation of a natural gas line has reduced BNL's reliance on oil as the primary source of fuel.
- Central Chilled Water Plant - This facility provides chilled water for ventilation and process cooling via a network of underground piping. The plant has a large refrigeration capacity, which reduces the necessity for local refrigeration plants, and once-through cooling.
- Waste Management Facility (WMF) - The WMF is a state-of-the-art complex of four buildings for managing the wastes generated during BNL's research and operation activities. This facility, which opened in December 1997, was built with advanced environmental protection systems and features. The WMF houses two areas permitted by the NYSDEC for storing and treating hazardous wastes, prior to shipment offsite for treatment and disposal at

other permitted Treatment, Storage, and Disposal Facilities.

1.5. GEOLOGY AND HYDROLOGY

The terrain of the site is gently rolling, with elevations varying between 13.3 and 36.6 meters (44 and 120 feet) above sea level. The land lies on the western rim of the shallow Peconic River watershed. The marshy areas in the north and eastern sections of the site are part of the headwaters of the Peconic River. The Peconic River both recharges to, and receives water from, the sole source aquifer system underneath Long Island, depending on the position of the water table relative to the base of the river bed. In times of sustained drought, the river water typically recharges to groundwater while with normal to above-normal precipitation, the river receives water from the aquifer.

BNL uses approximately 10 MLD (2.6 MGD) of groundwater to meet potable water needs in addition to heating and cooling requirements. Approximately 74 percent of the total water is returned to the aquifer through onsite recharge basins. About 19 percent is discharged into the Peconic River. Human consumption, evaporation (cooling-tower-and wind-losses) and sewer line losses account for the remaining seven percent. An additional 2.13 MLD (0.56 MGD) of groundwater are pumped from remediation wells for treatment, and then returned to the aquifer by the use of recharge basins. See Figure 1-8 for a graphical representation of groundwater usage at BNL.

Studies of Long Island hydrology and geology in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits (referred as the Upper Glacial Aquifer) are between 36 and 77 meters (120 and 250 feet) thick, and are generally composed of highly permeable glacial sands and gravel (Warren *et al.*, 1968). Water penetrates these deposits readily, and there is little direct run-off into surface streams unless precipitation is intense. On average, about half of the annual precipitation is lost to the atmosphere through evapotranspiration, and the other half percolates through the soil to recharge groundwater (Koppleman, 1978).

Many factors affect groundwater flow in the vicinity of BNL. An east-west groundwater divide is located approximately 0.8 km (0.5 miles) north of BNL (Scorca, *et. al.*, 1997). A second groundwater divide, which transects portions of the BNL site during periods of high water table position (i.e., during periods of inflow from the aquifer to the stream bed), defines the southern boundary of the area contributing groundwater to the Peconic River watershed. Groundwater flow direction across the BNL site is influenced by natural drainage systems varying between being eastward along the Peconic River, southeastward towards the Forge River, and southward toward the Carmans River. Figure 1-9 shows the typical ground water directional flow and elevation in terms of feet above mean sea level (AMSL). If depth to groundwater were measured from the surface of the land, it ranges from 1.52 meters (5 feet) near the Peconic River to about 24.38 meters (80 feet) in the higher elevation areas in the central and western portions of the site. In most areas at BNL, the horizontal velocity of groundwater is approximately 23 cm (0.75 feet) per day. In general terms, it takes approximately 20 to 22 years for groundwater to travel from the central, developed area of the site, to the BNL southern boundary.

BNL's site was identified by the Long Island Regional Planning Board and Suffolk County as being over a deep-flow recharge zone for Long Island (Koppleman, 1978). This finding indicates that precipitation and surface water which recharge within this zone have the

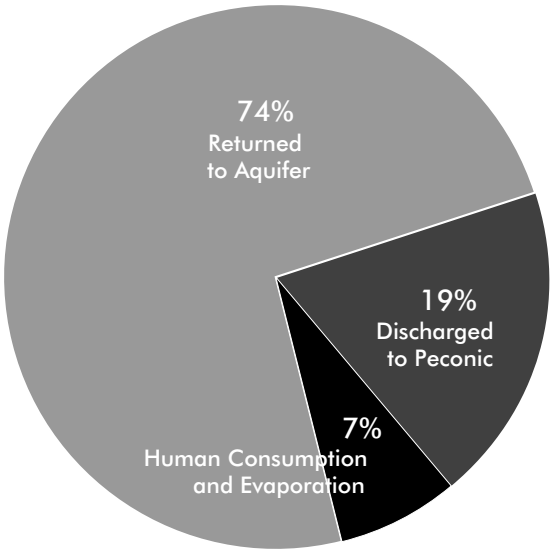


Figure 1-8. Use of Groundwater at BNL

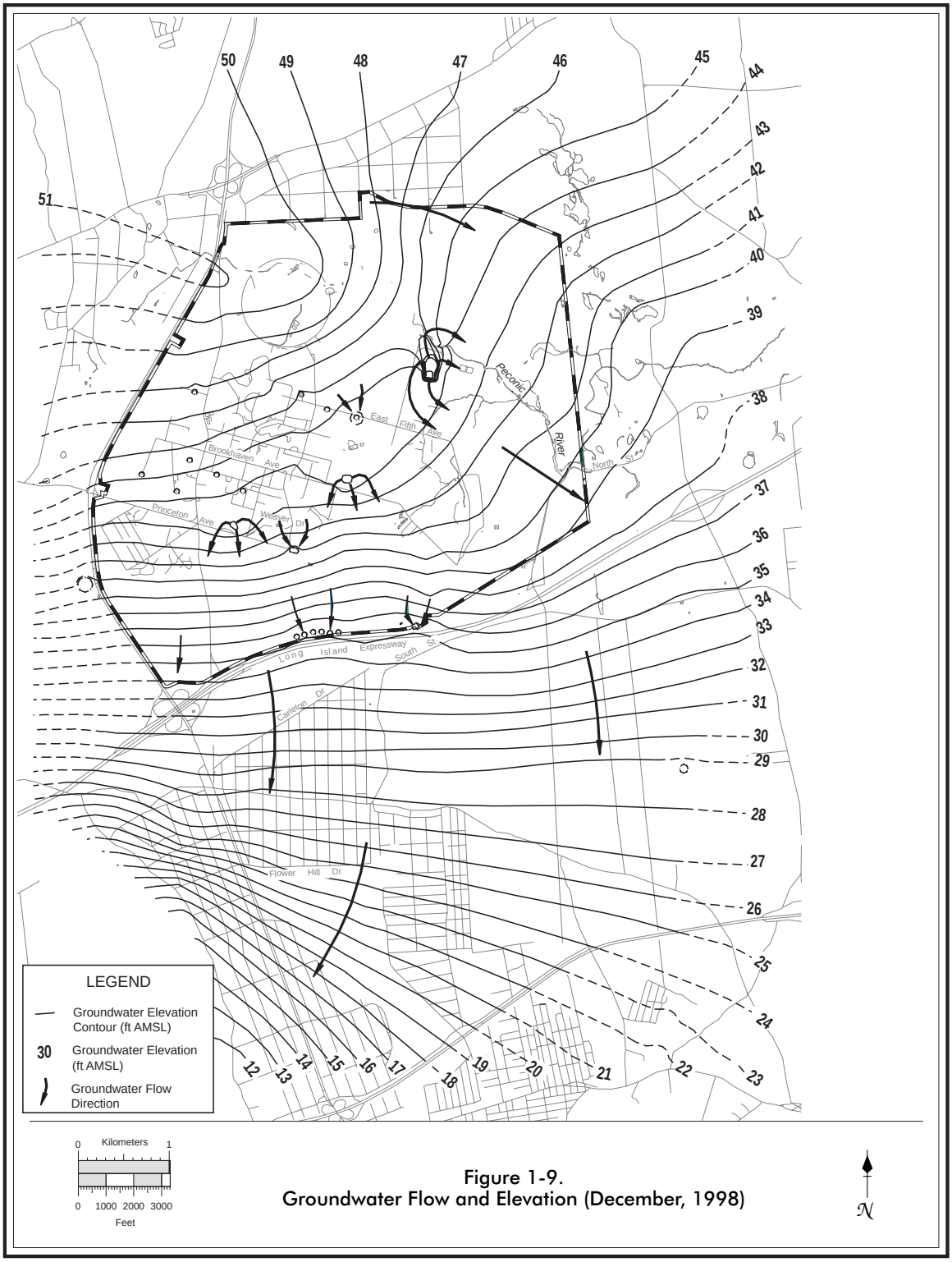


Figure 1-9.
Groundwater Flow and Elevation (December, 1998)

potential to replenish the lower aquifer systems lying below the Upper Glacial Aquifer. It is estimated that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. The extent to which groundwater at the BNL site contributes to deep flow recharge has been confirmed through the use of an extensive network of shallow and deep wells installed at BNL and surrounding areas (Geraghty and Miller, 1996). In coastal areas,

these lower aquifers discharge to the Atlantic Ocean or to the Long Island Sound.

1.6. CLIMATIC DATA

The Laboratory can be characterized as a breezy, well-ventilated site, like most of the eastern seaboard. The prevailing ground level winds are from the southwest during the summer, from the northwest during the winter, and about equal from these two directions during the spring and fall (Nagle, 1975; Nagle, 1978). "A Wind Rose" is a graphical depiction of the annual frequency distribution of wind speed and direction. Figure 1-10 shows the 1998 annual Wind Rose for BNL, measured at a height of 88 meters (288 feet).

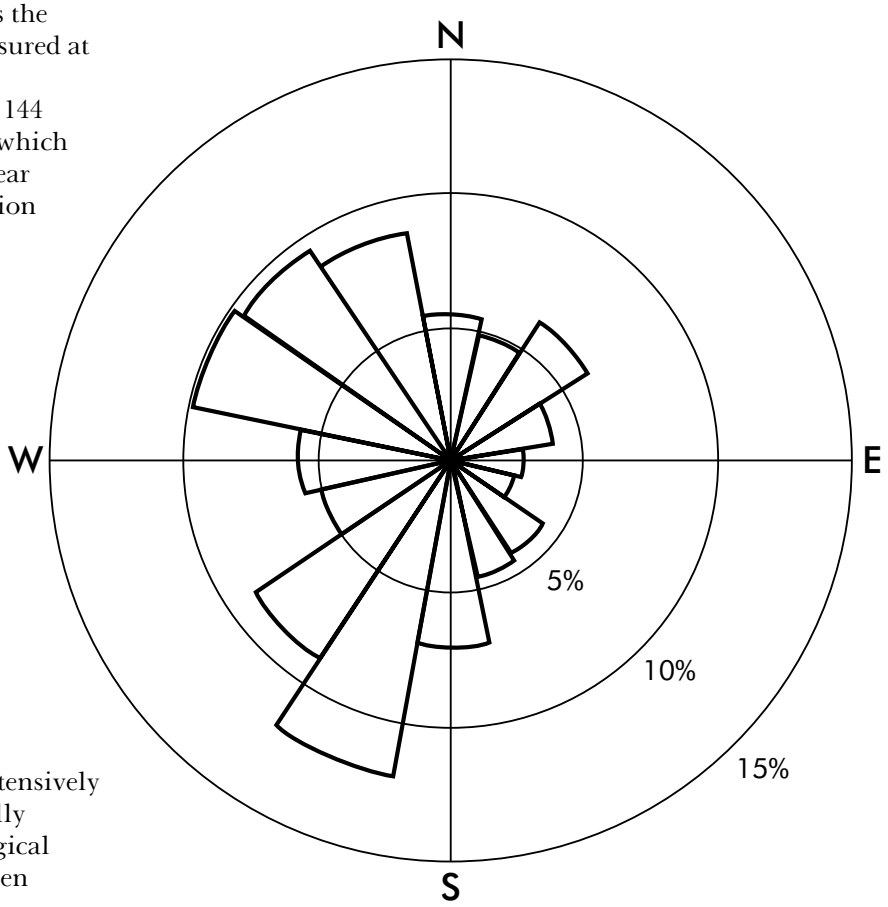
The total precipitation for 1998 was 144 centimeters (cm), or 56.61 inches (in), which is about 20.32 cm (8 in) above the 50-year annual average. Most of the precipitation was received from January through June. Precipitation for the months of July to December was below normal for 1998, leading to drier conditions on site at the end of 1998. Figures 1-11 and 1-12, respectively, present the 1998 monthly and historical precipitation data. The monthly mean temperature in 1998 was 11.7°C (53.1 °F), ranging from a monthly mean low temperature of -2.3°C (27.8 °F) to a monthly mean high temperature of 28.3°C (83 °F). Figure 1-13 shows the 1998 and historical monthly mean temperatures.

1.7. ECOLOGICAL RESOURCES

BNL natural resources have been extensively mapped to identify any environmentally sensitive areas, and to inventory biological species. Over 230 plant species have been identified onsite.

The Laboratory is located in a section of the Oak/Chestnut forest region of the Coastal Plain. BNL property constitutes five percent of 404.7 sq-km (100,000 acre) Pine Barrens on Long Island. Because of the general topography and porous soil, there is little surface runoff or open water. Upland soils tend to be very well drained, while depressions form small pocket wetlands with standing water on a seasonal basis. There are also six major regulated wetlands onsite. Hence, a mosaic of wet and dry areas on the site are correlated with variations in topography and depth to the water table. Without fires or other disturbances, the vegetation normally follows the moisture gradient closely. In actuality, vegetation onsite is in various stages of succession, reflecting the history of disturbances to the area, the most important having been land clearing, fire, local flooding, and draining.

The fifteen mammal species endemic to the site include species common to mixed hardwood forests and open grassland habitats. The white-tailed deer density is at least 100 per square mile according to a BNL deer popula-



Notes:
1. The arrows formed by the wedges indicate wind direction. This diagram indicates that the predominant wind direction in 1998 was towards the north-northeast.
2. Each concentric circle represents a 5 percent frequency, so wind blew towards the NNE 12% of the time in 1998.
3. Wind was calm 2.3% of the time in 1998
4. Wind directions were measured at a hieght of 88 meters.

Figure 1-10. Annual Wind Rose for 1998

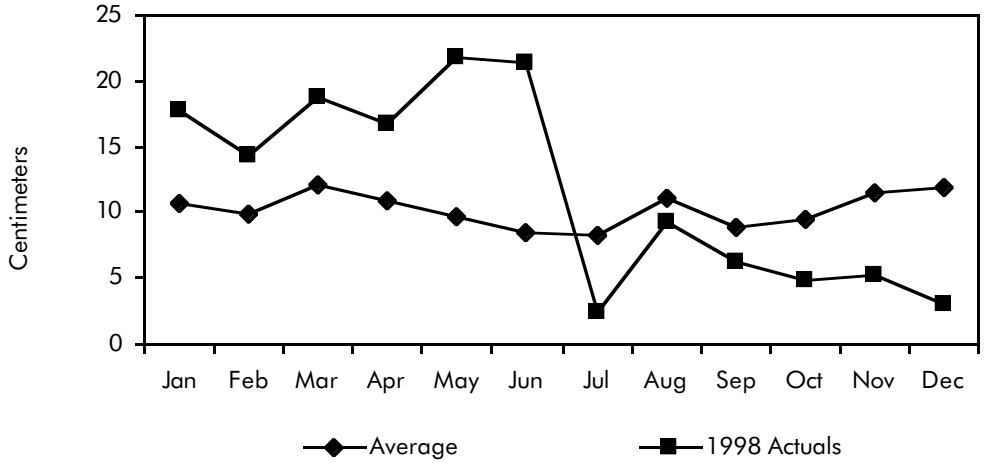


Figure 1-11. Monthly Precipitation Trends

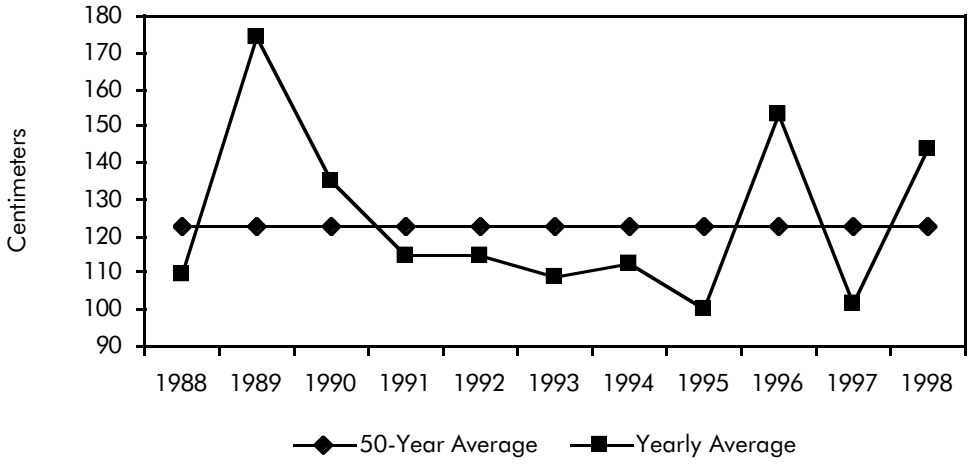


Figure 1-12. 10 Year Precipitation Trend

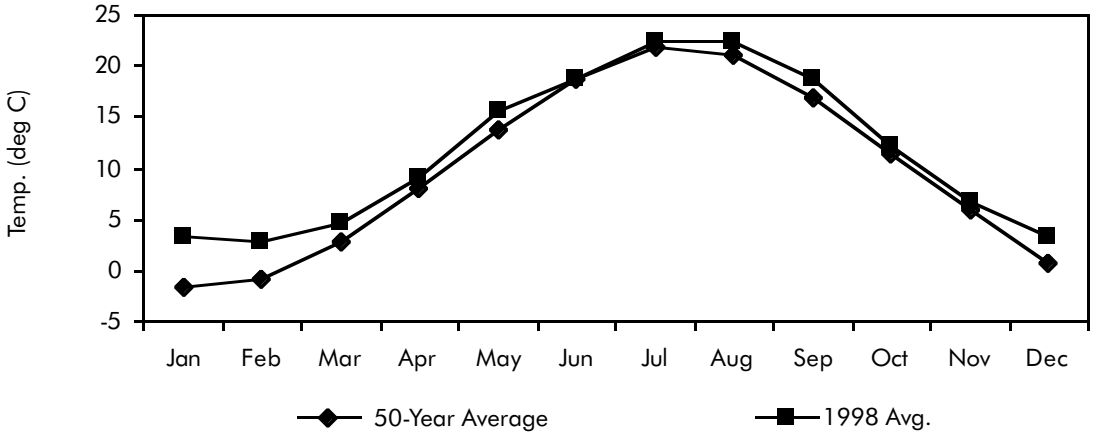


Figure 1-13. Monthly Mean Temperature Trend

tion study issued in 1993 (Thomlinson, 1993). At least 85 species of birds have been observed at BNL, a result of its location within the Atlantic Flyway, and the scrub/shrub habitats which offer food and rest to migratory songbirds. Open fields bordered by hardwood forests at the recreation complex are excellent hunting areas for hawks. Nine amphibian and ten reptile species have been identified. Permanently flooded retention basins and other watercourses support aquatic reptiles. Recent ecological studies at the BNL site have confirmed thirteen breeding sites for the NYS-endangered eastern tiger salamander *(Ambystoma Tigrinum)* in BNL's vernal ponds and some recharge basins. Figure 1-14 is a photograph of the spotted salamander *(Ambystoma Maculatum)*. Nine species of fish have also been identified. The banded sunfish *(Eanneacanthus Obesus)* is a NYS species of "special concern", as it occurs solely within the Peconic River system: it has been confirmed as inhabiting the Peconic River onsite (Scheibel, 1990; Corin, 1990). Part of the Peconic River running through BNL's property was designated "scenic" in accordance with the NYS's Wild, Scenic, and Recreational River Systems Act.

Figure 1-14. Spotted Salamander *(Ambystoma Maculatum)*

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Environmental Management System

CHAPTER 2

Brookhaven National Laboratory (BNL) is committed to continually improving its environmental program. To further these ends, the Laboratory is developing and implementing an improved Environmental Management System (EMS) to ensure that it operates in an environmentally responsible manner that protects the ecosystem and human health. BNL's EMS is consistent with International Standards Organization (ISO) 14001 standards with enhancements in the area of compliance assurance. Compliance, pollution prevention, waste minimization and conservation of resources are being integrated into the planning, decision-making, and implementation phases of all site activities.

Programs such as the Facility Review Project have been established to continue to define, prioritize and remedy existing problems. The Process Evaluation Project, a comprehensive review of industrial and experimental processes used onsite, is scheduled for completion in early 1999.

An extensive program to monitor environmental quality is in place. Compliance monitoring, one aspect of the monitoring system, ensures adherence to regulatory and permit limits. A second aspect, restoration monitoring, measures the impact of past operations, determines the extent of problems and assures remedial measures are effective; and surveillance monitoring, the third aspect, evaluates what impact, if any, current operations have on environmental media.

Progress is reported on several crucial aspects of environmental stewardship at BNL. The Laboratory received a Department of Energy 1998 Energy Management Achievement Award for water conservation efforts. Water conservation efforts in 1997 resulted in a savings of 815 million liters per year. Reductions in cooling water implemented in 1998 should save in excess of an additional 500 million liters per year and require that fewer chemical additives be used and stored. Building energy use is 24 percent less today than it was in 1985 and hazardous waste generation meaningfully reduced.

Significant progress has been made in moving ecological protection to the forefront at BNL. The Laboratory is openly communicating on issues and progress with neighbors, regulators, employees, and other interested parties. Some issues remain. They will be discussed in the Compliance section (Chapter 3).

With the adoption of the environmental policy articulated by Director Marburger (see page 1-1), Brookhaven National Laboratory (BNL) furthered the implementation of a comprehensive Environmental Management System (EMS) designed to ensure that the Laboratory's programs are managed in an environmentally responsible manner that protects the ecosystem and human health. The following are the major principles and commitments associated with that policy which forms the EMS cornerstone:

2.1 ENVIRONMENTAL POLICY GOALS, AND COMMITMENTS

- Achieve and maintain compliance with applicable environmental requirements. These requirements include over 50 sets of local, state and federal laws, regulations and 60 permits.
- Integrate pollution prevention, waste minimization and resource conservation into site activities in the planning, decision-making and implementation phases. Conserve natural resources and ensure that environmental emissions, effluents and waste generation are As Low As Reasonably Achievable (ALARA).
- Define, prioritize and remedy existing environmental problems. This commitment encompasses removal or treatment of contamination caused by historical practices as well as an environmental monitoring program to provide early detection of any threat to the environment. In addition, the monitoring program identifies potential pathways for exposure of the public and the environment, as well as evaluating what impact BNL activities may be having on the environment. Data from monitoring assesses compliance with applicable regulatory and permit limits.
- Emphasize continual improvement. Proactive measures to prevent problems are to be utilized. When problems do occur, the root

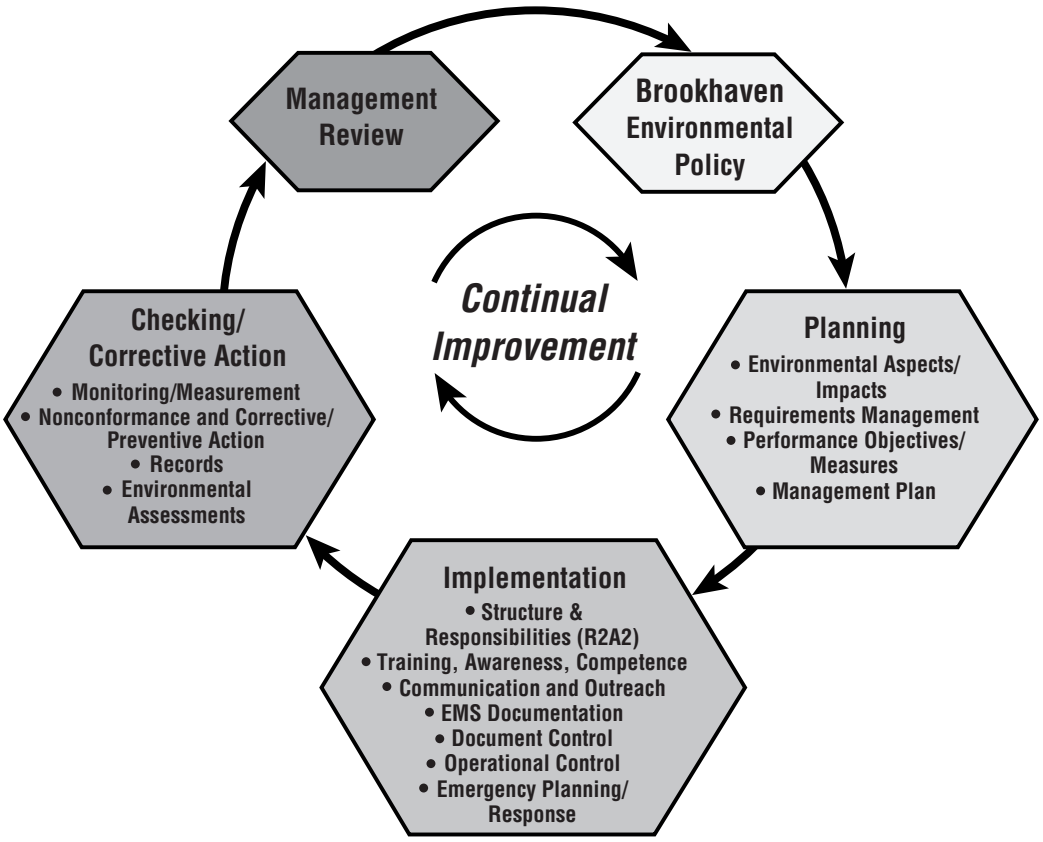

Figure 2-1. Key Elements of Environmental Management System

cause is investigated, and corrective actions taken as appropriate.

- Openly communicate with neighbors, regulators, employees and organizations about program progress and performance.

All BNL employees are expected to practice environmental stewardship so that BNL can excel in protecting the environment and thus regain public trust through improved compliance with environmental requirements.

An EMS improvement initiative is currently underway. The EMS improvement (Section 2.2.1), the Facility Review Project (Section 2.3) and the Process Evaluation Project (PEP) (Section 2.4) are discussed below. The Laboratory is investing over eight million dollars in these initiatives. They are designed to address problems created by historical activities, thoroughly evaluate present-day operations, and implement improvements in the future to protect the environment, and assure compliance.

2.2 ENVIRONMENTAL MANAGEMENT SYSTEM (EMS) AND IMPROVEMENTS

BNL continues to develop and implement an improved EMS to ensure that environmental policy considerations are integrated into all facets of BNL's missions. This systematic approach is designed to eliminate, reduce or control environmental risks and impacts, and achieve and demonstrate environmental excellence. Figure 2-1 shows the five principles of the EMS and the program elements that comprise the system.

The U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Energy (DOE) signed a Memorandum of Agreement (MOA) on March 23 1998. In the MOA, DOE and BNL committed to use the International Standards Organization (ISO) 14001 framework for their EMS, with improvements in the area of compliance assurance, pollution prevention and community outreach. The 17 major elements of an EMS are listed in Table 2-1,

Table 2-1. Elements of the Environmental Management System: Implementation of ISO 14001 at BNL

ENVIRONMENTAL POLICY	In November of 1998, BNL issued its environmental policy statement that describes BNL's commitment to the environment. This policy is used as a framework for planning and action (see page 1-1).
ENVIRONMENTAL ASPECTS	BNL has determined that the following environmental aspects of the Laboratory's operations have the potential to affect the environment: • Waste generation - regulated industrial, hazardous, radioactive, mixed, or regulated medical waste • Atmospheric emissions • Liquid effluents • Storage or use of chemicals and radioactive materials (potential for accidental release or contamination) • Natural resource usage - power consumption, water consumption. • Soil with the potential for induced radioactivity (e.g., soil activated at a beam stop). In addition, each facility at BNL will determine if their operations have other aspects that have the potential to impact the environment. The combined set of significant environmental aspects is used to identify training requirements, develop operational controls (including engineering controls, administrative control procedures, and pollution prevention opportunities), assess emergency planning issues, and determine applicable requirements.
LEGAL AND OTHER REQUIREMENTS	New or revised external requirement documents (e.g. new regulations) are analyzed to determine their applicability to the Laboratory, and what additional actions are required, if any, to achieve compliance. This may involve developing or revising laboratory documents, developing specific work instructions, administering training, installing engineered controls, or other methods.
OBJECTIVES AND TARGETS	BNL establishes environmental objectives and performance measures to drive improvements to the EMS and to measure progress in improving environmental performance. These objectives and measures focus on environmental aspects that can have a significant impact, reflect stakeholder concerns, and are aligned with commitments made in the environmental policy.

Table 2-1. Elements of the Environmental Management System: Implementation of ISO 14001 at BNL *(cont'd.)*

ENVIRONMENTAL MANAGEMENT PROGRAM	Organizations within BNL develop an action plan showing how they contribute to achieving BNL's objectives and targets while incorporating an EMS and committing needed resources to successfully implementing the plan. BNL also has a budgeting system designed to ensure that priorities are balanced, and that adequate resources are invested in environmental programs.
STRUCTURE AND RESPONSIBILITY	In 1998, BNL established a program to define employee's role and responsibilities in key areas including environmental protection. In addition, BNL reorganized to emphasize the importance of environmental activities by establishing an Environmental Services Division reporting directly to the Assistant Laboratory Director for the Environment, Safety, Health and Quality Directorate.
TRAINING, AWARENESS AND COMPETENCE	BNL is enhancing training programs for staff and visitors to ensure that they are trained and capable of carrying out their environmental responsibilities. Both the Process Evaluation Project and the Environmental Management System Improvement Project have training initiatives targeted for specific BNL populations. The training includes both a general environmental awareness course for all employees, and more specific training targeted for managers, internal assessors, team members responsible for coordinating EMS implementation, and operations personnel whose work has the potential to impact the environment.
COMMUNICATION	BNL is developing improved processes for internal and external communications on environmental issues and enhanced community outreach activities such as the establishment of a Citizens Advisory Committee.
EMS DOCUMENTATION	Procedures are being documented, maintained and implemented to ensure successful achievement of environmental goals. A web-based system called the Standards Based Management System (SBMS) will be developed to improve the quality, usability of and access to Laboratory-level information and providing a systematic framework for managing and operating the Laboratory. SBMS will contain BNL information that includes policy and standards, regulatory requirements, manuals, and Laboratory-wide procedures that control different processes and types of work performed at BNL.
DOCUMENT CONTROL	SBMS contains a comprehensive document control system to ensure effective management of procedures and other system records. When facilities require additional procedures to control their work, document control protocols are implemented to ensure that workers have access to the current versions of work instructions.
OPERATIONAL CONTROL	Systems are being evaluated to identify the need for additional administrative or engineered controls, then implementation plans are being developed for needed upgrades.
EMERGENCY PREPAREDNESS AND RESPONSE	BNL has a program to provide time critical response to hazardous materials or other environmental emergencies. This program includes procedures for preventing as well as responding to emergencies.
MONITORING AND MEASUREMENT	Appropriate monitoring, reviewing, and reporting is important to ensure effective functioning of the EMS and timely identification and implementation of corrective measures. BNL has a comprehensive, site-wide environmental monitoring program, and environmental performance is summarized annually in this Site Environmental Report.
NONCONFORMANCE, AND CORRECTIVE AND PREVENTIVE ACTIONS	BNL is improving processes to identify and correct problems. This includes development of a "lessons learned" program to prevent recurrences.
RECORDS	EMS related records, including audit and training records, are maintained to ensure integrity, to protect them from loss and enable retrieval.
EMS AUDIT	To periodically verify that the EMS is operating as intended, audits are conducted. These audits, conducted as part of the site-wide self-assessment program, are designed to ensure that any nonconformance to the ISO 14001 standard is identified and addressed. In addition, BNL has conducts regulatory compliance audits to assure operations comply with environmental requirements.
MANAGEMENT REVIEW	In addition to audits, a management review process is being implemented to ensure top management involvement in the assessment of the EMS, and as necessary, to address the need for changes and continual improvement.

along with a summary of how BNL plans to satisfy each element.

2.2.1 EMS IMPROVEMENT

The goal of the EMS improvement project is to develop, improve and deploy the EMS. It was initiated in July 1998 and is expected to be completed in the year 2000, when most of the site is registered to ISO 14001 standards. The first year of the project included two major steps: development of institutional EMS program requirements, and testing and validating the requirements in pilot facilities. Three facilities volunteered to participate in the pilot phase of project implementation: the Relativistic Heavy Ion Collider (RHIC) Project, Reactor Operations, and Waste Management Program (WM). Deployment throughout the balance of facilities at the BNL is scheduled to begin in July 1999.

BNL plans to pursue a phased approach to ISO 14001 registration by piloting the registration process at select facilities in 1999 and 2000, then seeking to register the entire Laboratory to the ISO 14001 standard in 2001. The registration process will involve rigorous audits by an independent, third-party auditor accredited by the American National Standards Institute, Registrar Accreditation Board. The auditors will evaluate BNL's conformance to the standard, whether or not the program is effectively implemented, and whether an effective corrective action program is in place.

The improved EMS that is being developed and deployed throughout BNL includes a commitment to continual improvement. The Performance Based Management System and the Integrated Assessment Program (IAP) provide processes for enhancing the EMS and achieving improvements in overall environmental performance.

The Performance Based Management System is a method of developing, aligning, balancing and deploying Laboratory strategic objectives. The system drives the improvement agenda of the BNL by linking a prioritized set of incentivized performance objectives. Objectives include: putting in place mechanisms assigning responsibility at all relevant levels of the organization, starting with senior management; implementing suggested actions for improvement; and routinely measuring progress against these objectives, to focus efforts and resources on relevant and important areas. Employees can see how their work fits in and then align their efforts toward achieving BNL missions.

IAP provides BNL with a framework to support continual improvement in environmental strategic objectives. The primary elements of the Laboratory's IAP are:

- *Self-Assessment* is the evaluation of internal processes by an organization to allow for identification of strengths and opportunities for improvement. Among the many elements in a self-assessment program, the environmental portion of the assessment can include such items as performance measures and compliance checks (see additional discussion below).
- *Peer Review* is a process to evaluate and independently verify the adequacy of engineering designs and operational controls.
- *Independent Oversight* is a mechanism to independently verify the effectiveness, efficiency and adequacy of the Self-Assessments programs.
- *Internal Audit* is the process of examining and evaluating the adequacy and effectiveness of the Brookhaven Science Associates (BSA) systems of internal management controls.

These elements generate information on scientific, technical, environmental safety and health programs, quality, community involvement, business, and operational performance for the BNL management, staff, DOE, neighbors, and regulators. With respect to the environment, the program achieves the following:

- provides accurate environmental performance information to promote early identification and resolution of problems that may affect the Laboratory's ability to achieve its strategic objectives
- verifies and addresses the public's expectations to improve the environmental aspects associated with operations and research
- verifies conformance to established internal and external regulatory requirements.

The Self-Assessment Program is designed to promote an atmosphere of continuous improvement. This process ensures the development of high quality and efficient services and operations, establishes a sound environmental program foundation that will foster excellence across BNL, and is an integral component of the Laboratory's IAP. The activities selected

each year for assessment emphasize operations related to Laboratory Critical Outcomes, organizational goals as expressed through strategic planning initiatives, customer satisfaction, and compliance.

The program is augmented by programmatic, external audits conducted by DOE. BNL is also subject to oversight by external regulatory agencies (see Section 3.15 of Chapter 3). In addition, corporate offices for Battelle Memorial Institute and the subcontractors perform independent reviews. For example, Battelle and Waste Management Federal Services (the waste management contractor) conducted gap analyses to evaluate existing components of the EMS and identify areas where improvements were needed.

Self-Assessments conducted in 1998 utilized a combination of internal and independent peer reviews. Assessments conducted in 1998 included an evaluation of compliance with regulatory requirements, an appraisal of the achievements of waste/effluent/emission reduction goals, evaluation of the effectiveness of EMS project communication, the scientific and technical accuracy of environmental documents, an assessment of the current status of BNL's EMS, and an EMS gap analysis. A wide variety of assessment techniques were used in the reviews. These included direct observation, survey, customer feedback, and performance measure reviews. Self-Assessment activities culminate with a written summary report including an evaluation and development of corrective action plans or improvement goals with established milestones. Corrective actions are tracked to closure, with the manager being ultimately responsible for timely response.

2.3 FACILITY REVIEW PROJECT

In the spring of 1997, BNL initiated a comprehensive examination of site facilities to identify any past or current activities having the potential to degrade the environment. Program managers reviewed and prepared reports to document the BNL operational history of each building, including both current and previously demolished structures; to identify environmental vulnerabilities; and to recommend corrective actions if needed.

During this project, BNL reviewed more than 900 systems, facilities and operations that had the potential to affect the environment, including tanks, pipes, sumps, cesspools, storage areas, past practices, etc. Representatives from the Suffolk County Department of Health Services (SCDHS) participated in the BNL Facility Review Project by accompanying Laboratory personnel on inspections of all BNL facilities. They also reviewed each individual building report that was prepared to document BNL's findings resulting from this project. However, the scope of the SCDHS examination of BNL included topics beyond that of the BNL Facility Review Project. For example, the SCDHS evaluated BNL facilities for compliance with Suffolk County Sanitary Codes and performed an extensive review of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) activities. The SCDHS developed their own independent list identifying their environmental concerns with BNL; this list currently contains over 1300 issues. While a subset of issues on both BNL and the SCDHS lists are duplicates, there are also distinct issues on each list due to the differences in scope.

Among the processes, storage areas, past practices, pits and tanks identified in the building reviews, 75 have been categorized as either Significant Findings or Lesser Issues. A Significant Finding is one that has the potential for releases to the environment, now or in the past, that could contaminate the groundwater above drinking water standards (DWS). A Lesser Issue is one that has the potential for releases to the environment, now or in the past, that could impact the groundwater but not above the DWS.

Other items identified under this project include general operating practices; equipment storage and utilization; administrative issues (e.g., labeling and registration) particularly regarding tanks; past practices relating to undocumented releases of low-level radioactivity; and remediation activities that took place in the past but were not documented. None of these remaining processes, practices or areas is believed to have resulted in a significant impact to the groundwater or public safety. However, they will be evaluated to determine whether any further corrective actions are required.

Corrective actions have been developed for each of the Significant Findings and Lesser Issues. Notable progress has been made on 75 percent of these issues, including the removal

of ten underground storage tanks and the removal of contaminated water in the Brookhaven Graphite Research Reactor (BGRR) sump systems (see Section 1.2 of Chapter 1 for a discussion of BGRR). Two drywells, one septic tank, a series of oil-water separators, and underground piping have also been addressed.

An integrated database has been developed which includes the environmental issues identified by BNL as well as those identified by the SCDHS. This tool will be used to track and verify progress on all facility review issues. All of these issues will be reviewed to determine an appropriate disposition. Wherever possible, this disposition will include integration into existing long term Laboratory programs or new initiatives such as the EMS and the PEP.

2.4 PROCESS EVALUATION PROJECT (PEP)

The PEP has been developed to satisfy the requirements of Attachments 1 and 1A of the MOA. PEP evaluates all experiments and industrial processes at BNL that generate wastes, effluents or emissions. It identifies and establishes the regulatory status of wastes, effluents and emissions to ensure that they are managed in compliance with applicable local, state, and federal environmental regulations and permits, and ensure they pose no threat to the environment. Opportunities for pollution prevention and operational vulnerabilities are also identified during the review. This project will result in an unprecedented level of knowledge about processes at BNL and will improve efficiency as well as compliance.

The strategy for implementing the process evaluations incorporates the development of the Environmental Compliance Representative (ECR) program. These environmental professionals are tasked with directly supporting process reviews and providing technical support to researchers and facility managers. Embedding environmental professionals in the line organizations will improve and assure compliance with environmental laws, regulations, and policy. Upon project completion, ECRs will transition to site-wide technical support roles. In this role, they will help implement systems for continuous improvement of environmental performance, with emphasis on pollution prevention and waste minimization.

During 1998, the PEP project management plan was developed, approved and funded by BNL. The ECR program was developed and the hiring process was initiated. Approximately 100 processes were determined to be "high priority", based upon criteria agreed to by BNL, DOE and USEPA. Process evaluations were initiated in September 1998 and expected to be completed in March 1999. The remainder of the processes will be evaluated by February 2000.

2.5 POLLUTION PREVENTION/WASTE MINIMIZATION

A strong Pollution Prevention /Waste Minimization Program (P2) is an essential element of successful accomplishment of BNL's environmental mission. The BNL P2 Program reflects national and DOE pollution prevention goals and policies, and represents an ongoing effort to make pollution prevention and waste minimization an integral part of the BNL operating philosophy.

Key elements of the P2 program are:

- Eliminating or reducing wastes, effluents, and emissions at the source where possible
- Ensuring that environmental effluents, emissions and wastes are As Low As Reasonably Achievable
- Achieving or exceeding BNL/DOE waste minimization, pollution prevention, recycling and affirmative procurement goals
- Conserving natural resources and energy
- Reusing and recycling materials
- Procuring environmentally preferable products (also known as "affirmative procurement")
- Complying with applicable requirements (e.g., New York State (NYS) Hazardous Waste Reduction Goal, Executive Orders)
- Reducing waste management costs
- Identifying funding mechanisms for evaluation and implementation of P2 opportunities
- Timely implementation of P2 projects
- Improving employee and community outreach and awareness of pollution prevention goals, plans and progress.

The overall goal of the P2 Program is to systematically integrate P2 considerations into all planning and decision making.

2.5.1 P2 PROGRAM ACCOMPLISHMENTS

BNL has achieved significant reductions in waste generated by routine operations. From 1993-1998, BNL reduced hazardous waste generation by 72 percent, mixed waste by 79 percent and radioactive waste by 51 percent. Implementation of P2 opportunities reduced waste management costs, and often resulted in process improvements.

Progress continued in 1998. The following P2 projects were implemented during the year:

- Ozone Water Treatment systems were installed on cooling towers for two RHIC experimental detectors (in buildings 1010 and 1002). Ozone is used to control bacterial fouling and prevent scale formation. The systems will eliminate the need for chemical treatment of the cooling water with corrosion inhibitors and biocides. It is estimated that this change will result in approximately $15,000 of savings per year due to reduced maintenance and chemical purchases. The environmental benefit will be a chemical-free, blowdown waste stream entering recharge basins. The effectiveness of these systems will be monitored to determine whether additional cooling towers should be retrofitted.
- The Primary/Secondary Flow Instrumentation Upgrade replaced mercury-filled instrumentation at the Brookhaven Medical Research Reactor with non-mercury instrumentation. This reduces the risk of a mercury spill in a radiation control area, and eliminates the potential for mixed waste.
- The Industrial Waste Evaporator at Central Shops Project involved procurement and installation of an evaporator to replace and upgrade an existing evaporator in use in the Central Shops organization. The new system will be utilized to evaporate non-hazardous industrial wastewater from spent coolants, mop waters, chip storage sump waters, and baths from the Centralized Degreasing Facility. These waste streams would otherwise require management and disposal as industrial wastes. The project will be completed in 1999.
- The Excess Lead Shield Block Utilization Project involves the reuse of lead bricks, that had been targeted for disposal as mixed waste, as shielding in the walls of the hot cell being constructed by the Waste Management program. The project involves segregation, surveying, inspection, and staging of lead-shielding stockpiles; the lead bricks in good condition going to the hot cell. This project, when fully implemented, will have a very high return-on-investment from the avoided cost of mixed waste disposal. The project will be completed in 1999.
- The Mercury Thermometer Substitution Project procured thermometers that contain alcohol instead of mercury but have the same scale and immersion length as currently stocked mercury-filled thermometers. This will reduce mercury waste generated by thermometer breakage. The project is part of a Laboratory-wide P2 program to reduce mercury use.
- The Natural Gas Conversion of the Central Steam Facility (CSF) Project was initiated in 1997 with the extension of a gas main (belonging originally to the Long Island Lighting Company, now KeySpan) leading into the CSF and burner modifications to Boilers 5 and 7. In 1998, with the installation of dual fuel burners on Boiler 6 earlier this year, natural gas became the primary fuel used at the CSF. Residual fuel oil burned at the CSF dropped more than 92 percent, from an average of 4,775,000 gallons per year for the three year period of 1994 to 1996, to just over 354,000 gallons in 1998. The use of cleaner burning natural gas, combined with the switch to low sulfur and low nitrogen residual fuel in 1995, resulted in significant reductions in CSF emissions enabling the plant to meet nitrogen oxide emission standards. Total criteria pollutant emissions from the CSF have been trimmed from approximately 561 tons in 1994 to just over 100 tons in 1998.

2.5.2 EMPLOYEE TRIP REDUCTION PLAN

BNL has had a rideshare program since 1995. This program was developed to comply with the Employee Travel Reduction Program rule (17 NYCRR Part 68). The New York State Department of Transportation repealed the rule in September 1996, in effect making employer participation in the program voluntary. Although the program is voluntary, BNL continues to assist employees in finding suitable rideshare partners by maintaining a ride-matching database. The Laboratory still

provides a guaranteed ride service for program participants, and continues to subsidize the cost of a defensive-driver course for employees active in ridesharing partnerships.

2.5.3 WATER CONSERVATION PROGRAM — 1998 ACCOMPLISHMENTS

The Reduction of Non-Contact Cooling-Water Program - Phase I project, initiated in 1997, was completed in early 1998. This project redirected cooling-water discharges from Buildings 555, 830, and 480 from sanitary to the storm sewer system. The goal was to reduce the contribution of "clean" water to the sanitary sewer, thereby increasing the concentration of biological matter in the Sewage Treatment Plant (STP) influent. Since biological matter is a food source for the microorganisms that treat the waste, the increased concentration of biological matter enhances biological activity and makes the treatment process more efficient. This project reduced water flow to the STP by 15 percentand saved over 800 million liters per year. BNL received a DOE Energy Management Achievement Award in 1998 for water conservation efforts.

During 1998, the Alternating Gradient Syncrotron (AGS) cooling-water source was changed from process water wells (i.e., Wells 101, 102 and 103) to the domestic water system. Previously the water drawn from these wells contained high concentrations of naturally occurring iron. The conversion to domestic water has significantly improved the quality of the discharge and has lowered water usage from 4,500 liter per minute (lpm) to 3,000 lpm (1,200 gpm to 800 gpm). Based on continuous use during the AGS operation cycle (approximately 250 days/year), this lowered consumption rate corresponds to water savings of approximately 545 million liter/year (144 million gallons/year). In addition, by converting to the domestic water system, fewer chemical additives are necessary to prevent iron fouling of the heat exchanges. Fouling of the recharge basin by iron deposition is also reduced.

2.5.4 ENERGY MANAGEMENT

Many of the BNL scientific experiments use particle beams generated and accelerated by electricity with the particles controlled by large electromagnets. The Laboratory spends over $20 million for energy each year. To help deal with large energy expenditures, as well as meet DOE goals for energy conservation, BNL's Energy Management Group was established in 1979. It is responsible for the development, implementation and coordination of an Energy Management Plan, and for leading BNL's effort to meet DOE's energy reduction goals.

DOE's In-House Energy Management Order 430.2 set a goal to demonstrate, on an annual basis, continuous cost-effective improvement in reducing building energy use per square foot and increase energy efficiency in industrial facilities, for all DOE sites. Success is measured by comparing current year consumption to the year prior. Energy management initiatives have been very successful at BNL. Laboratory energy-use per square foot of building for 1998, was 24 percent less than in 1985, well ahead of the DOE goal of a 20 percent reduction by 2000.

2.6 WASTE MANAGEMENT (WM) PROGRAM

The BNL WM is charged with managing the routine hazardous and radioactive wastes generated by the Laboratory. In addition, WM has a role in managing some industrial wastes (e.g., used oils, oil-contaminated debris) and assists the Environmental Restoration program in managing wastes resulting from cleanup activities. WM also manages onsite and offsite hazardous material waste shipments.

2.6.1 WASTE GENERATION

In 1998, BNL generated the following quantities and types of routine waste:

- Hazardous Waste: 38.1 metric tons (42 tons)
- Mixed Waste: 1.2 cubic meters (42.4 cu ft)
- Radioactive Waste: 256 cubic meters (9041 cu ft)
- Regulated and Toxic Substances Control Act Waste: 76.8 metric tons (84.6 tons).

2.6.2 FACILITIES AND CAPABILITIES

WM currently operates the Waste Management Facility (WMF) and the Waste Concentration Facility (WCF). The WMF is a permitted waste-storage facility (New York State Department of Environmental Conservation [NYSDEC] Part 373 Permit No. 1-422-00032/00102-0) consisting of four operations buildings: 855, 860, 865, and 870. See Figure 2-2 for

an aerial photograph of the WMF. Building 860 houses technical and operations staff. Building 855 is the waste-storage facility where hazardous, Polychlorinated biphenyl (PCB), and industrial solid, liquid, and gaseous wastes are stored and segregated by hazard class. Building 870 is the mixed-waste storage facility where radioactively-contaminated, hazardous, PCB, and industrial solid, liquid, and gaseous wastes are stored and segregated by hazard class. Building 865 is used for storage of radioactive waste solids.

WM plans two upgrades to Building 865 in 1999: construction of a hot cell and installing a waste compactor. The hot cell will allow management of high-activity wastes in a safe and more cost-effective manner. The waste compactor will allow consolidation of large radioactive solid packages into smaller packaging to minimize BNL waste disposal costs and conserve landfill space.

The WCF consists of Building 811 and 802. Building 811 provides storage of bulk quantities of radioactively contaminated aqueous liquids. Liquids are stored in permitted tanks for either onsite processing or offsite treatment. Building 802 contains the current onsite processing unit. The processing consists of evaporating aqueous liquids, which have been treated for the removal of heavy radioisotopes, under an existing air permit. There were no facility upgrades to the WCF for 1998. WM plans two major upgrades for the WCF in 1999. An annex to Building 811 will be constructed to concentrate and remove radioactive particles from aqueous liquids, effectively minimizing the amount of waste for processing or treatment. The second upgrade will take place at Building 802, replacing the current evaporating unit with a new, more energy efficient unit.

Before the new WMF was opened, WM operations were carried out in another onsite permitted hazardous waste-storage facility, the Hazardous Waste Management Facility (HWMF). The HWMF consisted of Buildings 360 (ignitable labpack storage), 361 (ignitable labpack storage), 368 (ignitable mixed-waste

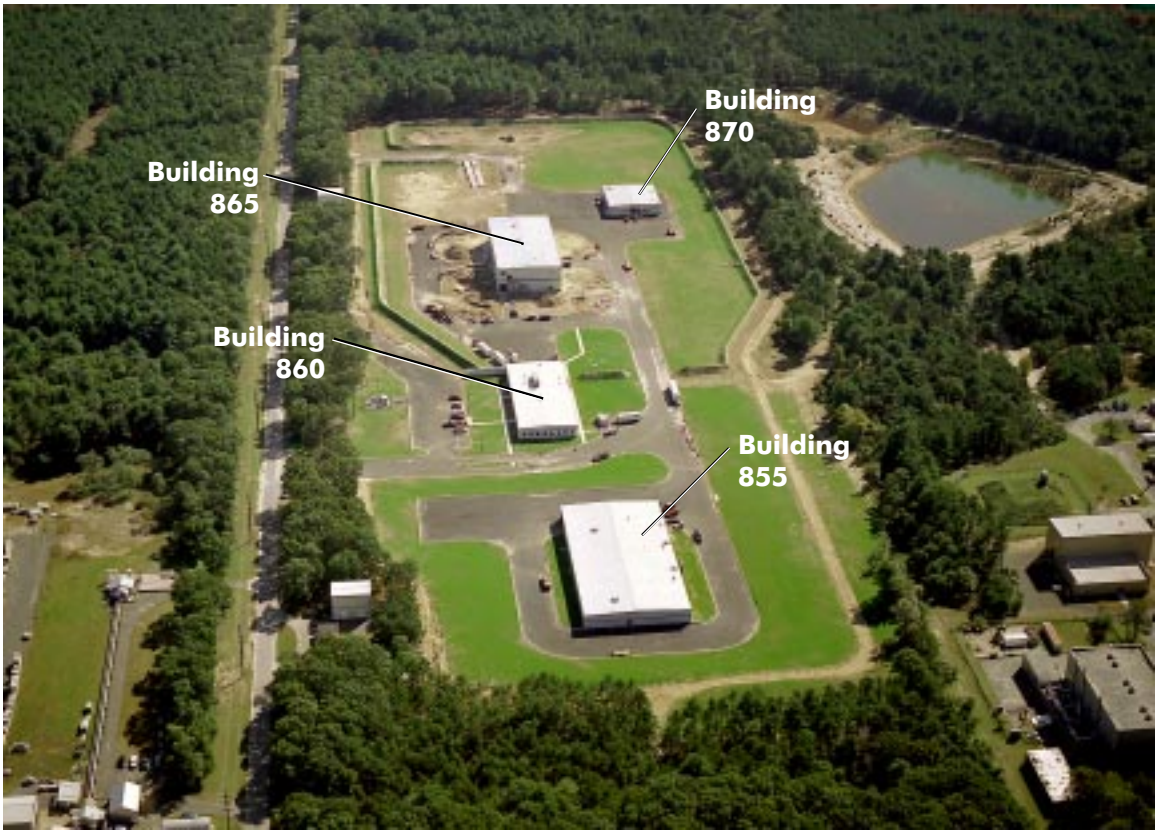

Figure 2-2. Aerial photogragh of the Waste Management Facility

storage), 444 (mixed-waste storage), 448 (labpack storage), and 483 (drum storage). All hazardous and mixed wastes were removed by the end of July 1998, and operations in the HWMF ceased. The facility was subsequently certified "closed" by a licensed Professional Engineer and documentation on the closure submitted to the NYSDEC. The ultimate management of the closed-HWMF will be addressed under the ER Program (BNL Operating Unit I Record of Decision).

In addition to the WMF and WCF, BNL has a number of 90-Day Hazardous Waste Accumulation and Hazardous Waste Satellite Accumulation Areas. Groups generating waste are responsible for properly packing, labeling, and segregating wastes at the generating location prior pick up by WM. Personnel handling waste are required to have training.

2.7 ENVIRONMENTAL RESTORATION (ER)

In 1980, the U.S. Congress enacted CERCLA (also known as Superfund) to ensure that sites with historical contamination were cleaned up, and to hold the responsible party liable for the cleanup. CERCLA established the National Priorities List (also known as the NPL). The NPL is a list of sites nationwide where cleanup of past contamination is required. In November 1989, BNL was included as one of 24 sites on the NPL that are located on Long Island. Much of the contamination at BNL is due to past accidental spills and practices for handling chemical and radiological material storage and disposal.

The process CERCLA mandates includes conducting a Preliminary Assessment (review of historical documents, interviews with employees, site reconnaissance), making a Site Inspection (which often includes sampling), conducting a Remedial Investigation (to characterize the nature, the extent of contamination and the existing risks), preparing a Feasibility Study (to present remedial action alternatives and evaluate alternatives), issuing a Record of Decision (to present DOE, USEPA and NYSDEC remedy), and performing Remedial Design/Remedial Action (which includes final design, construction specifications and carrying out the remedy selected). At each step, USEPA distinguishes between sites that do or do not require further action, based on threat to human health and the environment. An expedited cleanup action called a Removal Action can also be conducted. This only requires an Engineering Evaluation/Cost Analysis. This document evaluates and recommends specific cleanup actions.

Since its establishment in 1991, the Laboratory's ER program has been characterizing and removing sources of contamination (e.g., under ground tanks and pools) or treating the groundwater and soil contamination resulting from past BNL practices. ER groundwater cleanup efforts have included monitoring of existing groundwater wells, overseeing the installation of new, permanent groundwater monitoring wells, installing groundwater treatment systems and extension of public water service. Soil cleanup efforts have identified contaminated soils through sampling and resulted in various programs involving soil removal and treatment. Several landfills have been capped and 55 waste pits have been excavated.

2.7.1 PROGRESS BY OPERABLE UNIT (OU)

ER used historical facility records and sampling to determine where contamination might be present on the site today. These areas were geographically grouped into Operable Units (OU). (See Areas of Concern at BNL, Upton, New York. A Reference Handbook, June 1998). Table 2.2 provides a description of each Operable Unit (I - VII) and the ER actions taken during 1998. See Chapter 8 for a more detailed discussion.

2.7.2 ETHYLENEDIAMINETETRA ACID (EDTA) INVESTIGATION

In response to stakeholder inquiries, in 1998, BNL investigated soils, groundwater and potable water supplies near the AGS cooling water system outfall for ethylenediaminetetra acid (EDTA); a chelating agent. Chelating agents such as EDTA are used in cooling water systems to keep metal ions in suspension and prevent the metals from accumulating in heat exchange equipment. Low concentrations of EDTA were found in the groundwater adjacent to the AGS outfall. EDTA was also found in soil samples collected from within the AGS recharge basin. Stakeholders were concerned that a plume containing radionuclide contaminants might commingle with a plume containing excess chelating agents, and increase the movement of radionuclides in groundwater. There was no evidence, however, that the

Table 2.2. Environmental Restoration Progress

Operable Unit/ Project	Description and *Contamination Type*	1998 CERCLA Actions
Operable Unit I	Former Hazardous Waste Management Area, Landfills, and Disposal Pits *Low level radiological soil contamination, primarily cesium-137*	**Feasibility Study** • Completed OU I Draft Feasibility Study **Preliminary Assessment/Site Investigation** • Completed soil and groundwater sampling at the Former Medical Complex Area **Building 811** • Completed the Waste Pipe Trench Removal, Draft Work Plan for Bldg 811 • Completed the Bldg. 811 D-waste pipe trench removal • Completed the Work Plan for removal, treatment and disposal of sludges from Bldg. 811 **Landfill Removal Action & Chemical Holes** • Completed the Draft Closure Report for the Chemical Holes • Completed the Chemical Holes gas cylinder decommissioning • Shipped biological waste to GTS Duratek for incineration • Completed the 1997 Environmental Monitoring Report for the Current and Former Landfills • Shipped 150 cubic yards of debris from the glass holes staging area to GROWS landfill • Completed partial restoration (fill, grading and topsoil) of the Chemical Holes
Operable Unit II/VII	AGS Scrapyard & Soil Contamination *Low level radiological soil contamination, primarily cesium-137 & strontium-90*	**Remedial Investigation / Risk Assessment** • Completed the Draft Remedial Investigation Report Received DOE approval on Brookhaven LINAC Isotope Producer (BLIP) Soil Sampling and Analysis Plan and completed soil sampling
Operable Unit III	Potable Supply Wells/Spills *Low level chemical and radiological groundwater contamination primarily VOC's, tritium & strontium-90*	**Remedial Investigation / Risk Assessment & Feasibility Study** • Completed the Draft Final OU III Remedial Investigation/Risk Assessment • Completed the Draft OU III Feasibility Study • Held four community roundtables and one community workshop to obtain early input on the alternatives for cleaning up groundwater contaminated with volatile organics, tritium and strontium-90. **Onsite Actions** • Removed two Bldg 830 underground storage tanks and excavated contaminated soil • Completed the Work Plan for characterization of the Former Scrapyard & Drum Storage Area **Offsite Treatment** • Submitted the Offsite Groundwater Removal Action, Action Memo to the Administrative Record • Submitted the Offsite Action Pre-Design Report for Groundwater Cleanup to the Administrative Record • Conducted community information sessions on construction of groundwater treatment systems in the industrial park south of the lab • Received access agreement from North Fork Bank allowing construction of the offsite groundwater treatment system and initiated monitoring and remedial well installations • Installed and sampled six vertical profile wells in the industrial park south of BNL • Finalized the design for the offsite Groundwater Removal Action • Sent mailings and held three poster sessions on the groundwater treatment system for the industrial park south of BNL **Tritium Contamination** • Completed groundwater modeling for the HFBR tritium plume • Completed additional tritium groundwater characterization adjacent to the HFBR stack • Continued operation of the tritium pump and recharge system **Brookhaven Graphite Research Reactor (BGRR)** • Completed the BGRR Draft Soil/Groundwater Sampling Report and Sampling and Analysis Plan for the Pile Fan Sump • Completed the BGRR Final Sampling and Analysis Report

Table 2.2. Environmental Restoration Progress *(cont'd.)*

Operable Unit/ Project	Description and Contamination *Type*	1998 CERCLA Actions
Operable Unit IV	Central Steam Facility Spill & Bldg. 650 Sump Outfall *Low level chemical and radiological soil and groundwater contamination, primarily VOC's & strontium-90*	• Completed the Final OM&M Manual for the Air Sparge/Soil Vapor Extraction (AS/SEV) System • Completed the Quarterly 1, 2 & 3 OM&M Reports for AS/SVE System • Maintained operations, maintenance and monitoring for the AS/SVE System • Completed the Final Interim Remedy Monitoring Plan for Bldg. 650 Sump and Sump Outfall Area • Completed the 1997 Interim Remedy Monitoring Report for Bldg. 650 Sump & Sump Outfall Area • Maintained Interim Remedy Monitoring for the Bldg. 650 Sump and Sump Outfall Area • ETDA Investigation conducted
Operable Unit V	Sewage Treatment Plant & Peconic River *Low level heavy metal and radiological sediment and soil contamination, primarily Mercury, silver, copper & cesium-137*	• Submitted the Remedial Investigation / Risk Assessment Report to Administrative Record • Mailed information on the Remedial Investigation . Risk Assessment Report to members of the public on the environmental mailing list • Held five community roundtables on the plan for future sampling of the Peconic River • Additional sampling of OU V and the Peconic River for plutonium. 1998 sampling results were ambiguous, and resampling will be conducted in 1999. See discussion in Chapter 6, Section 6.1.1.
Operable Unit VI	Biology Fields *Low level pesticide groundwater contamination—ethylenedibromide (EDB)*	• Prepared Long-term Groundwater Monitoring Plan • Installed 20 permanent monitoring wells and 15 vertical profile borings offsite according to Draft Record of Decision and October 1997 Work Plan • Performed modeling and established baseline for monitored natural attenuation
Groundwater Monitoring	On-going Site-wide Project	• Completed the CY 1997 ERD Groundwater Monitoring Report • Submitted the CY 1999 ERD Sampling and Analysis Plan • Collected and analyzed over 1200 groundwater samples from 16 monitoring programs
Removal Actions		• Completed the Final Draft Closeout Report for the Cesspools Removal Action • Shipped 142 tons of contamination from the Boneyard Waste Project for offsite disposal (five Argonne bins and ten B-25 containers of sludge) • Completed the OM&M Manual for South Boundary Groundwater Pump and Treat System • Continued operation of Removal Action Groundwater Pump and Treat Rystem • Treated over 326 million gallons of groundwater and removed over 50 pounds of volatile organics

presence of EDTA has hastened the movement of radionuclides in the soil and groundwater downgradient of the AGS outfall or off the site. BNL discontinued the use of EDTA in the AGS cooling water system in 1998. Investigation of potential impacts of EDTA will continue in 1999. The investigation was conducted under the OU IV and OU III CERCLA related activities under the BNL Environmental Restoration program.

2.8 ENVIRONMENTAL MONITORING

In order to determine whether current BNL operations affect the environment and to ensure compliance with environmental permit requirements, the Laboratory has established a comprehensive, multi-media environmental monitoring program. Over 5000 samples were collected in 1998 as part of the Environmental Monitoring Program as shown in Table 2-3. The monitoring program is reviewed and

Table 2.3. BNL 1998 Sampling Program
Summary of Samples Collected Sorted by Media

Samples	Total Collected in 1998	Purpose
Groundwater	1,718	Monitoring is performed by the ER and ES organizations to determine impacts of past and present operations on groundwater quality.
Air - Tritium	1,240	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. This data is used to assess tritium levels downwind of the reactors.
Air - Particulate	480	Gamma analysis is performed on samples of particulate matter collected from air samples. Purpose is to ensure that there is no impact from BNL operations.
Air - Charcoal	190	Charcoal samples are used to assess for radioiodines, which may be released in reactor emissions.
Potable Water	195	Potable water wells are monitored routinely for chemical and radiological parameters to ensure compliance with SDWA requirements and for environmental surveillance purposes.
Fauna	56	Fish and deer are monitored routinely by gamma analysis to assess impacts to wildlife from past BNL operations.
Flora	15	Since the primary pathway from soils to fauna is via ingestion, vegetation is sampled to assess uptake of contaminants by plants.
On-Site Recharge Basins	115	Recharge basins used for waste water and storm water disposal are monitored in accordance with SPDES requirements and for environmental surveillance purposes.
Sewage Treatment Plant and the Peconic River	1,037	The STP influent and effluent and several Peconic River stations downstream are monitored routinely for organic, inorganic, and radiological parameters to assess BNL impacts on the estuary.
Precipitation	22	To determine impacts of Laboratory emissions on rainfall, precipitation samples are collected routinely from two locations.
Soils	138	Soil samples are collected from adjacent farms and other local areas to confirm that Laboratory emissions have no impact on surrounding areas.
Collected in 1998 Total Samples	**5,198**	

revised as necessary on an annual basis, to reflect changes in permit requirements, changes in facility specific monitoring activities, and the need to increase or decrease monitoring based upon the review of previous analytical results. As required under DOE Order 5400.1, an Environmental Monitoring Plan outlines annual sampling goals by specific media and frequency.

There are three components to the environmental monitoring program:

- Compliance monitoring is conducted to ensure that wastewater effluent, air emissions and groundwater monitoring data comply with regulatory permit conditions (issued under the federal Clean Air Act (CAA), Clean Water Act (CWA), Oil Pollution Act, Safe Drinking Water Act and New York State equivalents).
- Restoration monitoring is performed to determine overall impacts of past operations, to delineate the real extent of contamination, and to assure that remedial systems are performing as designed (CERCLA, Resource Conservation and Recovery Act [RCRA]).
- Surveillance monitoring is conducted to ensure there are no negative impacts on environmental media from Laboratory operations (DOE Order).

These programs may be broken down further by the relevant law or requirement (e.g., State Pollutant Discharge Elimination System [SPDES] or CAA) and even further by specific media and type of analysis. Control or background samples are also collected in order to compare BNL samples to areas that could not have been impacted by BNL operations.

2.8.1 ENVIRONMENTAL MONITORING PROGRAM PURPOSE AND SCOPE

Compliance monitoring is performed in accordance with environmental requirements (permits, regulations, etc.). These requirements may be separated into three categories: air, wastewater and groundwater.

- Monitoring of air emissions is conducted at reactors, accelerators and other radiological emission sources as well as the CSF. Real-time, continuous emission monitoring or continuous sample collection equipment is installed and maintained at these facilities, as required by permit conditions. Analytical data is reported routinely to the permitting agency (see Chapter 3 for details).
- Wastewater discharges are subject to CWA permit monitoring requirements. Monitoring is performed at the point of the wastewater discharge, and is used to ensure that the effluent complies with release limits. Twelve point source discharges are monitored under the BNL CWA program: three from the ER program, and nine under the SPDES program. Samples are collected daily, weekly, monthly, or quarterly as required by permit conditions, and monitored for organics, inorganics and radiological parameters. Monthly reports are filed with the permitting agency, which provide analytical results and an assessment of compliance for that reporting period.
- Groundwater monitoring is also performed in accordance with permit requirements. Specifically, monitoring of groundwater is required under the Major Petroleum Facility License and RCRA permit for the WM facility. Extensive groundwater monitoring is also conducted under the ER program as required under the Records of Decision for many of the OUs or Areas of Concern (see Chapter 8 for details). Additionally, to ensure that the Laboratory maintains a viable potable water supply, groundwater is monitored as required by the NYS Department of Health (see Chapter 3 for details).

Monitoring performed under the ER program is conducted to determine if past operations released or deposited contaminants in the environment or otherwise resulted in degradation of environmental media. This program typically includes collection of soil and groundwater samples in order to determine the lateral and vertical extent of the contaminated area. These samples are analyzed for organics, inorganics and radiological contaminants and the analytical results compared with recognized guidance or background concentrations. Areas where impacts have been confirmed are fully characterized and if necessary, remediated to mitigate continual impacts. Follow-up monitoring of groundwater is conducted in accordance with a Record of Decision.

The focus of the environmental surveillance program is to assess potential environmental impacts resulting from routine facility operations. This program includes collection of ambient air, surface water, groundwater, flora, fauna, and precipitation samples. Samples are analyzed for radiological, organic, and inorganic contaminants. Additionally this program performs routine review of data collected by thermoluminescent dosimeters (TLDs) (devices to measure radioactive exposure) placed on and offsite.

The results of monitoring and the analysis of the monitoring data are the subject of the rest of this SER report. Chapter 3 summarizes environmental requirements and compliance data; Chapters 5 through 9 give details on media specific monitoring data and its analysis; chapter 10 provides supporting information for understanding and validating most of the data shown in this report.

2.9 COMMUNITY INVOLVEMENT

A Community Advisory Council was formed to advise the Laboratory Director on BNL issues, operations, and activities of concern or interest to the community. BNL also has an Envoy Program, which builds on relationships that BNL employees have established within community organizations as a way to communicate about the Laboratory to a broader audience. Additionally, BNL has held several roundtables to solicit input from internal and external stakeholders on Laboratory matters of interest to them.

Public outreach activities include local civic association briefings; meetings and presentations to local, state and federal regulators and elected officials; and regular interactions with the business and educational community. In 1998, BNL hosted more than 10,000 student visitors; another 3,200 people visited the Laboratory through its Summer Sunday programs.

To improve communications between BNL and the community, the Community Involvement, Government and Public Affairs Directorate updated the look and information on the Laboratory's World Wide Web site. A survey was conducted that identified issues of importance to the community in order to focus coverage. To highlight the cutting-edge environmental research conducted at the Laboratory and provide information regarding cleanup initiatives, the Laboratory hosted an Environmental Fair, which drew over 3,000 visitors.

The Laboratory also issues press releases, publishes the Brookhaven Bulletin and Cleanupdate, and issues e-mail updates, to inform the public and staff about environmental activities. In 1998, BNL granted Newsday, the major daily Long Island newspaper, unprecedented access to employees and the site for a series of articles that explored the Laboratory's culture, detailed environmental cleanup activities on- and offsite, and reported on community initiatives.

BNL has made strong commitments to the Long Island environment and the safety and health of its community. The Laboratory is developing a broad spectrum of opportunities for community involvement and public outreach. BNL's Community Involvement Policy, written with input from BNL employees and the general public, lays the foundation for a heightened emphasis on community involvement throughout the Laboratory.

REFERENCES:

Memorandum of Agreement by and between the Environmental Protection Agency and the United States Department of Energy, EPA and DOE, March 23,1998

ISO/DIS 14001, ASTM, Environmental Management System—Specification with Guidance for Use. September, 1996.

Areas of Concern at BNL, A Reference Handbook. June 1998. Brookhaven National Laboratory, Upton, New York.

BNL Environmental Monitoring Plan for Calendar Years 1997 and 1998. March, 1997. Brookhaven National Laboratory, Upton, New York.

Compliance Status

CHAPTER 3

Brookhaven National Laboratory (BNL) is subject to more than 50 sets of federal, state and local environmental regulations and 60 site-specific permits. Tables 3-1, 3-2, and 3-3 itemize and describe these requirements. Routine checks are made to ensure that permit limits are met.

For regulations where monitoring is necessary, a brief description of the legislation and compliance status is given in this chapter. In 1998, BNL operated in compliance with the majority of these regulations. Exceptions include nine minor exceedances of wastewater discharge permit limitations, and noncompliance with certain administrative hazardous waste requirements for short-term storage. Chapters 5 and 6 provide details on air and water quality monitoring results.

Emissions that affect global warming, such as nitrogen oxides (NO_x) and sulfur dioxide (SO_2) were within permit limits. Three halon fire suppression systems were deactivated and 156 kilograms of halon recovered. Over 900 pounds of ozone-affecting refrigerants were recovered for recycling.

Improvements that helped ensure compliance this year, and for future years, include the upgrade to the Sewage Treatment Plant from primary to tertiary treatment facilities and the Spill Prevention Control Plan upgrade so that BNL is in full compliance with New York State Department of Environmental Conservation (NYSDEC) regulations and Department of Energy (DOE) orders. Fourteen spills occurred that were subject to reporting requirements; all were cleaned-up to NYSDEC satisfaction. BNL is taking steps to ensure full compliance with the applicable requirements of the Suffolk County Department of Health Services (SCDHS) toxic and hazardous materials storage regulations in Article 12. Twenty-six storage tanks were permanently removed, 31 were refitted with containment measures and more tanks will continue to be upgraded to meet Article 12 standards. There were no semi-volatile or floating products in groundwater at the Major Petroleum Facility.

External audits were conducted by the NYSDEC for hazardous waste and air emissions from the Central Steam Plant. In 1998, BNL was not cited by the NYSDEC or U.S. Environmental Protection Agency (USEPA) for violations. The SCDHS inspects potable water facilities annually and found the BNL potable water system to meet all drinking water requirements. A DOE inspection noted significant improvements in the groundwater protection program and restoration work.

3.1 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The many federal, state and local environmental statutes and regulations that BNL operates under are summarized in Table 3-1, along with a discussion of BNL's compliance status with regard to each requirement.

3.2 ENVIRONMENTAL PERMITS

A variety of processes and facilities at BNL operate under permits issued by environmental regulatory agencies. These permits include a State Pollutant Discharge Elimination System (SPDES) permit, a Major Petroleum Facility (MPF) license, a Resource Conservation Recovery Act (RCRA) permit for the new Waste Management Facility (WMF), a certificate from the New York State Department of Environmental Conservation (NYSDEC) registering tanks storing bulk quantities of hazardous substances, NYSDEC certificates for two registered gasoline vapor recovery systems, eight authorizations for the National Emission Standards for Hazardous Air Pollutants (NESHAPs), and 46 Certificates to Operate (CO) air emission sources from NYSDEC.

Table 3-1
Federal, State and Local Environmental Statutes Applicable to the BNL

Regulator, (Federal/State) Citation	Regulatory Program Description	Compliance Status	Report Reference Sections
USEPA/NYSDEC 40 CFR Parts 300, 302, 355 and 370 /None	CERCLA provides the regulatory framework for the remediation of releases of hazardous substances and the remediation of inactive hazardous waste disposal sites.	In 1989 BNL entered into a tri-party agreement between USEPA, NYSDEC and DOE. Remediation of the BNL site is conducted by the ER program in accordance with milestones established under this agreement.	2.8
USEPA/NYSDEC 40 CFR Part 50 - 80/ 6NYCRR Part 200 -258, 307	The Clean Air Act and the NYS Environmental Conservation Law regulate the release of air pollutants through the use of permits and air quality limits.	All air emission sources have permits or have been exempted under the NYS air program. Emissions of radionuclides are regulated by the USEPA, under NESHAPs authorizations.	3.5
U.S. Fish and Wildlife Service/NYSDEC 50 CFR Part 11/ 6NYCRR Part 182	The Endangered Species Act and corresponding NYS regulation prohibit activities that would jeopardize the continued existence of an endangered or threatened species or cause adverse modification to a critical habitat.	One Endangered Species has been identified onsite (the tiger salamander) and one NYS Species of Special Concern (the banded sunfish). The Laboratory is preparing a Wildlife Management Plan that outlines activities to protect species and enhance habitat.	3.12
USEPA/NYSDEC 40 CFR Part 162 - 171/ 6NYCRR Parts 320 - 329	The Federal Insecticide, Fungicide, and Rodenticide Act and corresponding NYS regulations governs the manufacture, and use of biocides, specifically the use, storage and disposal of pesticides and herbicides and pesticide containers and residuals.	The BNL maintains certified pesticide applicators for the application of pesticides/ herbicides site-wide. Each applicator attends training as needed to maintain all certifications current. Annual reports detailing the quantity and types of pesticides applied are filed for each applicator each year by February 1st.	3.10
USDOE/None 10 CFR Parts1021, 40 CFR Part 1021, 1500-1508	The National Environmental Policy Act (NEPA) requires federal agencies to follow a prescribed process to evaluate the impacts of proposed major federal actions and alternatives on the environment before an irreversible commitment of resources is made. The Department of Energy has codified its implementation of NEPA in 10 CFR 1021.	BNL is in full compliance with the NEPA requirements.	3.3

Table 3-1
Federal, State and Local Environmental Statutes Applicable to the BNL *(cont'd.)*

Regulator, (Federal/State) Citation	Regulatory Program Description	Compliance Status	Report Reference Sections
Advisory Council on Historic Preservation 36 CFR Parts 60, 63, 79, 800	The National Historic Preservation Act identifies, evaluates and protects historic properties eligible for listing in the National Register of Historic Places. Historic properties can be archeological sites, historic structures or historic document records or objects.	Three locations at BNL, Brookhaven Graphite Research Reactor, Old Cyclotron Complex, and World War I experimental foxhole trenches were identified by the New York State Historic Preservation Officer (NYSHPO) as potentially eligible for inclusion in the National Register of Historic Places in April 1991. Any activities involving these facilities is identified utilizing the NEPA process and an evaluation is initiated to determine if the proposed action would impact those features which extend eligibility to these facilities. To date, no actions have been proposed which have required additional consultation with the NYSHPO. Compliance with the intent of these laws has been achieved by BNL, although program implementation has not been fully developed beyond the NEPA process.	3.4
USEPA/NYSDEC 40 CR Part 109 -140, 230, 231, 401, 403/ 6NYCRR Parts 700-703, 750 - 758	The Clean Water Act and corresponding State Environmental Conservation Law seek to improve the quality of the waters of the US/ State by implementing a permitting program and establishing water quality standards.	Wastewater discharges are permitted by the NYSDEC. Permitted discharges include treated sanitary waste, cooling tower and stormwater discharges. With the exception of nine minor excursions, these discharges met the SPDES permit limits in 1998.	3.6
USEPA/NYSDEC 40 CFR Part 141-149/ 10 NYCRR Part 5	The Safe Drinking Water Act and NYS Department of Health standards for public water supplies, establish minimum drinking water standards and monitoring requirements.	BNL maintains a community water supply. This water supply meets all primary and secondary drinking water standards and operational and maintenance requirements.	3.6.3
USEPA/NYSDEC 40 CFR Part 260 - 280/ 6NYCRR Part 360 - 374	The Resource Conservation Recovery Act and NYS Solid Waste Disposal Act govern the generation, storage handling and disposal of hazardous wastes.	BNL is defined as a large quantity generator of hazardous waste and has two permitted storage facilities. While almost all wastes are handled and disposed in accordance with all Federal and State requirements, audits have identified several violations. These are being addressed by corrective action plans. All USTs were in compliance with the 12/22/98 deadline for upgrade.	3.8
USEPA/None40 CFR Part 700 - 766	The Toxic Substances Control Act regulates the manufacture, use and distribution of all regulated substances.	BNL manages all TSCA regulated materials, including PCBs, in compliance with all requirements.	3.9

Table 3-2 provides a summary of these permits. This table is organized by building number and then by type of permit. In addition to those listed, the operation of three groundwater pump and treat systems installed under the Interagency Agreement (IAG) are authorized under SPDES and air emission equivalency permits.

3.2.1 NEW OR MODIFIED PERMITS

3.2.1.1 STATE POLLUTANT DISCHARGE ELIMINATION SYSTEM (SPDES)

To accommodate wastewater effluents generated by Relativistic Heavy Ion Collider (RHIC) facilities, BNL submitted a request in 1997 to NYSDEC to modify the SPDES permit.

Table 3 -2. BNL Environmental Permits

Bldg./Facility Designation	Process/Equipment Description	Permitting Agency and Division	Permit Number	Expiration Date
197	welding shop	NYSDEC-Air Quality	472200 3491 19704	04-01-00
197	epoxy coating/curing exhaust	NYSDEC-Air Quality	472200 3491 19708	06-08-98(3)
206	cyclone G-10	NYSDEC-Air Quality	472200 3491 20601	04-01-00
207	belt sander	NYSDEC-Air Quality	472200 3491 20701	04-01-00
244	cyclone collector	NYSDEC-Air Quality	472200 3491 24401	01-28-99(3)
422	cyclone collector	NYSDEC-Air Quality	472200 3491 42202	11-29-96(3)
422	cyclone collector	NYSDEC-Air Quality	472200 3491 42203	11-29-96(3)
423	stage II vapor recovery	NYSDEC-Air Quality	472200 D365 WG	09-27-95(1)
423	welding hood	NYSDEC-Air Quality	472200 3491 42305	05-15-01
458	paint spray booth	NYSDEC-Air Quality	472200 3491 45801	04-23-97(3)
462	machining, grinding exhaust	NYSDEC-Air Quality	472200 3491 46201	11-29-96(3)
462	machining, grinding exhaust	NYSDEC-Air Quality	472200 3491 46202	11-29-96(3)
473	vapor degreaser/fume hood	NYSDEC-Air Quality	472200 3491 47301	03-22-96(4)
479	cyclone G-10	NYSDEC-Air Quality	472200 3491 47905	04-01-00
490	Inhalation Toxicology Facility	NYSDEC-NESHAPs	472200 3491 49001	05-15-01
490	Inhalation Toxicology Facility	NYSDEC-Air Quality	472200 3491 49002	05-15-01(2)
490	lead alloy melting	NYSDEC-Air Quality	472200 3491 49003	05-15-01
490	milling machine/block cutter	NYSDEC-Air Quality	472200 3491 49004	05-15-01
510	metal cutting exhaust	NYSDEC-Air Quality	472200 3491 51002	09-30-98(3)
510	calorimeter enclosure	U.S. EPA - NESHAPS	BNL-689-01	None
526	polymer mix booth	NYSDEC-Air Quality	472200 3491 52601	04-01-00
526	polymer weighing	NYSDEC-Air Quality	472200 3491 52602	04-01-00
535B	plating tank	NYSDEC-Air Quality	472200 3491 53501	04-01-00
535B	etching machine	NYSDEC-Air Quality	472200 3491 53502	04-01-00
535B	PC board process	NYSDEC-Air Quality	472200 3491 53503	05-15-01
535B	welding hood	NYSDEC-Air Quality	472200 3491 53504	09-30-98(3)
555	scrubber	NYSDEC-Air Quality	472200 3491 55501	04-01-00(2)
555	scrubber	NYSDEC-Air Quality	472200 3491 55502	04-01-00(2)
610	combustion unit	NYSDEC-Air Quality	472200 3491 6101A	05-15-01
610	combustion unit - ALF	NYSDEC-Air Quality	472200 3491 61005	05-15-01
610	combustion unit	NYSDEC-Air Quality	472200 3491 61006	05-15-01
610	combustion unit	NYSDEC-Air Quality	472200 3491 61007	12-18-02
630	stage II vapor recovery	NYSDEC-Air Quality	472200 D366 WG	09-27-95(1)
703	machining exhaust	NYSDEC-Air Quality	472200 3491 70301	05-15-01
705	building ventilation	U.S. EPA - NESHAPS	BNL-288-01	None
820	accelerator test facility	U.S. EPA - NESHAPS	BNL-589-01	None
865	lead melting pot	NYSDEC Air Quality	472200 3491 86501	01-14-03
902	spray booth exhaust	NYSDEC-Air Quality	472200 3491 90201	09-30-98
902	belt sander	NYSDEC-Air Quality	472200 3491 90202	05-15-01
902	sanding, cutting, drilling	NYSDEC-Air Quality	472200 3491 90203	05-15-01
902	brazing/soldering exhaust	NYSDEC-Air Quality	472200 3491 90204	05-15-01
902	painting/soldering exhaust	NYSDEC-Air Quality	472200 3491 90205	05-15-01
903	cyclone G-10	NYSDEC-Air Quality	472200 3491 90302	04-01-00
903	brazing process exhaust	NYSDEC-Air Quality	472200 3491 90303	09-30-98
905	machining exhaust	NYSDEC-Air Quality	472200 3491 90503	05-15-01
919A	solder exhaust	NYSDEC-Air Quality	472200 3491 91903	05-15-01
922	cyclone exhaust	NYSDEC-Air Quality	472200 3491 92201	04-01-00
923	electronic equip. cleaning	NYSDEC-Air Quality	submitted 3-93,	STATUS PENDING
924	spray booth exhaust	NYSDEC-Air Quality	472200 3491 92401	09-30-98
924	magnet coil production press	NYSDEC-Air Quality	472200 3491 92402	05-15-01
924	machining exhaust	NYSDEC-Air Quality	472200 3491 92403	05-03-98
930	electroplating/acid etching	NYSDEC-Air Quality	472200 3491 93001	05-15-01
930	bead blaster	NYSDEC-Air Quality	472200 3491 93002	05-15-01
AGS Booster	accelerator	U.S. EPA - NESHAPS	BNL-188-01	None
RHIC (a)	accelerator	U.S. EPA - NESHAPS	BNL-389-01	None

Table 3 -2. BNL Environmental Permits *(cont'd.)*

Bldg./Facility Designation	Process/Equipment Description	Permitting Agency and Division	Permit Number	Expiration Date
Radiation therapy facility		U.S. EPA - NESHAPS	BNL-489-01	None
Radiation effects /neutral beam		U.S. EPA - NESHAPS	BNL-789-01	None
CSF(b)	major petroleum facility	NYSDEC-Water Quality	1-1700	03-31-02
STP(c) &RCB(d)	sewage plant & recharge basins	NYSDEC-Water Quality	NY-0005835	03-01-00
WMF (e)	waste management	NYSDEC-Hazardous Waste	NYS ID No 1-4722-00032/00102-0	07-12-05
BNL Site	chem tanks-HSBSRC (f)	NYSDEC	1-000263	07-27-99

Notes:
a. Relativistic Heavy Ion Collider
b. Central Steam Facility
c. Sewage Treatment Plant
d. Recharge basins
e. New Waste Management Facility
f. Hazardous Substance Bulk Storage Registration Certificate.

1. Renewal submitted 9-6-95, NYSDEC has indicated the process is subject to registration only.
2. Process is not in service.
3. Permits for processes with past due expiration dates have been extended until NYSDEC approves BNL's Title V permit or until the NYSDEC reclassifies the processes as exempt and trivial pursuant to Part 201 provisions.
4. The vapor/sonic degreaser and fume hood shared a common exhaust stack. The degreaser has been removed. The fume hood is still used for aerosol spray coating and wipe cleaning of parts.

*Note: Renewal application submitted more than 30 days prior to expiration date; process can continue to operate under provisions of the NYS Uniform Procedures Act.

A draft permit was received in April 1998, that included temporary authorization to locally discharge cooling water blowdown from Buildings 1008, 1010, 1002, and 1004, as well as a stormwater discharge from the former Hazardous Waste Management Facility (HWMF). Permanent connection of these discharges to existing permitted point sources will be complete in 2001. The NYSDEC also included provisions to apply the more stringent of either the surface water or groundwater discharge standard to Sewage Treatment Plant (STP) effluent. These permit changes are expected to be finalized in 1999.

3.2.1.2 AIR

- WMF: In February 1998, the NYSDEC issued an operating permit for the lead melting pot to be used to process old lead shielding. The melter is located in Building 865 of the WMF.
- Title V: Facilities that are considered major sources of criteria pollutants or hazardous air pollutants must obtain a Title V operating permit under the Clean Air Act (CAA). This permit consolidates all emission sources and all of the applicable federal and state regulatory requirements into a single document. Since Central Steam Facility (CSF) boiler emissions of oxides of nitrogen and sulfur dioxide (NO_x and SO_2) exceed the major facility annual thresholds of 25 tons and 100 tons, respectively, BNL was classified as a major source.

The Title V Phase I application was submitted to the NYSDEC in December 1997. This part of the application summarized the applicable regulatory requirements, described site operations and activities, and summarized the pollutants released by BNL sources. The application also included a compliance plan to address three issues that were identified during its preparation, and a statement certifying that BNL will continue to comply with all applicable requirements.

Phase II of the application was submitted in December 1998. Before the application was prepared, BNL conducted walk-through inspections of all facilities. The inspections identified more than 2,800 emission sources. Most of these were classified as exempt or trivial sources in accordance with provisions of 6 NYCRR Part 201, and included processes such as welding/soldering, degreasing, sandblasting, machining, aerosol painting, and parts cleaning. Activities or emission sources that share common regulatory requirements

were grouped together into sixteen emission units. Individual permits for processes have been extended until NYSDEC issues BNL's Title V Permit, or until NYSDEC reclassifies the processes as exempt or trivial under Part 201 provisions. Table 3-3 summarizes the sources included in each emission unit, and the applicable regulatory requirements.

3.3 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

Provisions in NEPA require federal agencies to follow a prescribed process to evaluate the impacts of proposed major federal activities on the environment before an irreversible commitment of resources is made. During 1998, environmental evaluations were completed for 115 proposed projects in accordance with Department of Energy (DOE) Order 451.1 and 10 CFR 1021 (DOE's Rules Implementing NEPA). Of these, 74 were considered minor actions requiring no additional documentation, and 41 projects were addressed through submission of Environmental Evaluation Notification Forms to DOE. An Environmental Assessment was completed and a Finding of No Significant Impact issued for the Booster Applications Facility. BNL also provided information to DOE and DOE contractors on the preparation of an Environmental Impact Statement for BNL's High Flux Beam Reactor (HFBR). This document is expected to be released for public review and comment during 1999.

3.4 NATIONAL HISTORIC PRESERVATION ACT/ ARCHEOLOGICAL RESOURCE PROTECTION ACT (NHPA/ARPA)

These two acts identify, evaluate and protect historical and archeological sites eligible for listing in the National Register of Historical Places. The sites may include Native American Indian lands and historic structures, objects and documents. During 1998, activities associated with NHPA/ARPA were limited to completion of the annual Department of Interior questionnaire regarding historic/ cultural resources. Staff attended a training

Table 3-3. Summary of Title V Permit Application Emission Units

Emission Unit ID	Emission Unit Description	Applicable Regulations	Summary of Requirements
U45801	Unit is a paint spray booth used to apply protective and decorative coatings to miscellaneous metal parts and room furnishings.	6 NYCRR Part 228	Establishes VOC content limits for coatings based on the type of surfaces coated.
U49001	Unit has three walk-in enclosures used for research on processes to treat fireproofing products by chemically converting the asbestos containing material into a non-regulated asbestos-free product. Redundant High Efficiency Particulate Arrestor (HEPA) filters are used in the exhaust system. Caustic and acidic aerosols generated by the process are controlled by a wet scrubber device.	40 CFR 61 Subpart M	Requires the use of HEPA filters certified to remove at least 99.97 percent of 0.3 micron particles and daily visual monitoring of potential source of asbestos emissions including air cleaning devices and process equipment.
U49003	Unit has a lead melting machine, a milling machine, and a block cutter used to fabricate block shielding fabricated for patients who receiving treatment at the Radiation Therapy Facility. The shielding, is styrofoam and lead alloy used to protect against unwanted radiation. Particulates are collected in a fabric filter.	6 NYCRR Part 212 6 NYCRR Part 200	Limits particulate emissions to 0.05 grains/ dry standard cubic foot, for emission sources whose permit to construct was received by NYSDEC after July 1 1973. Requires emission control devices to be operated and maintained properly.
U61005	Unit is two Central Steam Facility, commercial-institutional sized boilers. Boiler 1A, a midsize boiler, has a nominal heat capacity of 16.4 MW (56.7 MMBtu/hr) used for peaking and intermittent loads. Boiler 5, a large boiler with nominal heat capacity of 65.3MW (225 MMBtu/hr), is used to meet winter baseloads. Boiler 5 has dual fuel (oil or natural gas) capabilities.	6 NYCRR Part 225-1 6 NYCRR Part 225-2 6 NYCRR Part 227-1 6 NYCRR Part 227-2	Limits sulfur content of fuel oils. Limits contaminants in oil burned in boilers. Establishes opacity limits for boilers. Establishes NOx emission limits for large and mid-size boilers that burn natural gas and oil.

Table 3-3. Summary of Title V Permit Application Emission Units *(cont'd.)*

Emission Unit ID	Emission Unit Description	Applicable Regulations	Summary of Requirements
U61006	Unit is a commercial-institutional sized boiler with a nominal heat capacity of 42.6 MW (147 MMBtu/hr) located at the Central Steam Facility. Boiler 6 has dual fuel firing capabilities that allow it to burn oil or natural gas.	6 NYCRR Part 225-1 6 NYCRR Part 225-2 6 NYCRR Part 227-1 6 NYCRR Part 227-2 40 CFR 60 Subpart Db	Limits sulfur content of fuel oils. Limits contaminants in oil burned in boilers. Establishes opacity limits for boilers. Establishes NOx emission limits for large and midsize boilers burning natural gas and oil. Requires continuous monitoring systems to measure NOx emissions.
U61007	Unit is a Central Steam Facility commercial-institutional sized boiler with a nominal heat capacity of 42.6 MW (147 MMBtu/hr) built in 1996. Constructed after June 19 1986, it requires continuous emission monitoring for opacity. This boiler has dual fuel firing capabilities allowing it to burn oil or natural gas.	6 NYCRR Part 225-1 6 NYCRR Part 225-2 6 NYCRR Part 227-1 6 NYCRR Part 227-2 40 CFR 60 Subpart Db	Limits sulfur content of fuel oils. Limits contaminants in oil burned in boilers. Establishes opacity limits for boilers. Limits NOx emission for large and midsize boilers. Requires continuous monitoring systems to measure NOx emissions.
UFLEET	Unit is BNL's fleet of vehicles of 244 gasoline powered vehicles with gross vehicle weight ratings (GVWRs) of 8500 pounds or less, and 46 gasoline powered vehicles with GVWRs greater than 8500 pounds. The remaining fleet vehicles are exempt from Part 217.	6 NYCRR Part 217	Sets inspection and maintenance require-ments for gasoline and diesel powered vehicles. Emission and safety inspections are done at Building 630; maintenance and repairs at the vehicle maintenance shop.
UFUELS	Unit is two onsite gasoline refueling facilities. Building 630 is contractor operated servicing employee vehicles. The facility has three pumps that dispense low, medium and high octane grades of gasoline. Building 423, is a refueling facility for BNL fleet gasoline powered vehicles with two pumps dispensing low octane gasoline. Underground storage tanks at both facilities have Stage I and Stage II engineering controls.	6 NYCRR Part 225-3 6 NYCRR Part 230	Limits the Reid vapor pressure of gasoline from May 1st to September 15th, oxygen content October 1st to April 30th, and re-quires the sale of reformulated gas all year. Specifies Stage I and Stage II engineering controls at all refueling stations that pump more than 454,000 liters (120,000 gallons).
UHALON	Unit has 593 portable Halon 1211 fire extinguishers, 138 Halon 1301 cylinders with 39 fixed total flooding fire suppression systems and three Halon 1301 reserve tanks.	40 CFR 80 Subpart H	Requires certified technicians and halon recovery equipment to test, service, main-tain, repair, or dispose halon-containing equipment.
UINSIG	Unit has a magnet coil coating operation, the Printed Circuit Board Laboratory, an operation for etching magnet end blocks, and a small scale printed circuit board etching and electroplating operation.	6 NYCRR Part 201-6	Requires maintenance of records to verify aggregate emissions of criteria pollutants and hazardous air pollutants from all sources are below levels established in Section 201-6.3.
ULEADM	Unit is a soft metal pot furnace installed at the new Waste Management Facility used to recycle lead shielding.	6 NYCRR Part 200	Requires emission control devices be operated and maintained properly.
ULITHO	Unit includes two lithographic offset printing machines used to print BNL's published materials.	6 NYCRR Part 234	Limits the volatile organic compound content of solutions used in printing.
UMETAL	Unit has 16 cold cleaning operations in various site locations to clean metal parts.	6 NYCRR Part 226	Specifies administrative and operating requirements for this equipment.
UMVACS	Unit covers BNL fleet vehicles equipped with air conditioners.	40 CFR 80 Subpart B	Requires certified technicians use refriger-ant recovery equipment when vehicle air conditioners are serviced or repaired.
URADEF	Unit covers on-site activities and operations that generate radioactive airborne emissions.	40 CFR 61 Subpart H	Sets monitoring requirements for emissions of radionuclides so that public does not receive dose higher than 10 mrem/yr.
URFRIG	Unit includes 21 centrifugal chillers, 38 reciprocating chillers, 4 rotary screw chillers, 193 split air conditioning units, and 245 package air conditioning units.	40 CFR 80 Subpart F	Requires certified technicians use refriger-ant recovery equipment when vehicle air conditioners are serviced or repaired.

session conducted by the Advisory Council on Historic Preservation in December 1998. The course has helped to refocus the Laboratory on cultural and historic issues. In 1999, the Laboratory will begin work on a Programmatic Agreement with the Advisory Council, and on petitioning the New York State Historic Preservation Officer to include several BNL facilities on the National Register of Historic Places. Three locations have been identified by the New York State Historic Preservation Office as eligible for inclusion on the National Historic Register: the Brookhaven Graphite Research Reactor (BGRR), the Cosmotron, and foxhole remnants from Camp Upton activities.

3.5 CLEAN AIR ACT (CAA)

The objectives of the CAA regulations (administered by the Environmental Protection Agency [USEPA] and NYSDEC) are to improve or maintain regional ambient air quality through administrative, operational and engineering controls on stationary or mobile sources of air pollution. Both conventional and hazardous air pollutants are regulated under the CAA.

3.5.1 CONVENTIONAL AIR POLLUTANTS

BNL has a variety of non-radioactive air emissions sources that are subject to federal or state regulations. The following subsections describe the most significant sources and the methods used to comply with the applicable regulatory requirements.

Reasonable Available Control Technology (RACT)

Requirements in RACT establish emission standards for NO_x for boilers with maximum operating heat inputs greater than or equal to 14.5 MW (50 MMBtu /hr). Emission tests conducted in 1995 confirmed that BNL Boilers 1A and 5 met NO_x and SO_2 emission standards when burning low nitrogen and sulfur content residual fuel (below 0.3 percent). To ensure continued compliance, quarterly composite samples of fuel deliveries are analyzed by an outside laboratory to confirm the fuel-bound nitrogen and sulfur content. Compliance with the 130 ng/J (0.30 lbs/MMBtu) NO_x emissions standard for Boilers 6 and 7 is demonstrated by continuous emission monitoring of flue gas. For the year, NO_x emissions from Boilers 6 and 7 averaged 63 ng/J (0.145 lbs/MMBtu) and 61 ng/J (0.140 lbs/MMBtu) respectively, and there were no recorded exceedances of the NO_x emissions standard for either boiler. In 1998, natural gas was the predominant fuel burned in the two boilers.

Halon

To comply with the new halon recovery and recycling requirements of 40 CFR 82, Subpart H that went into effect on April 6, 1998, halon 1211 and 1301 recovery/recycling dquipment was installed on April 21, 1998. These halon recovery/recycling devices are used when portable fire extinguishers or fixed systems are removed from service, and during periodic hydrostatic testing of halon. All BNL personnel who conduct the periodic hydrostatic testing of halon cylinders received vendor training on the use of the new equipment in August 1998. In 1998, three existing halon 1301 fire-suppression systems in Building 490 were deactivated. Approximately 156 kilograms (345 pounds) of halon 1301 was recovered from system cylinders and was placed into halon reserve tanks.

3.5.1.1 OZONE DEPLETING SUBSTANCES (ODS)

All refrigerant recovery and recycling equipment used by refrigerant service technicians is certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. Approximately 890 pounds of R-11, 26 pounds of R-12, and 52 pounds of R-22 were recovered and reclaimed for future use from equipment that was serviced during 1998. Under the BNL Maintenance Management Center, Preventative Maintenance Program, refrigeration equipment containing ODS is regularly inspected and maintained. As a matter of practice, if a refrigerant leak is found, technicians will either immediately repair the leak or will isolate the leak and prepare a work order for the needed repairs. This standard practice exceeds the leak repair provisions of 40 CFR 82.156.

3.5.2 NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAPS)

3.5.2.1 MAXIMUM AVAILABLE CONTROL TECHNOLOGY (MACT)

During preparation of the BNL Title V Phase II application, staff examined existing state and federal regulations that are adminis-

tered under the CAA to determine their applicability to BNL activities and operations. Based on this review, it was concluded there are no proposed or promulgated MACT standards applicable to BNL operations.

3.5.2.2 ASBESTOS

In 1995, BNL was issued a permit to operate an exhaust system for equipment used to mix and spray chrysotile asbestos insulation onto test panels in the former Inhalation Toxicology Facility. Prefilters and High Efficiency Particulate Air (HEPA) filters were installed in series in the exhaust systems of each of the three process hoods to meet the pollution control requirements of 40 CFR Part 60, Subpart M. BNL personnel responsible for the mixing and spraying operations conduct regular inspections of the pollution-control equipment and monitor both the equipment and exhaust systems daily for evidence of visible emissions. To date, no visible emissions of asbestos have been observed. As required, BNL provided advance notice to the USEPA Region II office for one demolition job involving the removal of regulated asbestos containing materials. BNL also provided the USEPA with an annual notice of nonscheduled small renovations for 1998. During 1998, 176 linear meters (579 linear feet) of pipe insulation and 47 square meters (505 square feet) of surface material were removed.

3.5.2.3 RADIOACTIVE AIRBORNE EMISSIONS

In 1998, the maximum offsite dose due to airborne radioactive emissions from the Laboratory continued to be far below the 10 mrem annual dose limit in 40 CFR 61, Subpart H. The dose to the Maximally Exposed Individual (MEI) resulting from airborne emissions, calculated using USEPA's CAP88-PC (CAA Assessment Package-1998) model, was 0.2 mrem (2 μSv). More detail on estimated dose is found in Chapter 9. All data pertaining to radiological air emissions and dose calculations were transmitted to the USEPA on time, in fulfillment of the June 30 annual reporting requirement.

3.6 CLEAN WATER ACT (CWA)

The generation and disposal of wastewater effluents generated by Laboratory operations are regulated under the CWA, as implemented by the NYSDEC, and DOE Order 5400.5. The goal of the CWA is to achieve a level of water quality which promotes the propagation of fish, shellfish and wildlife, provide waters suitable for recreational purposes, and to eliminate the discharge of pollutants. New York State was delegated CWA authority in 1975. The SPDES permit provides the basis for regulating wastewater effluents at BNL. The SPDES permit establishes release concentration limits and dictates monitoring requirements.

The BNL SPDES permit was issued in 1995. This permit provides monitoring requirements and lists effluent limits for ten outfalls:

- Outfall 001 is the discharge of treated effluent from the STP to the Peconic River.
- Outfalls 002 - 006, 008 and 010 are recharge basins used for the discharge of cooling tower blowdown, once-through cooling water and stormwater.
- Outfall 007 is backwash water from the Water Treatment Plant filter building.
- Outfall 009 consists of numerous subsurface and surface wastewater disposal systems that receive predominantly sanitary waste, and steam and air compressor discharges.

3.6.1 BNL SEWAGE TREATMENT PLANT (STP) OUTFALL 001

Sanitary and process wastewaters generated by Laboratory operations are conveyed to the STP plant for subsequent treatment prior to discharge to the Peconic River. In 1997, the STP underwent significant structural modifications and was upgraded from a primary plant (i.e., separation of settleable solids and floatables) to a tertiary treatment system (i.e., biological reduction of organic matter and reduction of nitrogen). This treatment process became fully functional in 1998.

A summary of the monitoring results for the STP is provided in Table 3-4. Figures 3-1 through 3-6 plot five year trends for the maximum monthly concentrations of copper, iron, lead, silver, nickel, and zinc in the STP outfall as documented in monitoring reports. The SPDES permit limits are also shown. Due to the inclusion of nickel in the SPDES permit in 1995, the trend plot only contains analytical results for 1995 through 1998. Table 3-4 shows that the Laboratory documented 100 percent compliance with all parameters except iron and Biological Oxygen Demand (BOD) removal in 1998. Iron excursions were reported

Table 3-4. Summary of Analytical Results for Waste Water Discharges to Outfall 001[1]

Analyte	Min.	Max.	Min. Monitoring Frequency	SPDES Limit	No. of Exceedances	Percent Compliance*
Max. Temperature Degrees Fahrenheit	46	81	Daily	90	0	100
pH SU	6	7.1	Cont. Recorder	Min.: 5.8 Max.: 9.0	0	100
Avg. 5 day Biological Oxygen Demand (BOD) mg/L	< 2	3.5	Twice Monthly	Avg.: 10	0	100
Max. 5 day BOD mg/L	< 2	6.9	Twice Monthly	Max.: 20	0	100
% BOD Removal	74	98	Monthly	85	1	92
Avg. Total Suspended Solids (TSS) mg/L	<4	5.2	Twice Monthly	Avg.:10	0	100
Max. TSS mg/L	<4	10.2	Twice Monthly	Max.:20	0	100
% TSS Removal	87	> 98	Monthly	85	0	100
Settleable Solids mg/L	0	0	Daily	0.1	0	100
Ammonia Nitrogen mg/L	< 0.05	0.6	Twice Monthly	2	0	100
Total Nitrogen mg/L	4	11.5	Twice Monthly	NA	NA	100
Cyanide ug/L	<10	<10	Twice Monthly	100	0	100
Copper mg/L	0.043	0.062	Twice Monthly	0.15	0	100
Iron mg/L	0.112	1.6	Twice Monthly	0.37	4	86
Lead mg/L	0.002	0.005	Twice Monthly	0.015	0	100
Nickel mg/L	< 0.003	0.012	Twice Monthly	0.11	0	100
Silver mg/L	0.003	0.009	Twice Monthly	0.015	0	100
Zinc mg/L	0.035	0.09	Twice Monthly	0.1	0	100
Mercury mg/L	0.0001	0.0006	Twice Monthly	0.0008	0	100
Toluene µg/L	< 1	< 1	Twice Monthly	50	0	100
Methylene Chloride µg/L	< 1	3	Twice Monthly	50	0	100
1,1,1-Trichloroethane µg/L	< 1	5	Twice Monthly	50	0	100
2-Butanone µg/L	< 1	< 1	Twice Monthly	50	0	100
Max. Flow MGD	0.65	1.3	Cont.Recorder	Max. 2.3	0	100
Avg. Flow MGD	0.496	0.763	Cont. Recorder	NA	0	100
Avg. Fecal Coliform MPN/100 ml	<2	< 2	Twice Monthly	200	0	100
Max Fecal Coliform MPN/100 ml	<2	2	Twice Monthly	400	0	100

Notes:
ND: Analyte was Not Detected in the samples.
NA: Not Applicable
1. See Figure 4-2.
2. Min. = Minimum
3. Max. = Maximum

$$\% \text{ Compliance} = \frac{\text{Total No. Samples - Total No. Exceedances}}{\text{Total No of Samples}} \times 100$$

in January and February. Investigation of these excursions revealed that the unintentional discharge of 70 gallons of concentrated acid from a plating facility caused metallic iron present in the sewage sludge to become dissolved. The acid discharge resulted from the incomplete neutralization of sulfuric acid being used to precondition newly installed plastic plating tanks. A single excursion of BOD removal was reported during 1998. As discussed in previous Site Environmental Reports, the low concentration of biological matter in the sewage received at the STP makes achieving the 85 percent reduction difficult. Improved sampling techniques and reductions in "clean" water contributions to the STP have proven effective in raising the organic content of the STP influent.

Chronic Toxicity Testing

The chronic toxicity testing program initiated in 1993 for the STP effluent was continued following completion of the STP upgrade project in September 1997. Samples were collected in March, June, September and December and submitted to a contract laboratory for testing. As required by BNL's SPDES permit, this program consists of performing, seven-day, Tier II Chronic Toxicity Tests of the BNL STP effluent. Two fresh water organisms, water fleas (Ceriodaphnia dubia) and fathead minnows (Pimphales promelas), are used for

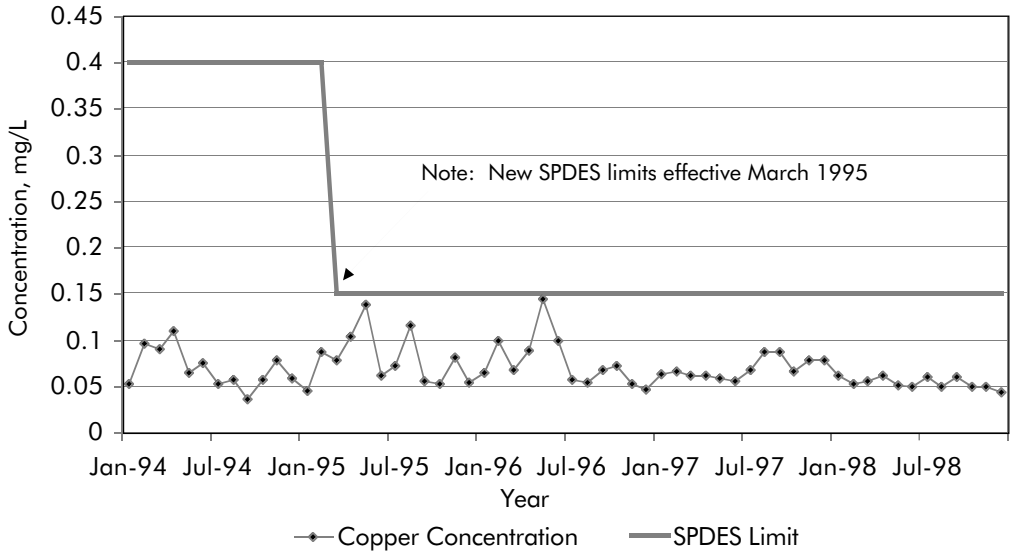

Figure 3-1.
Maximum Concentration
of Copper Discharged from
BNL STP, 1994-1998

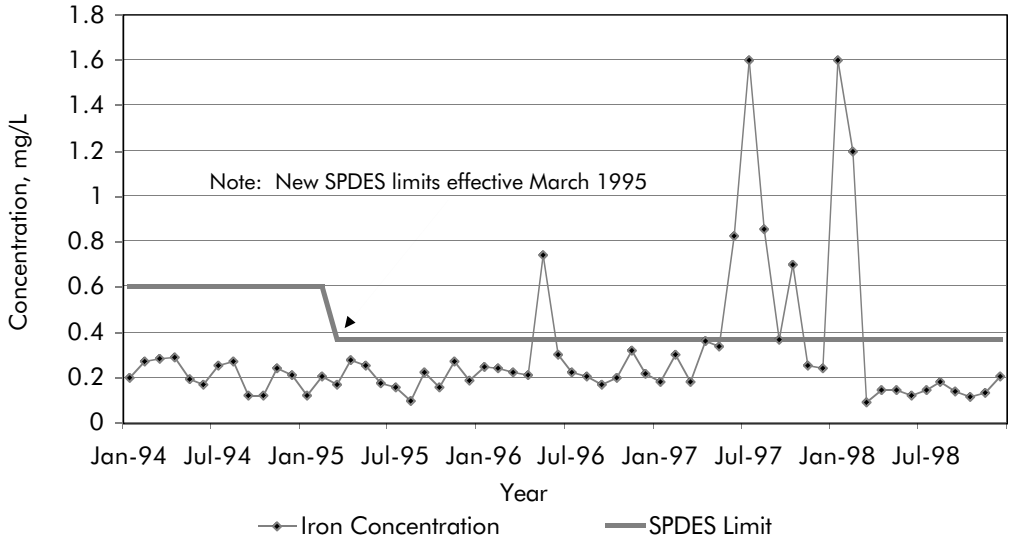

Figure 3-2.
Maximum Concentration
of Iron Discharged from
BNL STP, 1994-1998

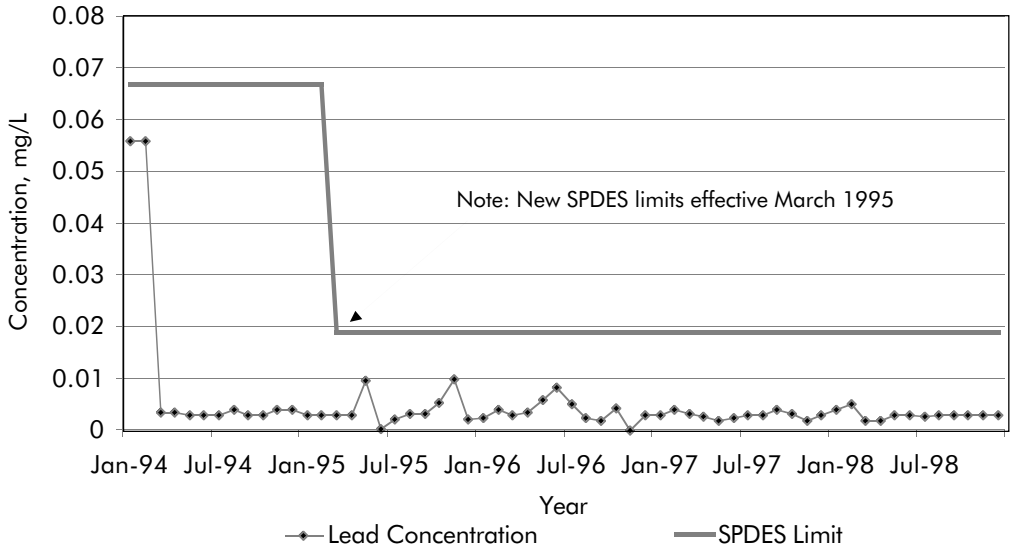

Figure 3-3. Maximum
Concentration
of Lead Discharged from
BNL STP, 1994-1998

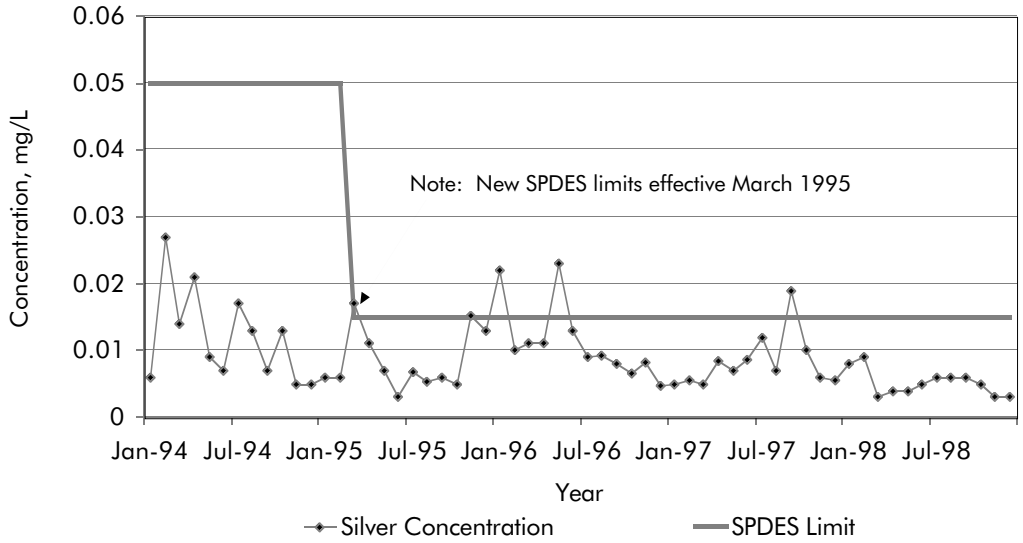

Figure 3-4. Maximum Concentration of Silver Discharged from BNL STP, 1994-1998

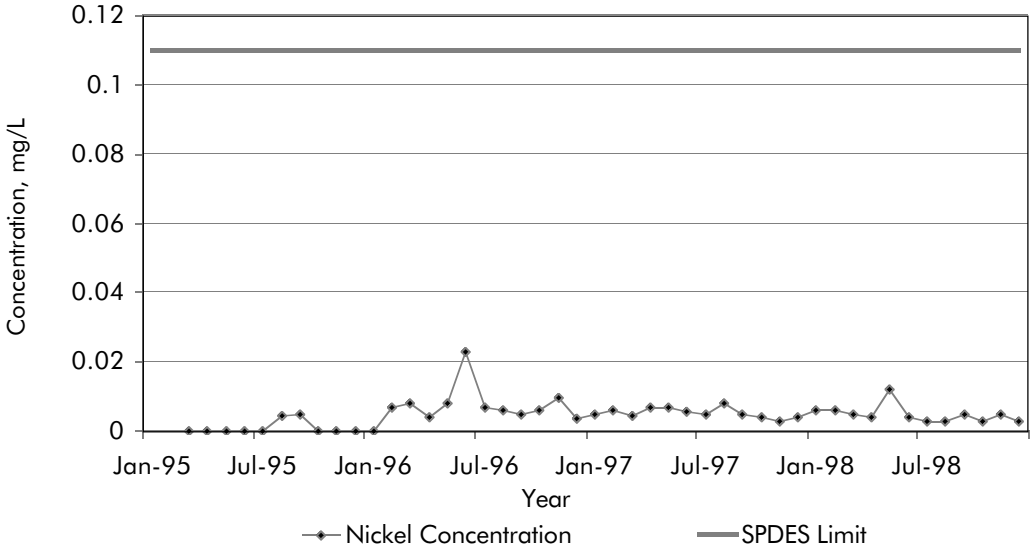

Figure 3-5. Maximum Concentration of Nickel Discharged from BNL STP, 1994-1998

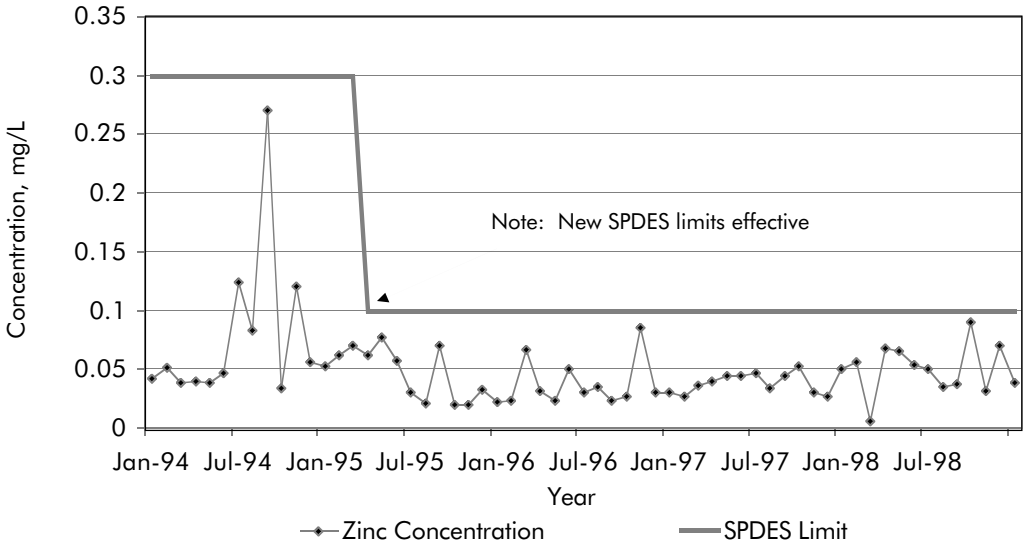

Figure 3-6. Maximum Concentration of Zinc Discharged from BNL STP, 1994-1998

testing. Sets of ten animals were exposed to varying concentrations of the STP effluent (i.e., 100, 50, 25, 12.5, and 6.25 percent) for seven days in each test. During the test, the size of fish and/or rate of reproduction for the water flea is measured and compared to untreated animals (i.e., controls). The test results were transmitted to the NYSDEC for review. Review of the toxicity data showed there was no acute toxicity exhibited for either organism, nor were any chronic effects such as changes in growth weight noted for the minnow. The rate of reproduction for the waterfleas raised in the pure STP effluent was, however, lower than the control group in two of the four tests. A "No Observable Effect Concentration" of 50 percent was reported for both tests. Due to the variability in the toxicity results, testing will continue through 1999.

3.6.2 BNL RECHARGE BASINS AND STORMWATER OUTFALLS 002 - 010

Outfalls 002 - 010 discharge to groundwater, replenishing the underlying aquifer. Monitoring requirements for each of these discharges vary, depending on the type of wastewater received and the type of cooling water treatment reagents used. Table 3-5 summarizes the monitoring requirements along with performance for 1998. During 1998, single event pH excursions at four of the recharge basins were the only exceedances for these discharges. Elevated pH in the BNL domestic water system was the primary contributing cause of these excursions. In 1997, a corrosion control study recommended that to minimize dissolution of lead from soldered joints, the pH of the BNL domestic water system should be maintained at 8.0 or higher. Difficulties in controlling the

Table 3-5.
Summary of Analytical Results for Waste Water Discharges to Outfalls 002 - 010[1]

Analyte		Outfall 002	Outfall 003	Outfall 004	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of exceedances
Flow	N	CR	CR	CR	CR	CR	CR	CR	12	12		
MGD	Min.	0.16	0.8	0.02	0.025	0.067	0.05	0	0	0		
	Max.	0.38	2.5	1.4	0.35	0.22	0.29	0.2	1.05	0.92		
pH	Min.	6.6	6	5.8	6.8	6.8	6.8	6.8	5.8	7		
SU	Max.	8.3	8.8	6.4	8.4	8.6	8.9	9.0	8	8	8.5	4
Oil and	N	12	12	NR	12	12	12	NR	11	11		
Grease	Min.	< 5	< 5	NR	< 5	< 5	< 5	NR	< 5	< 5		
mg/L	Max.	< 5	< 5	NR	9.8	< 5	< 5	NR	5	< 5	15	0
Copper	N	NR	NR	NR	4	NR	NR	NR	NR	NR		
mg/L	Min.	NR	NR	NR	0.01	NR	NR	NR	NR	NR		
	Max.	NR	NR	NR	0.06	NR	NR	NR	NR	NR	1	0
Zinc	N	NR	4	NR	NR	NR	NR	NR	NR	NR		
mg/L	Min.	NR	0.008	NR	NR	NR	NR	NR	NR	NR		
	Max	NR	0.02	NR	NR	NR	NR	NR	NR	NR	5	0
Iron (total)	N	NR	NR	NR	NR	NR	NR	5	NR	NR		
mg/L	Min.	NR	NR	NR	NR	NR	NR	200	NR	NR	NA	0
	Max.	NR	NR	NR	NR	NR	NR	260	NR	NR		
Iron (dissolved)	N	NR	NR	NR	NR	NR	NR	5	NR	NR		
mg/L	Min.	NR	NR	NR	NR	NR	NR	0.047	NR	NR		
	Max.	NR	NR	NR	NR	NR	NR	2.54	NR	NR	NA	0

Notes:
CR: Continuous Recorder
NR: Analysis Is Not Required
NA: Not Applicable
SU: Standard Units

1. See Figure 4-1.

addition of caustic used to raise the pH, and the increased concentration of caustic in cooling-tower blowdown due to evaporative loss, were determined to be the root cause of pH excursions. To prevent future excursions, tighter controls on the addition of caustic have been imposed. In an effort to balance the recommendations of the corrosion control study and SPDES permit conformance, a permit modification was requested to raise the upper pH limit to 9.0. Since Long Island groundwater is naturally slightly acidic (pH = 5.5), the discharge of slightly alkaline wastewater would not have a detrimental impact on groundwater quality.

3.6.3 SAFE DRINKING WATER ACT (SDWA)

The distribution and supply of drinking water is regulated under the federal SDWA through 40 CFR Parts 141 - 143. In NYS, implementation of the SDWA is delegated to the NYS Department of Health and administered by the Suffolk County Department of Health Services (SCDHS). Since BNL provides potable water to more than 15 service connections, it must comply with the requirements for a public water supply. Monitoring requirements are prescribed annually by SCDHS and a Potable Water Sampling and Analysis Plan prepared to comply with these requirements. Containment is the desired method of protecting a public water system, and includes the installation of cross connection control devices at the interface between the facility and the domestic water main.

3.6.3.1 POTABLE WATER

BNL maintains six wells for the distribution of potable water. All wells are treated with activated carbon or air stripping to remove Volatile Organic Compounds (VOCs) to meet Drinking Water Standards. Three of those wells are also treated to reduce naturally occurring iron.

Tables 3-6 and 3-7 provide the potable water supply monitoring data for 1998. BNL monitors potable wells regularly for bacteria, inorganics, organics, and asbestos as required by Department of Health regulations. BNL also voluntarily monitors drinking water supplies for radiological contaminants. Examination of the table shows that color, iron and 1,1,1-trichloroethane (TCA) exceeded drinking water standards. Treatment via activated carbon or at the Water Treatment Plant (WTP) effectively reduced these contaminants to well below drinking water standards. At the point of consumption, all drinking water supplies complied fully with drinking water standards during 1998. Section 8.1.1 of Chapter 8 provides additional data on environmental surveillance testing done on potable wells which goes above and beyond SDWA testing requirements.

3.6.3.2 CROSS-CONNECTION CONTROL

The SDWA requires that public water suppliers implement practices to protect the public water supply from sanitary hazards, including connection of potable water supplies to systems containing hazardous substances (i.e., cross-connections). Such practices include the implementation of a rigorous cross-connection control program. Cross-connection control is the preferred method of protecting a public water system, and includes the installation of cross-connection control devices at the interface between the facility and the domestic water main. Installation of cross-connection control devices is required at all facilities where hazardous materials are used in a manner that could result in the introduction of these hazardous substances into the domestic water system under any condition. In addition, cross-connection controls at the point of use is also required to protect other users within a specific facility from hazards posed by other facility operations.

BNL installs and maintains over 150 cross-connection control devices at interfaces to the potable water main and secondary control devices at the point of use. Ninety-two cross-connection control units were tested in 1998. Any problems noted in these 92 units were immediately corrected, and devices were retested to ensure viability. Improvements are being implemented through the EMS to ensure that all devices onsite are tested annually, and that they conform with the applicable regulatory requirements.

3.6.3.3 UNDERGROUND INJECTION CONTROL

Underground Injection Control (UIC) is regulated under the SDWA. Proper management of UIC devices (drywells, cesspools, septic tanks and leaching fields) is critical to the

Table 3-6. Potable Water Wells and Potable Distribution System, Bacteriological, Inorganic Chemical and Radiological Analytical Data (1,2)

Compound	Well No. 4 (FD)	Well No. 6 (FF)	Wel No. 7 (FG)	Well No. 10 (FO)	Well No. 11 (FP)	Well No. 12 (FQ)	Potable Distribution Sample	NYS Drinking Water Standard	
Water Quality Indicators									
Total Coliform	ND	ND	ND	ND	ND	ND	ND	Negative	
Color	* 40	* 70	5	<5	<5	<5	5	15	Units
Odor	0	0	0	0	0	0	0	3	Units
Cyanide	<10	<10	<10	<10	<10	<10	<10	NS	µg/L
Conductivity	95	109	126	112	137	122	190	NS	µmhos
Chlorides	15.1	17.9	21	14	18.6	17.2	19.4	250	mg/L
Sulfates	7.1	9.7	11.5	10	13	10.4	11.6	250	mg/L
Nitrates	0.14	0.17	0.25	0.4	0.57	0.27	0.51	10	mg/L
Ammonia	0.04	0.03	0.02	<0.02	<0.02	<0.02	<0.02	NS	mg/L
pH	6.3	6.3	6.3	6.6	6.4	6.8	8.3	NS	SU
Methylene Blue Active Substances	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	NS	mg/L
Metals									
Antimony	<5.9	<5.9	<5.9	<5.9	<5.9	<5.9	<5.9	6.0	µg/L
Arsenic	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	50	µg/L
Barium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.0	mg/L
Beryllium	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	4.0	mg/L
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	µg/L
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	mg/L
Fluoride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.2	mg/L
Iron	*2.1	* 4.3	* 0.85	<0.02	<0.02	0.02	0.03	0.3	mg/L
Lead	2.9	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	15	µg/L
Manganese	0.28	0.15	0.02	<0.01	<0.01	<0.01	<0.01	0.3	mg/L
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.0	µg/L
Nickel	<0.04	< 0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.1	mg/L
Selenium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	10.0	µg/L
Sodium	8	10.5	13.6	9.7	12.7	12.8	21.8	NS	mg/L
Thallium	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	2.0	µg/L
Zinc	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	5.0	mg/L
Radioactivity									
Gross Alpha Activity	< 0.75	< 0.52	< 0.73	< 2.0	< 2.0	< 2.0	ANR	15.0	pCi/L
Beta	< 1.09	1.34	< 1.06	1.07	1.33	0.6	ANR	50.0	pCi/L
Tritium	< 309	< 335	< 33	417	< 372	353	ANR	20000.0	pCi/L
Strontium-90	< 1.6	< 1.1	< 1.1	< 1.3	< 1.2	< 1.7	< 1.8	8.0	pCi/L
Other									
Asbestos	ANR	ANR	ANR	ANR	ANR	ANR	< 0.19	7	M.Fibers/L
Calcium	ANR	ANR	ANR	ANR	ANR	ANR	9.1	NS	mg/L
Alkalinity	ANR	ANR	ANR	ANR	ANR	ANR	52.5	NS	mg/L

Notes:
1. This table contains the maximum concentration (minimum pH value) reported by the analytical laboratory.
2. See Figure 4-11.
*: Wells are treated at the WTP for color and iron reduction prior to site distribution.
NS: DWS Not Specified
ANR: Analysis Not Required
ND: Not Detected

protection of underground sources of drinking water. In New York, the UIC program is implemented through the USEPA, since the NYSDEC did not adopt the new UIC regulatory requirements. The NYSDEC had already implemented a similar program through its CWA initiative. Under the UIC program, all Class V injection wells must be included in an inventory maintained with the USEPA.

BNL has an inventory of approximately 120 active UICs. These are all classified as Class V Injection Wells consisting primarily of

Table 3-7. Potable Water Wells, Analytical Data for Principal Organic Compounds, and Micro-Extractables

Compound	WTP Effluent (F2)	Well No. 4 (FD)	Well No. 6 (FF)	Well No. 7 (FG)	Well No.10 (FO)	Well No. 11 (FP)	Well No. 12 (FQ)	NYS DWS
	µg/L							
Dichlorodifluoromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Vinyl Chloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2
Bromomethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Fluorotrichloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	0.7	< MDL	5
Dichloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
trans-1,2-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
cis-1,2-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
2,2-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Bromochloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,1-trichloroethane	< MDL	8.4*	< MDL	< MDL	< MDL	4.2	< MDL	5
Carbon Tetrachloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,2-trichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Dibromomethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
trans-1,3-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
cis-1,3-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,2-trichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Trihalomethanes	< MDL	0.8	< MDL	0.8	< MDL	< MDL	< MDL	100
1,1,2,2-tetrachloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,3-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,1,2-tetrachloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Bromobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,2,2-tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	5
1,2,3-trichloropropane	ND	ND	ND	ND	ND	ND	ND	5
2-chlorotoluene	ND	ND	ND	ND	ND	ND	ND	5
4-chlorotoluene	ND	ND	ND	ND	ND	ND	ND	5
1,3-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
1,2-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
1,2,4-trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	5
1,2,3-trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5
Benzene	ND	ND	ND	ND	ND	ND	ND	5
Toluene	ND	ND	ND	ND	ND	ND	ND	5
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	5
m-xylene	ND	ND	ND	ND	ND	ND	ND	5
p-xylene	ND	ND	ND	ND	ND	ND	ND	5
o-xylene	ND	ND	ND	ND	ND	ND	ND	5
Styrene	ND	ND	ND	ND	ND	ND	ND	5
Isopropylbenezene	ND	ND	ND	ND	ND	ND	ND	5
n-propylbenzene	ND	ND	ND	ND	ND	ND	ND	5
1,3,5-trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	5
tert-butylbenzene	ND	ND	ND	ND	ND	ND	ND	5
1,2,4-trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	5
sec-butylbenzene	ND	ND	ND	ND	ND	ND	ND	5
p-isopropyltoluene	ND	ND	ND	ND	ND	ND	ND	5
n-butylbenzene	ND	ND	ND	ND	ND	ND	ND	5
methyl tert. Butylether	ND	ND	ND	ND	ND	ND	ND	50

Notes:
Analysis for Synthetic Organic Compounds was not required in 1998.
< MDL: Less than the Minimum Detection Limit
*: Water obtained from wells 4, 6,and 7 is treated at the WTP prior to site distribution. The concentration of 1,1,1 trichloroethane in the WTP effluent (F2) met all drinking water standards.

stormwater drywells or small residential cesspools. In 1997, the USEPA cited BNL for not having a complete inventory of UICs. A complete inventory was submitted along with an area-wide permit application in December 1997. During 1998, there were no routine industrial discharges to UICs. BNL is planning to close approximately 58 UICs between 1999 and 2000.

3.7 SPILL PREVENTION, EMERGENCY PLANNING, AND REPORTING

Several federal, state, and local regulations involve the management of storage facilities containing chemicals, petroleum and other hazardous materials that are applicable to BNL. These regulations include specifications for storage facilities, release reporting requirements, and release planning document requirements.

3.7.1 SPILL PREVENTION CONTROL AND COUNTERMEASURES PLAN (SPCC)

BNL must maintain an SPCC Plan as a condition of its Major Petroleum Facility License and the Oil Pollution Act (40 CFR Part 112). This plan is part of BNL's emergency preparedness program and outlines mitigating or remedial actions that would be taken in the event of a petroleum release. The plan also provides information regarding the design of storage facilities, release prevention, and provides maps showing the location of all storage facilities. The SPCC plan was updated in 1998 to include response to chemical releases to meet the requirements of the Chemical Bulk Storage regulations (6NYCRR Part 598). The SPCC Plan is maintained on-file with the NYSDEC, USEPA, and the DOE. BNL demonstrated full compliance with the SPCC requirements in 1998.

3.7.2 EMERGENCY PLANNING AND COMMUNITY RIGHT TO KNOW ACT (EPCRA) AND SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) TITLE III REPORTING REQUIREMENTS

Emergency Planning and Community Right to Know Act (EPCRA) and Title III of the Superfund Amendments Reauthorization Act (SARA) require reporting of inventories and releases to the Local Emergency Planning Committee and the State Emergency Response Commission for certain chemicals that exceed reporting thresholds. BNL fully complied with these requirements in 1998. BNL submitted the required reports under EPCRA Section 302-303, 304, 311-312. In 1998, there were no chemical releases that were subject to release reporting requirements under Section 313.

3.7.3 SPILL RESPONSE, REPORTABLE RELEASES AND OCCURRENCES

If a spill occurs, BNL personnel are required to immediately contact the onsite Fire Rescue Group. The Fire Rescue Group is trained in responding to releases of hazardous materials. The first step in a response would be to contain and control any release, and notify additional response personnel (BNL environmental professionals, industrial hygienists, etc.) The environmental professionals would assess the spill for environmental impact and determine reportability. Any release of petroleum products to soils or surface water is reportable to the NYSDEC and SCDHS. In addition, releases of petroleum products greater than five gallons to outdoor impermeable surfaces or containment areas are also reported. Spills of chemicals in quantities greater than Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) Reportable Quantities (as specified in 40 CFR Part 302.4) are reportable to the National Response Center, NYSDEC, and SCDHS. Remediation of the spill is then conducted as appropriate. As an example, if a piece of heavy equipment ruptured a hydraulic line and there was a release of hydraulic oil to the soil, immediate actions would be taken to stop the leak, and then contaminated soils would be excavated and containerized for offsite disposal.

During 1998, there were 56 spills, of which only 14 met the external agency reporting criteria. Some of these spills were historical releases discovered during construction or other operations (i.e., the release did not necessarily occur in 1998). All spills were remediated to the satisfaction of the NYSDEC, and all contaminated residuals were collected, containerized and disposed. Table 3-8 provides information on the reportable spills, including the date of the spill, material involved, quantity, and includes a summary of the cause and remedial action taken. In addition, the table notes if the spill was reportable through the DOE Occurrence Report Processing System (ORPS). The remainder of the spills were small (typically less than a gallon), and were also immediately cleaned up.

Table 3-8. Summary of Chemical and Oil Spill Reports

Incident #, Date	Material	Quantity	ORPS* Report	Source/Cause; Corrective Actions
98-02 01/20/98	Hydraulic Fluid	< 1 gal.	Yes	Excavation equipment used for an Environmental Restoration job leaked hydraulic fluid. A plastic container was placed beneath the equipment to capture dripping product. The owner of the equipment, which was leased by BNL, repaired the leaking hydraulic hose that day. Contaminated soil was recovered and placed in a drum for offsite disposal.
98-05 1/31/98	Dimethyl Silicone	~ 10 gal.	Yes	A new silicon filled transformer developed a leak when placed into service 01/31/98. The unit was allowed to drain into two 55-gallon drums until the fluid level was below the leak point. There was minor spillage to the soil over the edge of the concrete support pad. All affected soil/gravel was containerized along with absorbent material.
98-06 02/5/98	Roof Coating	< 5 gals.	Yes	During transfer of construction debris into a roll off container, the driver of a front end loader observed a tar-like substance on the soil in the transfer area. Further investigation of the contents in the roll off container suggested that the material came from a five gallon container of Perma Primer™ roof coating that was apparently crushed during transfer activities. Spilled product, contaminated soil and absorbent materials used to prevent migration of product with stormwater runoff were recovered and containerized for offsite disposal.
98-11 02/24/98	Cooling Water	100 gals.	Yes	An outdoor cooling coil developed a leak due to freezing. The cooling water contained tritium at a concentration of 2.5E6 pCi/L. The water was released to a monitored point source discharge (Outfall 002). Monitoring of the discharge showed the effluent contained less than 2.5E3 pCi/L which is approximately 1/8 the of the drinking water standard. The coil was isolated and repaired.
98-13 02/25/98	Hydraulic fluid	~1 quart	Yes	A forklift leaked hydraulic fluid onto gravel in RHIC blockyard. A leaking tilt cylinder was the cause. An oil sheen was observed in shallow puddles following recent rain. Affected soil and gravel were containerized. The forklift was repaired.
98-19 03/30/97	Synthetic Compressor Oil	5 - 15 gal.	Yes	Compressor oil was released from a helium-oil separator on the south side of Bldg. 1005H. The fluid level sight-glass was broken, allowing a release to adjacent soil. Affected soil was removed and containerized for disposal.
98-26 05/19/98	Hydraulic fluid	1 - 2 gal.	Yes	A street sweeping vehicle developed a hydraulic line leak at the intersection of Upton Rd. and Brookhaven Ave. The vehicle came to rest near a storm grate, which was immediately diked off by F/R personnel. Little if any product was believed to have entered the grate. A small area of soil was affected. Absorbent pads and Dry-Zorb™ were applied to area and collected for disposal. The vehicle reservoir was allowed to drain in place (while catching additional product) and was towed to maintenance area for repair.

Table 3-8. Summary of Chemical and Oil Spill Reports *(cont'd.)*

Incident #, Date	Material	Quantity	ORPS* Report	Source/Cause; Corrective Actions
98-29 5/28/98	Process Oil	50 -60 gals.	Yes	While removing backfill material from the Smoke Study Control room associated with the old Bldg. 710 meteorological tower, the backhoe operator discovered oil leaking from an opening in a process tank that was lying on its side. It was estimated that 50 to 60 gallons of an unknown type of oil had leaked from the process tank. Miller Environmental was called in to oversee spill clean-up. The pooled oil and contaminated soil were recovered into drums for offsite disposal.
98-33 07/2/98	Gasoline/Motor Oil	~ 3 gallons	No	A motor vehicle accident occurred involving a sole motorcycle. Extensive damage to the motorcycle resulted in a release of approximately 3 gallons of gasoline and motor oil to the pavement and adjacent soils. Speedi-Dry™ was used to prevent further spillage to soils. All contaminated media was removed and containerized for offsite disposal.
98-41 8/28/98	No. 2 fuel oil	10 gal.	Yes	A contractor over filled a receiving tank with No. 2 fuel oil. The overfill resulted in a spill to the soil of approximately 10 gallons. Speedi-Dry™ was immediately applied to area for gross absorbtion, and the grounds crew containerized affected soil into 55-gallon drums for proper disposal.
98-46 09/29/98	Gasoline	~ 5 gals.	Yes	A contractor punctured the gasoline tank of his car when he backed into a metal stake protruding from the ground outside Bldg. 1008. Fire and Rescue personnel placed a plastic container under the vehicle to prevent further soil contamination as they raised the vehicle off the stake using a pneumatic jack. Approximately five cubic yards of gasoline-contaminated soil were excavated and transferred to a roll-off container for offsite disposal.
98-50 10/6/98	Transformer Oil	< 5 gallons	Yes	During inspection of Bldg. 1007W, an employee noticed oil within a floor drain. Investigation of the floor drain and associated piping using video equipment showed that oil had reached a drywell. Due to overburden, access to the drywell is limited. Remediation to date included removal of standing oil from the floor drain.
98-52 10/20/98	Compressor Oil	< 1/2 gal.	No	While transporting a tray of compressor oil to Bldg. 1005H, the technician dropped the tray, resulting in spillage to soil. Expeditious response limited the spread and quantity of contaminated media. All oil-containing soils were containerized for offsite disposal.
98-56 12/21/98	Diesel Fuel	< 1/2 gallon	No	During replacement of underground fuel oil piping at Building 912A, contaminated soils were discovered. All soils were excavated and placed into a 55-gallon drum for offsite disposal. A discreet source could not be located.

ORPS: Occurrence Reporting Processing System

In addition to the spills noted, there were three other incidents reported through ORPS that were environmental in nature. These included a violation of a Technical Safety Requirement at the Medical Research Reactor, a minor release of hydrogen chloride gas from a small "empty" lecture bottle inside a laboratory, and a continuous air-monitoring false alarm at Building 703. There were no onsite or offsite environmental consequences resulting from these incidents.

3.7.4 MAJOR PETROLEUM FACILITIES (MPF)

BNL is in full compliance with its MPF License requirements. The storage of 2.3 million gallons of petroleum products (principally No. 6 Fuel Oil) subjects BNL to licensing by the NYSDEC (6NYCRR Part 611 and Article 12 of the NYS Navigation Law). The current license was renewed in 1997. The license requires BNL to monitor groundwater in the vicinity of the seven active storage tanks (ranging in size from 60,000 to 600,000 gallons), which are all above-ground. Monitoring consists of monthly checks for floating product, and twice yearly tests for VOCs. No VOCs or floating products were found in the groundwater in 1998. (See Chapter 8 for additional information on groundwater monitoring results).

3.7.5 CHEMICAL BULK STORAGE

All underground tanks, and all aboveground tanks larger than 185 gallons, that store specific chemical substances listed in 6NYCRR Part 597 must be registered with the NYSDEC. In 1998, BNL had a total of nine registered tanks: seven above-ground tanks storing water treatment chemicals (for cooling towers, wastewater or potable water treatment) and two for storing gallium trichloride used in neutrino experiments. The tanks range in size from 475 to 2,000 gallons. As noted above, BNL upgraded the SPCC plan in 1998 to include response to chemical releases from these tanks. BNL is in full compliance with Bulk Storage requirements.

3.7.6 ARTICLE 12

Article 12 of the Suffolk County Sanitary Code, administered by the Suffolk County Department of Health Services (SCDHS) regulates the storage and handling of toxic and hazardous materials in above or underground storage tanks, drum storage facilities, piping systems, and transfer areas. It specifies design criteria to prevent environmental impacts resulting from spills or leaks. It also specifies administrative requirements, like labeling for identification purposes, registration and spill reporting procedures. In 1987, BNL entered into a Memorandum of Agreement with the SCDHS. In this agreement, the DOE and BNL committed to conform to the environmental requirements of Article 12.

There are 542 BNL storage facilities listed in the Suffolk County tanks database. This number includes CERCLA tanks that are not regulated under Article 12. The number also includes tanks that are empty or contain radioactive materials. The database lists active as well as inactive storage tanks and tanks of unknown status (e.g., whether removed or existing). Storage facilities listed in the database include facilities storing fuel (some of which are also regulated under the MPF), wastewater, chemicals and facilities needed to support radiological research.

As of the end of 1998, of the tanks listed in the Suffolk County data base, 13 fully conform with all Article 12 administrative, maintenance and technical requirements. Many of the other tanks require administrative corrective actions (e.g., corrected registrations, submittal of plans to SCDHS, proper labeling, etc.) or maintenance (e.g., replacement of light bulbs). Less than one-quarter of the facilities were found to be in technical non-conformance with Article 12 requirements (e.g. no secondary containment, high level detection etc.). BNL is working with SCDHS to determine the ultimate closure/status of an additional 62 storage facilities.

BNL is working towards achieving full conformance with the technical requirements of Article 12. BNL has an on-going program to upgrade and/or replace existing facilities to conform with these requirements. During 1998, 26 tanks were permanently removed and an additional 31 were upgraded to meet Article 12 technical standards. A new facility constructed at Building 811 provides containment for tankers handling radioactive waste and for portable waste treatment systems. Two new wastewater tanks were installed at Building 801 to replace two indoor tanks of suspect integ-

rity. At the HFBR, upgrades to the buried piping systems were approved and started.

In addition, plans and specifications were submitted to the SCDHS for the upgrade of 30 other storage facilities. These upgrades were in various stages of completeness during 1998. In its continuing commitment to attain conformance with Article 12, the Laboratory is seeking to extend funding for tank improvement projects to fully conform with the MOA requirements.

3.8 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The RCRA regulates wastes which are toxic, ignitable, reactive or corrosive (40 CFR 260-280, and 6NYCRR Parts 370-376). The regulations are designed to ensure that hazardous wastes are managed from "cradle to grave" in a manner that protects human health and safety and the environment. In New York, the RCRA program was delegated to the NYSDEC by USEPA, which still maintains an oversight role.

BNL is considered a large quantity generator, and also has a Treatment and Storage Facility final permit. As noted in Chapter 2, BNL has a number of 90 day storage and satellite accumulation areas. During 1998, BNL was not cited by NYSDEC or USEPA for violations of the hazardous waste requirements. Some compliance issues were noted during BNL internal assessments, and all were documented and promptly corrected.

3.8.1 RCRA/ TOXIC SUBSTANCES CONTROL ACT (TSCA) WASTE MORATORIUM

On May 17, 1991, DOE instituted a waste moratorium directing all their facilities to cease offsite shipments of RCRA/TSCA-regulated wastes that originated in radiologically controlled areas. To address this DOE-wide issue, BNL developed a DOE-approved waste certification program for all nonradioactive RCRA/TSCA wastes generated by BNL. The program uses process knowledge, analytical procedures and standard survey techniques to ensure RCRA/TSCA wastes shipped offsite to nonradioactive disposal facilities are free from radioactivity. Generators of waste are required to document and certify all results associated with the program. The moratorium was fully lifted by DOE in 1995, when BNL received final approval of its waste certification program.

3.8.2 FEDERAL FACILITIES COMPLIANCE ACT (FFCA) SITE TREATMENT PLAN FOR MIXED WASTE

Mixed wastes are wastes that are both hazardous (under RCRA) and radioactive. The FFCA issued in 1992 requires DOE to work with local regulators to develop a Site Treatment Plant to manage mixed waste. Development of the plan had two purposes: to identify available treatment technologies and disposal facilities (DOE or commercial) able to manage mixed waste produced at federal facilities; and to develop a schedule for treatment and disposal of these waste streams.

BNL updates its Site Treatment Plan annually and submits it to the NYSDEC. The update documents the current mixed waste inventory, and describes the efforts that BNL has undertaken to seek new commercial treatment and disposal outlets for various waste streams. One initiative that BNL has supported is DOE's Broad Spectrum Procurement. This initiative will help DOE facilities pool resources to assist in identifying potential mixed waste treatment and disposal outlets. Treatment and disposal outlets approved under the Broad Spectrum Procurement are available for use throughout the DOE complex.

3.9 TOXIC SUBSTANCE CONTROL ACT (TSCA)

The storage, handling and use of PCBs (Polychlorinated Biphenyls) are regulated under the Toxic Substances Control Act. All existing equipment containing PCBs must be inventoried, except small capacitors (less than 1.36 kilograms or 3 lbs) and items where the concentration of the PCB source material is less than 50 ppm. This inventory is updated by July 1st of each year. Capacitors manufactured prior to 1970 that are believed to be oil filled, but where the existence of PCBs can not be verified through an investigation of manufacturer's records, are handled as if they contain PCBs. All PCB articles and/or PCB-contaminated equipment must be labeled. BNL responds to any PCB spill in accordance with emergency response procedures. Several problems were detected during self-assessments, but as of the end of 1998, BNL was in full compliance with TSCA requirements.

3.10 FEDERAL INSECTICIDE FUNGICIDE AND RODENTICIDE ACT (FIFRA)

Pesticide storage and application is regulated under FIFRA. (Note: Pesticides include herbicides.) Most pesticides at BNL are used to control undesirable insects, mice and rats, to control bacteria in cooling towers, and to maintain certain areas (around fire hydrants, inside secondary containment berms) free of vegetation. Pesticides are also applied in agricultural research fields. Pesticide use is minimized wherever possible (e.g., through spot treatment of weeds). All pesticides are applied by NYS certified applicators. By February 1, each applicator files an annual report with the NYSDEC detailing pesticide use for the previous year. BNL is in full compliance with FIFRA requirements.

3.11 FLOODPLAINS/WETLANDS AND WILD AND SCENIC RECREATIONAL RIVERS AND OTHER SPECIAL PERMITS

As noted in Chapter 1, portions of the BNL site are situated on the Peconic River floodplain. The Peconic River is listed as a Wild and Scenic River by NYSDEC. BNL also has six major areas regulated as wetlands, and a number of vernal (seasonal) pools onsite. Construction and/or modification activities performed within these areas require permits from the NYSDEC.

Activities that could require review under these programs are identified during the NEPA process. In the preliminary design stages of a construction project, design details required for the permit application process are specified. These design details ensure that the construction activity will not negatively impact the area, or if it does, that the area will be restored to its original condition. When design is near completion, permit applications are filed. During and after construction, BNL must comply with the permit conditions.

Two activities were conducted in 1998 that required special permits. The first project was the construction of pumping stations for conveying sanitary waste and stormwater from RHIC facilities to the central collection system. In July, an application was submitted under the Long Island Wells permit program for dewatering in the RHIC area. Localized dewatering was necessary to permit construction of the pumping stations. This permit was issued and all pump stations installed in 1998. The second project involved the installation of a geomembrane and soil shielding at the RHIC ten o'clock station. This application was a request to renew a previously issued permit for RHIC construction. This permit was pending at the close of 1998.

During December of 1998, BNL experienced one incidence of noncompliance with these requirements. The request to renew a permit for construction in the northwest section of the Peconic River had been submitted to the NYSDEC in early December 1998. However, construction was initiated prior to receiving the renewal. As soon as this was realized, the work was immediately stopped, the DOE and NYSDEC were notified, and an investigation was initiated to determine the root cause of this problem. Construction will not be allowed to recommence until the renewed permit is received.

3.12 ENDANGERED SPECIES

One NYSDEC listed endangered species is found at BNL — the tiger salamander (Ambystoma tigrinum). Tiger salamanders are listed in NYS as endangered because populations have declined as a result of loss of habitat through development, road mortality during breeding migration, introduction of predatory fish into breeding sites, collection for bait and pet trade, water level fluctuations, pollution and general disturbance of breeding sites. BNL is preparing a Wildlife Management Plan to formalize the strategy and actions needed to protect the 13 confirmed tiger salamander breeding locations onsite. The strategy includes identifying and mapping habitats, monitoring, improving breeding sites, and controlling activities that could impact breeding.

The banded sunfish (Enneacanthus obesus) is also found in the Peconic River onsite at BNL. The banded sunfish has a "Special Concern" status within NYS. The reason for this status is that the only remaining population of the banded sunfish is located in eastern Long Island. Measures being taken by BNL to protect the banded sunfish and its habitat include:

- eliminating, reducing or controlling pollutant discharges,
- upgrading the STP to reduce nitrogen loading in the Peconic (completed in 1998),

- monitoring,
- maintaining adequate flow in the river and creating deep pools to enable the fish to survive drought,
- controlling disturbances, and
- culling predator species during sampling activities.

3.13 EXTERNAL AUDITS/OVERSIGHT

A number of federal, state and local agencies oversee BNL activities. BNL also has a comprehensive Self-Assessment program as described in Section 2.2.1.1of Chapter 2.

3.13.1 INSPECTIONS BY REGULATORY AGENCIES

In 1998, BNL was inspected by federal, state or local regulators on at least eight occasions. These inspections are summarized below.

Hazardous Waste

NYSDEC conducted a RCRA/hazardous waste compliance inspection in June-July 1998. No notification of noncompliance was received in 1998 as a result of this inspection .

Air Compliance

There were no air compliance inspections in 1998.

Potable Water

SCDHS conducts annual inspections of the BNL potable water system to collect samples and ensure that facilities are maintained. There were no findings, and all sample results were below Drinking Water Standards, except for iron, which is naturally occurring. As noted above in Section 3.7.1, BNL treats the drinking water supply prior to consumption to remove iron.

Sewage Treatment Plant (STP)

SCDHS conducts quarterly inspections of the BNL STPs. SCDHS deficiencies included finalization of an Operations Manual (completed in September), and a concern about the high-level alarm on the emergency generator (scheduled for repair in 1999).

NYSDEC was onsite July 8 evaluating Dissolved Oxygen levels at the STP and downstream in the Peconic in response to a fish kill at Donahue's Pond. Fish can suffocate when dissolved oxygen levels are too low. DEC found that dissolved oxygen levels were 16 times higher at the STP (8 ppm) compared to downstream offsite locations (0.5 ppm), indicating that the fish kill was not associated with BNL discharges.

3.13.2 DEPARTMENT OF ENERGY (DOE)

DOE staff from Headquarters, Chicago and the local Brookhaven Group (BHG) area office also oversee BNL activities. DOE-Headquarters conducted an Integrated Safety Management Assessment in 1998. The follow-up review focused on areas identified during the 1997 Integrated Safety Management evaluation as having significant weaknesses. They noted that BNL had made significant progress in work planning and control initiatives, and in groundwater protection and restoration activities. They also noted that DOE had taken a number of positive initiatives to improve oversight and assessment programs. Environmental Safety and Health and Operational documents were formalized to define the BHG oversight strategy and clarify roles and responsibilities. BHG had increased their presence and involvement in monitoring operations and conducted formal assessments of BNL

DOE-Chicago: In 1998, DOE-Chicago requested that Horne Engineering conduct an evaluation of the groundwater monitoring program at BNL. The report listed improvements needed in database integration, data validation, quality assurance documentation and procedures. All of these items had already been identified in BNL groundwater plans and were being addressed. DOE-Chicago also evaluated compliance with Title V and emergency planning for air releases for the CAA, and no compliance issues were identified. In late 1998, DOE Chicago also conducted an evaluation of the on-going EMS project, and made several recommendations for improvement.

DOE-BHG: DOE was in the process of strengthening their oversight program during 1998. An evaluation was conducted of CWA compliance, and no issues were identified. BHG also conducted a review of progress made in improving the NESHAPs compliance program, with several issues identified regarding confirmatory monitoring for small sources. BHG also evaluated the groundwater program.

3.13.3 ENFORCEMENT ACTIONS AND MOA'S

No new enforcement actions were issued to BNL in 1998. In 1997, USEPA proposed a Consent Order with a proposed penalty as a result of a multi-media compliance inspection conducted in 1997. Negotiations on the terms

of this Order continued in 1998. In 1997, USEPA had also issued a proposed Administrative Order on UIC compliance, and a Notice of Violation for CAA issues and TSCA violations. All USEPA requested information was submitted in 1997. There were no further activities related to these issues in 1998.

USEPA and DOE signed a voluntary Memorandum of Agreement (MOA) on March 23, 1998. (See Chapter 2 for a discussion of the MOA.) During 1998, BNL was in full compliance with the terms of the MOA.

All existing enforcement actions and Memorandums of Agreement are listed in Table 3-9, along with a summary of their status.

Table 3-9. Existing Agreements and Enforcement Actions Issued to BNL with Status

Number	Title	Parties	Effective Date	Status
Not Applicable	Federal Facilities Compliance Agreement (FFCA) on mixed waste	NYS DEC And DOE	1992	The FFCA requires that a Site Treatment Plan (STP), which a plan to manage mixed wastes, be written and updated annually. BNL is in compliance with this requirement.
Docket No. I-RCRA-98-0202	EPA Administrative Order (regarding compliance with RCRA requirements)	DOE and EPA	02/25/98	As a result of negotiations between EPA and BNL representatives, BNL agreed to conduct several Supplemental Environmental Projects (SEPs) to settle the complaint. Those SEPs were initiated in 1998.
Index No. 113-98-01	Compliance Order Clean Air Act	EPA and DOE	02/24/98	BNL, DOE and EPA met in May 1998 to review and clarify the issues presented in this order. Documentation necessary to support Laboratory operations was submitted to the USEPA prior to the issuance of the order. There was no further activity in 1998.
Not Applicable	Notice of Non-compliance (under TSCA)	EPA and DOE	02/12/98	All required information was submitted to EPA on 10/6/98; WMD will be implementing their revised Hazardous Waste Control Form in 1999.
Docket No. UIC-AO-98-01	Administrative Order on Consent - Safe Drinking Water Act	EPA and DOE	3/4/98 (date of receipt by DOE)	A meeting was held with the USEPA in May 1998 to review the Order, associated deliverables and an application for an Area Permit that was filed in December 1997. There were no further actions in 1998.
I-CERCLA-FFA-00201	Federal Facility Agreement under CERCLA Section 120 (Also known as the Interagency Agreement, or "IAG" on the Environmental Restoration program).	EPA, DOE, and NYS DEC	05/26/92	Provides the framework, which includes schedules, for assessing the extent of contamination and conducting the BNL clean-up. Work is performed either as an operable unit or removal action. The IAG integrates the requirements of CERCLA, RCRA, and NEPA. All IAG scheduled milestones were met in 1998.
Not Applicable	Suffolk County Agreement	SCDHS, DOE and BNL	Originally signed on 9/23/87	This Agreement was formalized to ensure that the storage and handling of toxic and hazardous materials at BNL is consistent with the technical requirements of the County Codes. The Agreement is being renegotiated to clarify and update the terms.
Not Applicable	Memorandum of Agreement (MOA) by and between the Environmental Protection Agency and the United States Department of Energy	EPA and DOE	03/23/98	BNL is currently in full compliance with the terms of the MOA. See Chapter 2 for further discussion.

Concepts of Radioactivity

CHAPTER 4

This chapter introduces some of the basic concepts of radioactivity. It is designed to provide the general reader with an overall understanding of the radiological sections of this report. Radiation-related terms and definitions are provided, along with a discussion of the analyses used to quantify radioactive material, the common sources of radioactivity in the environment, and how each contributes to an individual's radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides of environmental interest on the BNL site.

4.1 RADIOACTIVITY

The atom is the basic constituent of all matter and is one of the smallest units into which matter can be divided. Each atom is composed of a tiny central core of particles, or nucleus, surrounded by a cloud of negatively charged particles called electrons. Most atoms in the physical world are stable, meaning that they are not radioactive. However, some atoms posses excess energy which causes them to be physically unstable. In order to become stable, an atom rids itself of this extra energy by casting it off in the form of charged particles or electromagnetic waves, known as *radiation*. The three most important types of radiation are described below.

4.2 COMMON TYPES OF RADIATION

ALPHA An alpha particle is identical in make-up to the nucleus of a helium atom. Alpha particles have a positive charge, and have little or no penetrating power in matter. They are easily stopped by materials such as paper and have a range in air of only an inch or so. Naturally occurring radioactive elements such as radon emit alpha radiation.

BETA Beta radiation is composed of particles which are identical to electrons. As a result, beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha, but may be stopped by materials such as aluminum foil. They have a range in air of a few inches. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

GAMMA Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete. X-rays are essentially a form of gamma radiation.

4.3 NOMENCLATURE

Throughout this report, radioactive elements (also called radionuclides) are referred to by a name followed by a number, e.g., potassium-40. The number following the name of the element is called the mass of the element and is equal to the total number of particles contained in the nucleus of the atom. Another way to specify the identity of potassium-40 is by writing it as K-40, where 'K' is the chemical symbol for potassium as it appears in the standard Periodic Table of the Elements. This type of abbreviation is used in many of the data tables in this report.

4.4 DOSE UNITS

The amount of energy that radiation deposits in body tissue, when corrected for human risk factors, is referred to as *dose equivalent* or, more generally, as *dose*. Radiation doses are measured in units of *rem*. Since the rem is a fairly large unit, it is convenient to express most doses in terms of millirem (1,000 mrem = 1 rem). To give a sense of the size and importance of a 1 mrem dose, Figure 4-1 indicates the number of mrem received by an individual in one year from natural and background sources. These values represent typical values for residents of the United States. Note that the alternate unit of dose measurement commonly used internationally and increasingly in the United States is the *sievert*, abbreviated Sv. One Sv is equivalent to 100 rem. Likewise, 1 millisievert (mSv) is equal to 100 mrem.

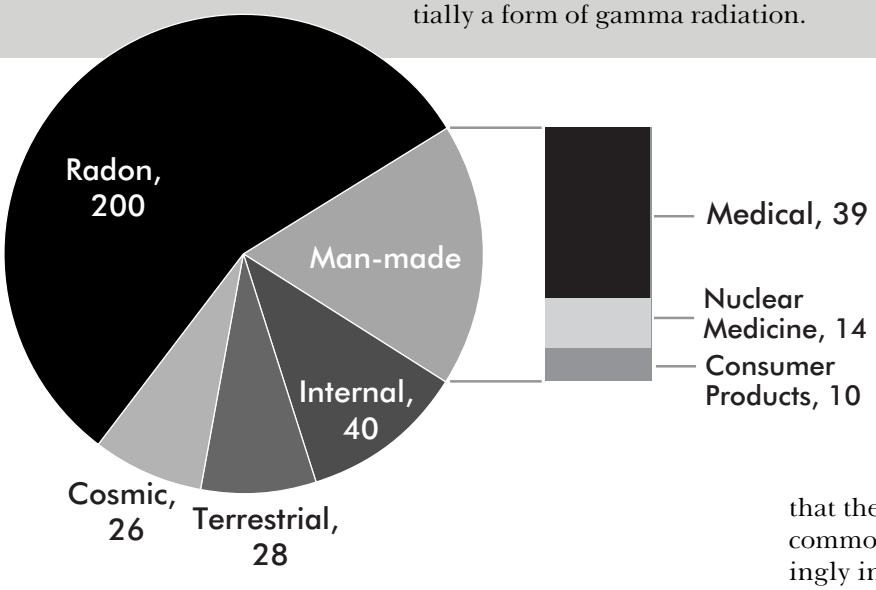

Figure 4-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem)
Source: NCRP Report No. 93.

4.5 SOURCES OF RADIATION

Radioactivity and radiation are part of the earth's natural environment. Human beings are exposed to radiation from a variety of common sources, the most significant of which are listed below.

COSMIC Cosmic radiation primarily consists of charged particles which originate in space, beyond the earth's atmosphere. This includes radiation from the sun and secondary radiation generated by the entry of charged particles into the earth's atmosphere at high speeds and energies. Radioactive elements such as hydrogen-3 (tritium), beryllium-7, carbon-14, and sodium-22 are produced in the atmosphere by cosmic radiation. The average dose from cosmic radiation to a person living in the United States is about 26 mrem per year.

TERRESTRIAL Terrestrial radiation is released by radioactive elements present in the soil since the formation of the earth about five billion years ago. Common radioactive elements contributing to terrestrial exposure include isotopes of potassium, thorium, actinium, and uranium. The average dose from terrestrial radiation to a person living in the United States is about 28 mrem per year.

INTERNAL Internal exposure occurs when radionuclides are ingested, inhaled, or absorbed through the skin. Radioactive material may be incorporated into food through the uptake of terrestrial radionuclides by plant roots. Human ingestion of radionuclides can occur when plant matter or animals that consume plant matter are eaten. Most exposure to inhaled radioactive material results from breathing the decay products of naturally-occurring radon gas. The average dose from eating foods to a person living in the United States is about 40 mrem per year; the average dose from radon product inhalation is about 200 mrem per year.

MEDICAL Millions of people every year undergo medical procedures which utilize radiation. Such procedures include chest and dental x-rays, mammography, thallium heart stress tests, tumor irradiation therapies and many others. The average dose from x-ray examinations and nuclear medicine procedures in the United States is about 39 and 14 mrem per year, respectively.

ANTHROPOGENIC Sources of anthropogenic (man-made) radiation include consumer products such as static eliminators (containing polonium-210), smoke detectors (containing americium-241), cardiac pacemakers (containing plutonium-238), fertilizers (containing isotopes of the uranium and thorium decay series), tobacco products (containing polonium-210 and lead-210) and many others. The average dose from consumer products to a person living in the United States is 10 mrem per year.

4.6 TYPES OF RADIOLOGICAL ANALYSIS

The quality of environmental air, water and soil with respect to radioactive material can be assessed using several types of analysis. The most common analyses are described as follows.

GROSS ALPHA	Alpha particles are emitted in a range of different energies. An analysis which measures all alpha particles simultaneously, without regard to their particular energy, is known as a gross alpha activity measurement. This type of measurement is valuable as a screening tool to indicate the magnitude of alpha-emitting radionuclides that may be present in a sample.
GROSS BETA	This is the same concept as described above, except that it applies to the measurement of beta particle activity.
TRITIUM	Due to the nature of the radiation emitted from the tritium atom, a special analysis known as liquid scintillation counting is required to quantify it. See Section 4.10.2 for further details.
STRONTIUM-90	Due to the nature of radiation emitted by strontium-90, a special analysis is required. Samples are chemically processed to separate and collect any strontium atoms which may be present. The collected atoms are then analyzed separately.
GAMMA SPECTROSCOPY	This analysis technique identifies specific radionuclides. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each nuclide, acting as a 'fingerprint' to identify a specific nuclide.

The unit used to express the quantity of radioactive material in a sample is the *curie*, abbreviated Ci. This is a measure of the rate at which radioactive atoms are transformed to stable atoms. Since the curie is a relatively large unit for measuring environmental samples, the *picocurie* (pCi) is often used. This unit is equal to one trillionth of a curie, or 0.037 decays per second. The alternate unit for quantifying radioactivity is the becquerel, abbreviated Bq. One Bq is equal to 1 decay per second.

4.7 STATISTICS

4.7.1 UNCERTAINTY

Because the emission of radiation from an atom is a random process, a sample counted several times will yield a slightly different result each time; single measurement is, therefore, not definitive. To account for this phenomenon, the concept of uncertainty is applied to radiological data. Each individual analysis result is shown in this report in the format of $x \pm y$, where x is the result and $\pm y$ is the 95 percent confidence interval of the result. That is, there is a 95 percent probability that the true value of x lies between $x + y$ and $x - y$. Conversely, there is a 5 percent probability that the true value of x lies outside of this range.

4.7.2 NEGATIVE VALUES

Since natural radiation is present everywhere, uncontaminated environmental media such as soil, air and water will show some degree of radioactivity. This has to be taken into consideration when analyzing a potentially contaminated sample. There must be a reasonable assurance that natural background radiation is not mistaken for contamination in an unknown sample. To address this, an instrument background is established prior to each unknown sample analysis. This is an analysis of a sample which is composed of the same material as the unknown, but which is known to be clean. When measuring the very small amounts of radioactive material typically encountered in environmental media, where only a few radiation events are counted, it is common for the sample result to be less

than the instrument background. When the background is subtracted, a negative net value results, signifying that the sample contains no added radioactive material.

4.8 SCIENTIFIC NOTATION

Since many of the numbers used in measurement and quantification in this report are either very large or very small, many zeroes are required to express their value. Because this is inconvenient, scientific notation is used as a kind of numerical shorthand. Scientific notation is based on the principle of representing numbers in multiples of ten. For example, the number one million could be written as 1,000,000. Alternatively, this number could be written in scientific notation as 1×10^6. That is, "one times ten raised to the sixth power." Since even this shorthand can be cumbersome, it can be reduced even further by using the capital letter E to stand for 10^x, or "ten raised to the power of some value *x*." Using this notation, 1,000,000 would be represented as 1E6. Scientific notation is also used to represent very small numbers like 0.0001, which can be written as 1×10^{-4} or 1E-4. This notation is used in some tables in this report.

4.9 PREFIXES

Another method of representing very large or very small numbers without the use of many zeroes is to use prefixes to represent multiples of ten. For example, the prefix *milli-* means that the value being represented is one thousandth of a whole unit, so that one milligram is equal to one thousandth of a gram. Other common prefixes used in this report are shown in Table 1.

4.10 RADIONUCLIDES OF ENVIRONMENTAL INTEREST

4.10.1 STRONTIUM-90

Strontium-90 is a beta-emitting radionuclide with a half-life of 28 years (i.e., after 28 years only one half of the activity from the original remains). It is found in the environment principally as a result of *fallout* from above ground nuclear weapons testing. (Fallout refers to the deposition of radionuclides on soils and water bodies as a result of being dispersed high into the earth's atmosphere during nuclear explosions.) Strontium-90 released in the 1950's and early 1960's is still present in the environment today due to its lengthy half-life. Additionally, nations which were not signatories of the Nuclear Test Ban Treaty of 1963 have conducted tests which have contributed to the global strontium-90 inventory. This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

The data in the environmental report are reported by method of analysis. Because strontium-90 requires a unique method of analysis, it is reported as a separate parameter in this report's data tables. The level of sensitivity for detecting strontium-90 using state of the art analysis methods is quite low (less than 1 pCi/L), which makes it possible to detect strontium-90 at levels which are indicative of the environmental sources described above.

No processes on the BNL site actively release strontium-90 as part of their operation. When strontium-90 is detected onsite at levels above those associated with fallout and other background sources, it is due to historic landfill practices of the 1950s and 60s or to the former

Table 4-1. Common Measurement Unit Prefixes

Prefix	Multiplier		Prefix	Multiplier	
milli (m)	1×10^{-3}	1E-3	kilo (k)	1×10^{3}	1E3
micro (μ)	1×10^{-6}	1E-6	mega (M)	1×10^{6}	1E6
nano (n)	1×10^{-9}	1E-9	giga (G)	1×10^{9}	1E9
pico (p)	1×10^{-12}	1E-12	tera (T)	1×10^{12}	1E12

operation of the Brookhaven Graphite Research Reactor, which was permanently shut down in 1968.

4.10.2 TRITIUM

Among the radioactive materials that are used or produced at Brookhaven National Laboratory, tritium has received the most public attention. Tritium exists in nature and is formed when cosmic radiation from space interacts with the gaseous nitrogen in the earth's upper atmosphere. Approximately 4 million Ci (1.5E5 TBq) per year are produced in the atmosphere in this way, with the total global quantity being about 70 million Ci (2.6E6 TBq) at any given time (NCRP, 1979). As a result of the 1950's and early 1960's above ground weapons testing program, the global atmospheric tritium inventory was increased by a factor of about 200. Other human activities such as consumer product manufacturing and nuclear power reactor operations have also released tritium into the environment. Commercially, tritium is used in such products such as self-illuminating exit signs and wrist watches (exit signs may contain as much as 25 Ci [925 GBq] of tritium). It also has many uses in medical and biological research as a labeling agent in chemical compounds and is frequently used in universities and other research settings.

Of the sources mentioned above, the most significant contributor to tritium in the environment has been above-ground nuclear weapons testing. In the early 60s, the average tritium concentration in surface streams in the United States reached a value of 4,000 pCi/L (148 kBq/L) (NCRP, 1979). Approximately the same concentration was measurable in precipitation. Today, the level of tritium in surface waters in New York State is below 200 pCi/L (7.4 kBq/L) (NYSDOH, 1993), less than the detection limit of most analytical laboratories.

Tritium has a half-life of 12.3 years. When an atom of tritium decays, it releases a beta particle, causing transformation of the tritium atom into stable (non-radioactive) helium. This beta radiation is of a very low energy when compared to the emissions of other radioactive elements and it is easily stopped by the body's outer layer of dead skin cells; only when taken into the body can tritium cause an exposure. Because of it's low energy radiation and short residence time in the body, the health threat posed by tritium is very small for most credible exposures.

Environmental tritium is found in two forms: gaseous elemental tritium and tritiated water (or water vapor), in which at least one of the hydrogen atoms in the H_2O water molecule has been replaced by a tritium atom. Hence, its short hand notation *HTO*. All tritium released from BNL sources is in the form of HTO.

4.10.3 CESIUM-137

Cesium-137 is a man-made, fission-produced radionuclide with a half-life of 30 years. It is found in the environment as a result of past above-ground nuclear weapons testing and can be observed in the upper levels of environmental soils at very low concentrations, usually less than 1 pCi/g (0.04 Bq/g). It is a beta-emitting radionuclide, but can be detected by gamma spectroscopy by the gamma emissions of its decay product, barium-137m.

4.11 DEFINITION OF RADIOLOGICAL TERMS

The following terms are used throughout this report where radiation and radioactive material are discussed:

ACTIVATION	The process by which a non-radioactive material is made radioactive through exposure to a field of neutrons or high energy particles.
ACTIVATION PRODUCT	An element which has become radioactive through the process of activation.
ACTIVITY	Synonym for radioactivity.

ANTHROPOGENIC RADIONUCLIDES	Radionuclides produced as a result of human activity, i.e., man-made.
BACKGROUND RADIATION	Radiation present in the environment as a result of naturally-occurring radioactive materials, cosmic radiation, or man-made radiation sources, including fallout.
BECQUEREL	A quantitative measure of radioactivity, abbreviated Bq. This is an alternate measure of activity used internationally and with increasing frequency in the United States. One Bq of activity is equal to one nuclear decay per second. All references to quantities of radioactive material in this report are made in curies, followed in parentheses by the equivalent in Bq.
DECAY PRODUCT	A nuclide resulting from the radioactive disintegration of a radionuclide, being formed either directly or as a result of successive transformations in a radioactive series. A decay product may be either radioactive or stable.
DERIVED CONCENTRATION GUIDE (DCG)	The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g. air inhalation/immersion, water ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The values have been established by DOE in Order 5400.5, "Radiation Protection of the Public and the Environment".
CURIE	A quantitative measure of radioactivity, abbreviated Ci. One Ci of activity is equal to 3.7×10^{10} decays per second.
EFFECTIVE DOSE EQUIVALENT	A normalized value which allows the risk from radiation exposure received by a specific organ or part of the body to be compared with the risk due to whole body exposure. It is equal to the sum of the doses to different organs of the body multiplied by their respective weighting factors.
EFFLUENT	Any liquid discharged to the environment.
EMISSION	Any gaseous discharge to the atmosphere.
FALLOUT	Radioactive material made airborne as a result of above-ground nuclear weapons testing that has been deposited on the earth's surface.
HALF-LIFE	The time required for the activity of a radioactive sample to be reduced by one half.
MDL	Minimum Detection Limit. This is the lowest level to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDL are sometimes measurable, they represent values which have a reduced statistical confidence associated with them (less than 95 percent confidence).

NUCLIDE	A species of atom characterized by the number of protons and neutrons in the nucleus.
RADIOACTIVE SERIES	A succession of nuclides, each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member of the series is called the parent, and the intermediate members are called daughters or progeny.
RADIOACTIVITY	The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic wave from the atom. Also known as activity.
RADIONUCLIDE	A radioactive atom.
REM	The unit by which human radiation exposure is assessed. This is a risk-based value used to estimate the potential health effects to an exposed individual or population.
SIEVERT	The alternate unit for assessing the risk of human radiation exposure, used internationally and with increasing frequency in the United States, is the sievert, abbreviated Sv. One sievert is equal to 100 rem.
SPALLATION	The process by which a high energy particle striking a nucleus causes fragments to be ejected from the nucleus. The resulting atom is usually radioactive.
STABLE	Non-radioactive.
TLD	Thermolumi-dosimeter. A device used to measure radiation exposure to occupational workers or radiation levels in the environment.

Air Quality

CHAPTER 5

To monitor facility operations and ensure compliance with the federal Clean Air Act, Brookhaven National Laboratory (BNL) performs continuous air emission sampling at several facilities. In addition to facility emission monitoring, environmental air sampling is conducted to verify local air quality. Total radiological and regulated, nonradiological air releases for 1998 are tabulated in this chapter. Ambient radiological air quality data collected at various onsite locations are also summarized.

The most significant contributors to radioactive air emissions from the BNL site were the Brookhaven Medical Research Reactor (BMRR), the High Flux Beam Reactor, and the Brookhaven Linac Isotope Producer. Over the course of 1998, a total of 2,455 Ci (91 TBq) of airborne radioactive material was released from these facilities. Releases of gaseous argon-41 from the BMRR accounted for 96 percent of this total. Total radionuclide emissions were consistent with those of recent years.

Conversion of three boilers at the Central Steam Facility to dual-fuel (oil/natural gas) firing capability allowed an increase in the use of natural gas with associated declines of 11 tons of particulate matter, 8.5 tons of nitrogen oxides (NO_x), and 66.2 tons of sulfur dioxide (SO_2) from 1997 levels.

5.1. AIRBORNE EMISSIONS - RADIOACTIVE

Federal air quality laws and Department of Energy (DOE) regulations governing the release of airborne radioactive material include 40 CFR 61 (Subpart H, the National Air Emission Standards for Hazardous Air Pollutants or NESHAPs), and DOE Orders 5400.1, General Environmental Protection Program, and 5400.5, Radiation Protection of the Public and the Environment. Under NESHAPs, a section of the federal Clean Air Act (CAA), facilities whose emissions have the potential to deliver a radiation dose of greater than 0.1 mrem/yr (1 μSv/yr) to a member of the public must be continuously monitored. Those facilities which fall below this value require only periodic, confirmatory monitoring. Annual emissions are discussed in the following sections and associated dose calculations are presented in Chapter 9. Figure 5-1 indicates the location of each of the monitored facilities within the BNL site.

5.1.1. BROOKHAVEN MEDICAL RESEARCH REACTOR (BMRR)

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 and a high efficiency particulate air (HEPA) filter to remove any particulate matter, and finally, a charcoal filter for the

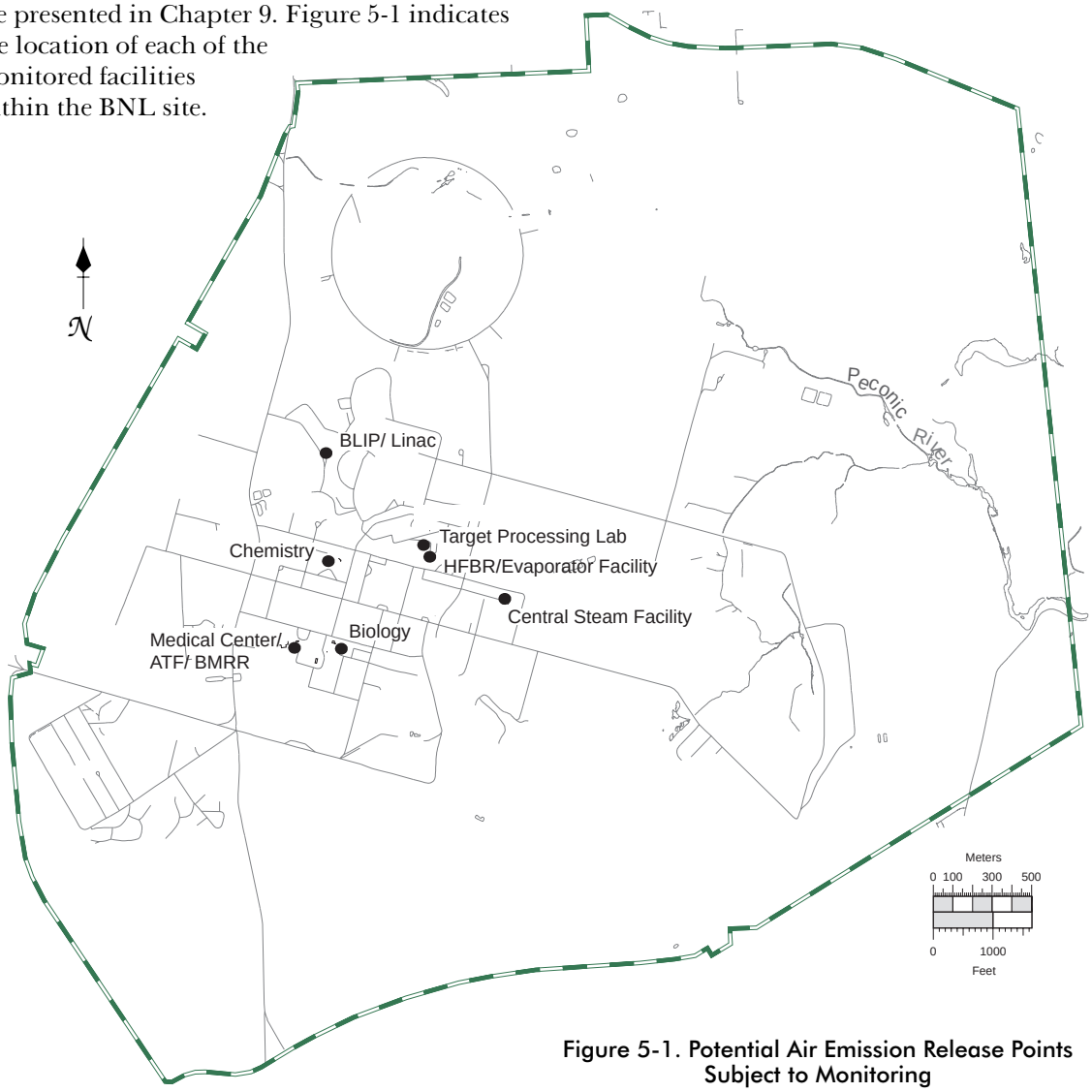

Figure 5-1. Potential Air Emission Release Points Subject to Monitoring

removal of radioiodines produced by the fissioning of fuel. Following the filter bank, the air is exhausted to a 46 meter (150 ft) stack adjacent to the reactor containment building.

A real time monitor is in place to track argon-41 air emissions, while passive filter media are used to collect and quantify radioiodines and particulates. Because non-argon radionuclide concentrations in the air emissions are of a much lower concentration and total activity, they contribute less than 10 percent of the total public dose resulting from the BMRR's air emissions. In accordance with NESHAPs, these nuclides are sampled only on a periodic basis to confirm that their concentrations remain consistent with expected levels. Therefore, annual release totals for these nuclides are not included in this report.

In 1998, the BMRR released 2,359 Ci (87 TBq) of argon-41 to the atmosphere. This value is consistent with this facility's emissions totals for previous years. Argon-41 consistently constitutes the greatest fraction of all radionuclide activity released from the BNL site.

5.1.2 HIGH FLUX BEAM REACTOR (HFBR)

The HFBR is capable of operating at power levels ranging from 30 to 60 MW (thermal).

Heavy water is used 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 non-radioactive isotope of hydrogen known as *deuterium*.) Heavy water flowing in the reactor 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 is dependent upon the reactor power level and the amount of time elapsed since the last reactor shutdown or coolant change out. This, in turn, determines the amount of tritium which may eventually be released as an airborne emission. 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 operations. Diffusion at valve seals and other fittings also occurs. Tritiated water vapor (abbreviated "HTO") is thus released from reactor systems to building air where it is routed to the facility's 98 meter (320 ft) stack. Concentrations of HTO in air emissions are determined by the use of an integrating silica gel absorbent.

The HFBR has been in a stand-by mode since January 1997 following the discovery of an underground plume of tritium emanating from the spent fuel storage pool. This pool was drained in December 1997 to prevent additional leakage as well as to facilitate repairs. Though the HFBR did not operate in 1998, the reactor vessel remained filled with D_2O containing 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 1998, 37 Ci (1.4 TBq) of airborne HTO were released from the HFBR (see trend plot shown in Figure 5-2).

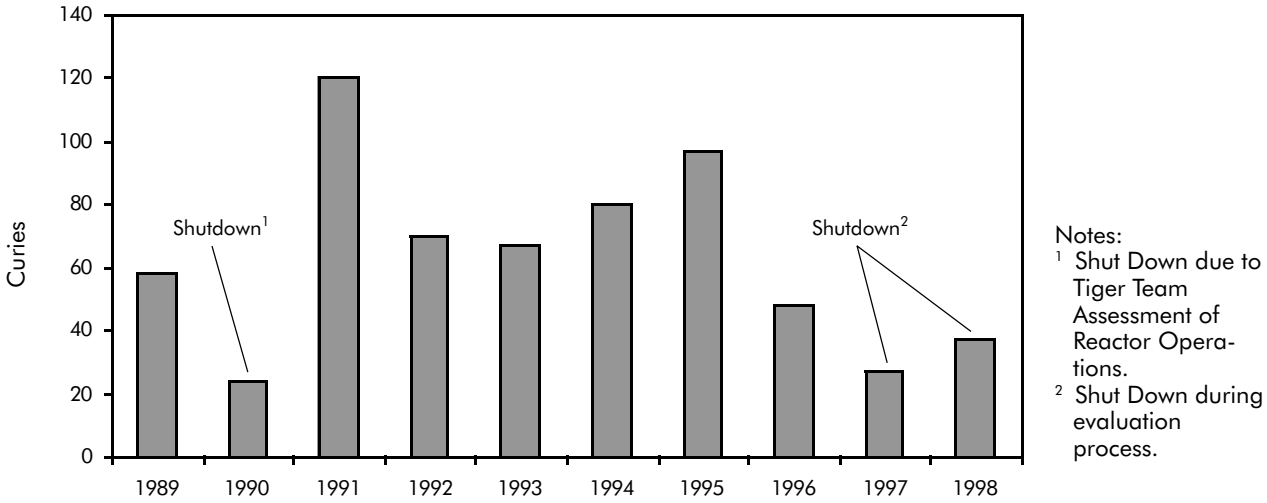

Figure 5-2. HFBR Airborne Tritium Emissions, 10 Year Trend

5.1.3. BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP)

Protons from the Linear Accelerator (Linac) are sent via an underground beam tunnel to the BLIP where they strike various target metals. These metals, which become activated by the proton beam, are then transferred to the Building 801 Target Processing Laboratory for later use in radiopharmaceutical production. The targets are cooled by a continuously recirculating water system. During irradiation, several radioisotopes are produced in the 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 emission. A total of 58 Ci (2.1 TBq) of oxygen-15 was released as an airborne emission in 1998. Other radionuclides such as tritium and germanium-69 were released in much smaller quantities. See Table 5-1 for a complete listing.

5.1.4. EVAPORATOR FACILITY

The Building 802 Evaporator Facility was constructed to reduce the total amount of HTO water released to the Peconic River from BNL operations. Since the proposal followed the promulgation of NESHAPs, the facility was evaluated for compliance with the Rule prior to construction. Following submission of an application to construct the facility, formal approval from the United States Environmental Protection Agency (USEPA) Region II was awarded. Wastewater processing began in 1995.

Liquid waste generated onsite which contains residual radioactive material is processed at the Building 811 Waste Concentration Facility (WCF). At the WCF, suspended solids and a high percentage of radionuclides are removed from the liquid using a reverse osmosis process. However, because of its chemical properties, tritium is not removed during this process. The HTO water which remains following waste concentration is delivered to the Evaporator Facility where it is converted to steam and released as an airborne emission. This method is preferable to release via surface water because (1) there is virtually no potential to influence the groundwater aquifer, and (2) the potential for this tritium to contribute to an offsite dose is minimized by atmospheric dispersion. The emission is directed to the same stack used by the HFBR for building air exhaust. In 1998, 2.2 Ci (81 GBq) of HTO were released as an airborne emission from the Evaporator Facility.

Since the waste concentration process does not remove all other radionuclides with complete efficiency, radionuclides other than tritium are released at much lower activity levels (see Table 5-1 for a listing). The activity values listed in the table are estimated since facility emissions are tracked by an inventory system. Liquid shipments to the Evaporator Facility are sampled and analyzed prior to delivery to determine actual radionuclide concentrations. The total emissions for a water tanker delivery are calculated by computing

Table 5-1. Airborne Radionuclide Releases from Monitored Facilities

Facility	Nuclide[1]	Half-life[2]	Ci-Released[3]
BMRR	Ar-41	1.8 h	2.36E+03
Bldg. 801	As-74	18 d	9.38E-06
	Br-77	57 h	7.81E-05
	Cs-137	30 y	7.33E-07
	F-18	110 m	1.74E-01
	Ga-68	68 m	1.33E-01
	Ge-69	36 h	1.37E-04
	Rb-86	18.6 d	2.36E-05
	Se-75	120 d	6.74E-07
HFBR	Be-7	53 d	1.21E-07
	Cs-137	30 y	1.25E-07
	V-48	16 d	3.48E-08
	H-3	12.3 y	3.73E+01
BLIP	O-15	2 m	5.77E+01
	H-3	12.3 y	7.46E-03
	Be-7	53 d	9.97E-06
	Ge-69	36 h	1.33E-04
	Rb-86	18.6 d	1.55E-05
Evaporator Facility	Co-56	79 d	1.94E-05
	Co-57	271 d	6.71E-05
	Co-58	71 d	4.07E-05
	Co-60	5.2 y	1.44E-06
	Cs-137	30 y	2.68E-06
	Ga-66	9.4 h	7.31E-05
	H-3	12.3 y	2.18E+00
	Mn-54	312 d	2.48E-06
	Rb-83	86 d	7.46E-05
	Zn-65	244 d	8.02E-05

Notes:
1. While other nuclides are released from the BMRR, none contribute more than 10% of the total public dose due to BMRR air emissions. See text for discussion.
2. Half-life abbreviations:
   m = minutes
   h = hours
   d = days
   y = years
3. 1 Ci = 3.7×10^{10} Bq.

the product of the concentration and the total volume evaporated. This method is very conservative since some fraction of the chemically reactive radionuclides bind to the interior surfaces of the boiler system; hence, airborne releases and projected doses from this facility are most likely overestimated.

5.1.5. BUILDING 801 TARGET PROCESSING LABORATORY

Target metals which have been irradiated at the BLIP facility are transported to the Building 801 Target Processing Laboratory, where the useful isotopes are chemically extracted. Airborne radionuclides released during the extraction process are drawn through multistage HEPA and charcoal filters and then vented to the HFBR stack (see Table 5-1 for isotopes and quantities). Radionuclide quantities released from this facility annually are small, typically in the microcurie to millicurie (or megabecquerel) range. Isotopes released to the atmosphere from Building 801 operations are not significant contributors to the site perimeter dose via the airborne pathway (less than one percent).

5.1.6. ADDITIONAL MINOR SOURCES

There are several research departments within BNL conducting work which involves very small quantities of radioactive materials (in the microcurie to millicurie [or megabecquerel] range). This material is typically 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 the work conducted with these sources. Due to the use of filters, the nature of the 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 NESHAPs 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 buildings 463, 555, 318, 490, 490A, 703W and 830. Hosted in these buildings are a wide range of research operations including the fields of biology, chemistry, medicine, applied science and advanced technology.

5.1.7. PREVIOUSLY UNCHARACTERIZED EMISSION SOURCES EVALUATED IN 1998

As part of an initiative to review processes at BNL which could produce radioactive air emissions, a number of key facilities were inspected in 1998. The review identified the Linac and Alternating Gradient Syncrotron (AGS) cooling tower #2 as requiring air compliance assessments. The conclusions of the assessments are discussed below

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5.1.7.1. LINEAR ACCELERATOR (LINAC)

The Linac produces beams of polarized protons of energies up to 200 MeV for use at both the AGS and BLIP facilities. Due to the composition of the beam and the energies involved, production of airborne radionuclides through air activation and/or spallation interactions is possible. The most significant production point of airborne radionuclides inside the tunnel occurs where the beam crosses an air gap as it enters the BLIP vacuum system. These radioactive products are available for atmospheric release via the tunnel ventilation exhaust stack, located adjacent to the BLIP building. Radionuclides detected during sampling in 1998 include carbon-11 (half life, T½ = 20 min), nitrogen-13 (T½ = 10 min), sulfer-38 (T½= 3 hrs), chlorine-38 (T½ = 37 min), and chlorine-39 (T½ = 55 min). The total annual release of each isotope is no more than a few microcuries (megabecquerels).

The CAP88-PC (CAA Assessment Package-1988) computer dose modeling code was used to estimate the maximum public dose which could be caused by the radioactive air emissions from the Linac facility in a typical year. (See Chapter 9 for a description of the CAP88-PC model.) The model projects that the annual effective dose equivalent to the maximally exposed individual is approximately 0.000003 mrem (3E-4 mSv). This value is very small, compared to the annual limit under NESHAPs, which is 10 mrem (0.1 mSv) for all air emission sources. As stated in Chapter 4, the typical person's dose from exposure to natural radiation sources is about 300 mrem/yr (3 mSv/yr).

5.1.7.2. ALTERNATING GRADIENT SYNCROTRON (AGS) COOLING TOWER #2

Magnets used to steer the AGS particle beam experience significant heating and are cooled

via a recirculating, non-contact water loop. Under certain conditions such as High Energy Proton operations, low concentrations of radioactive elements may be produced in the cooling water when it circulates in the vicinity of the beam line. Radioisotopes which exist as gases may be liberated from the water when exposed to air during circulation in the outdoor cooling tower. These gaseous isotopes can constitute an airborne emission. The radionuclides which are likely to be released via this mechanism include oxygen-14 (T½ = 1.2 min), oxygen-15 (T½ = 2.1 min), nitrogen-13 (T½ = 10 min), and carbon-11 (T½ = 20 min). Tritium is also present and may be emitted from the tower as water vapor in microcurie (megabecquerel) quantities per year. Modeling using CAP88-PC indicates that the typical annual dose to the maximally exposed individual from this source is approximately 0.00002 mrem (2E-3 mSv). Again, a very small value as compared to the NESHAP annual limit.

5.2. AIRBORNE EMISSIONS - NON-RADIOACTIVE

Several state and federal regulations covering nonradioactive releases require facilities to conduct periodic or continuous emissions monitoring in order to demonstrate compliance with emission limits. BNL has several emission sources subject to state and/or federal regulatory requirements that do not require emissions monitoring (see Chapter 3 for more details). The Central Steam Facility (CSF) is the only BNL site that must perform nonradioactive emissions monitoring.

The CSF supplies steam for heating and cooling to all major facilities through the underground steam distribution and condensate grid. The location of the CSF is shown in Figure 5-1. The combustion units at the CSF are designated as Boiler Nos. 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 was installed in 1965, and has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers No. 6 and 7 were installed respectively in 1984 and 1996. Both of these boilers have heat inputs of 42.6 MW (147 MMBtu/hr).

Because of their design, heat inputs, and dates of installation, Boiler Nos. 6 and 7 are subject to Chapter 6 of the New York Code of Rules and Regulations (NYCRR) Part 227-2, and the New Source Performance Standard, 40 CFR Subpart Db. As such, these boilers are equipped with continuous emissions monitors (CEM) for nitrogen oxides (NO_x). Boiler No. 7 emissions are also continuously monitored for opacity in accordance with Subpart Db requirements. All four boilers are monitored for oxygen and carbon dioxide. Emissions from these boilers are reported on a quarterly basis to the USEPA and the NYSDEC.

In the spring of 1997, the Long Island Lighting Company 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 the replacement of the existing steam atomized oil burners with two Peabody-Hamworthy dual-fuel low NO_x burners, and the addition of a natural gas train connection to the gas main were completed in early 1998. After shakedown testing of the new dual-fuel burners was completed in August, the CSF started burning natural gas in Boiler 6 for steam production.

From May 1 to September 15 (the peak ozone period), compliance with the 130 ng/J (0.30 lbs/MMBTU) NO_x emissions standard is demonstrated by calculating the 24 hour average emission rate from CEM readings and comparing the value to the emission standard. The remainder of the year, the calculated 30-day rolling average CEM emissions rate is used to establish compliance. In 1998, there were no measured exceedances of the NO_x emission standard for either boiler. Owing to the increased use of natural gas, annual particulate, NO_x, and sulfur oxide (SO_2) emissions at the CSF in 1998 declined by 11.0 tons, 8.5 tons, and 66.2 tons respectively from totals recorded in 1997. On an equivalent-heat input basis, particulate emissions at the CSF dropped by 10.6 tons, NO_x emissions dropped by 6.2 tons, and SO_2 emissions fell by 64.2 tons.

5.3. AIR MONITORING

As part of the environmental monitoring program, an array of stations is in place around the BNL site to collect air samples which are used to determine radiological air quality (see Figure 5-3). As shown in the photo, the blockhouses are fenced for security purposes to control access and protect costly

sampling equipment from inadvertent intruders. Six stations are located in dedicated blockhouses (see Figure 5-4 for locations). At each blockhouse, glass fiber filter paper is used to capture airborne particulate matter, charcoal cartridges are used to collect potential radioiodines (none were detected in 1998), and silica gel tubes are used to collect water vapor for tritium analysis (with the exception of Station S5 which does not contain a tritium sampler). Filter paper is collected weekly and analyzed for gross alpha and beta activity using a gas-flow proportional counter. Silica gel samples are also collected weekly and processed for liquid scintillation analysis. Charcoal cartridges are collected monthly and analyzed by gamma spectroscopy. In addition to the blockhouses, 18 pole-mounted, battery-powered silica gel samplers are distributed throughout the site, primarily along the site boundary.

In addition to these samples, the New York State Department of Health (NYSDOH) receives duplicate filter samples which are collected at Station P7, located at the southeast boundary. These samples are also collected on a weekly basis and are analyzed by an independent NYSDOH Laboratory. Analytical results are comparable to those collected by BNL and are reported annually in a document called "Environmental Radiation In New York State".

Figure 5-3. Environmental Air Sampling Blockhouse

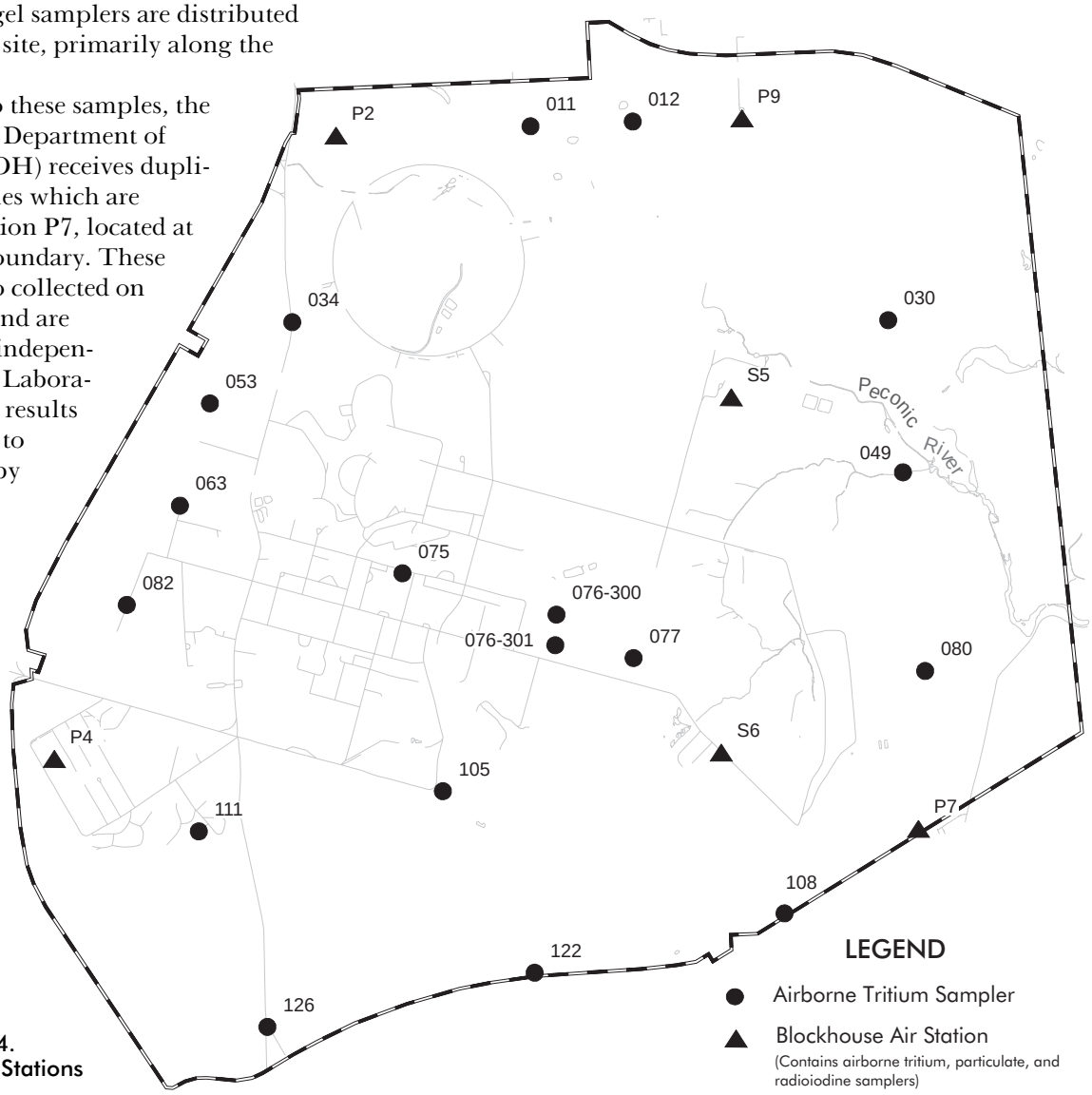

Figure 5-4. Air Monitoring Stations

5.3.1. GROSS ACTIVITY

Particulate filter analytical results are reported in Table 5-2. Annual average gross alpha and beta airborne activity levels were equal to 0.0005 pCi/m^3 (0.02 mBq/m^3) and 0.015 pCi/m^3 (0.6 mBq/m^3), respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 5-5; the results at this location are typical for the site. The trend shows a seasonal variation of concentrations within a range which is representative of natural background. Note, however, that gross alpha activity is not plotted because the vast majority of results were below the Minimum Detection Limit (MDL). Measurable activity is primarily due to radionuclide decay products associated with natural uranium and thorium.

As part of a state-wide monitoring program, the NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions (NYSDOH, 1993). The NYSDOH reports that typical airborne gross beta activity at that location varies between 0.005 and 0.025 pCi/m^3 (0.2 to 0.9 mBq/m^3). Sample results measured at BNL fall well within this range, demonstrating that onsite radiological air quality is consistent with that observed in locations in New York State not located near radiological facilities.

Table 5-2. Gross Activity Detected in Air Particulate Filters

Sample Station		Gross Alpha (pCi/m^3)	GrossBeta (pCi/m^3)
P2	N	52	52
	Max.	< 0.002	0.052±0.0036
	Avg.	0.0006±0.0002	0.016±0.002
	NBD	52	2
P4	N	52	52
	Max.	< 0.002	0.040±0.003
	Avg.	0.0005±0.0001	0.016±0.002
	NBD	52	3
P7	N	52	52
	Max.	< 0.013	0.026±0.003
	Avg.	0.0004±0.0002	0.014±0.002
	NBD	52	6
P9	N	52	52
	Max.	< 0.003	0.035±0.004
	Avg.	0.0006±0.0002	0.014±0.002
	NBD	52	2
S5	N	52	52
	Max.	< 0.014	0.052±0.004
	Avg.	0.0005±0.0004	0.016±0.003
	NBD	52	3
S6	N	52	52
	Max.	< 0.008	0.045±0.009
	Avg.	0.0006±0.0002	0.015±0.002
	NBD	52	2

Notes:
1. All values shown with 95% confidence interval.
2. N = Number of samples collected.
3. NBD = Number of samples with results below the Minimum Detection Limit.

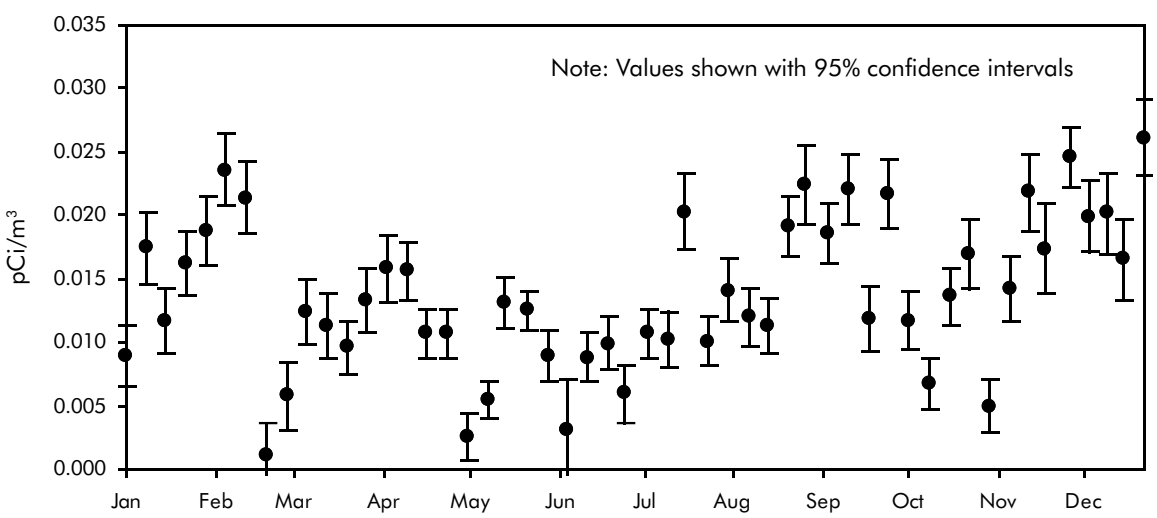

Figure 5-5. Airborne Gross Beta Concentration Trend recorded at Station P7

Table 5-3. Ambient Airborne Tritium Measurements

Station	Wind Sector	Validated Samples	Maximum (pCi/m³)	Average (pCi/m³)
006-300 (P9)	NE	48	< 3.3	0.3±0.4
011-300	NNE	35	2.5±1.5	0.1±0.3
012-300	NNE	35	7.1±3.0	0.6±0.6
017-300 (P2)	NNW	46	4.2±1.6	0.2±0.3
030-300	ENE	28	4.9±2.3	0.2±0.5
034-300	NNW	42	9.6±3.6	0.5±0.5
049-300	E	31	< 5.5	0.3±0.5
053-300	NW	45	5.2±1.6	0.3±0.4
063-300	W	43	16.2±8.8	0.5±0.8
075-300	SW	39	26.4±2.6	1.6±1.6
080-300	ESE	35	4.5±1.6	0.3±0.4
082-300	W	41	5.7±2.4	0.0±0.4
088-300 (S6)	SE	50	75.2±4.4	28.9±4.8
090-300 (P7)	ESE	51	5.8±2.5	0.4±0.4
105-300	S	41	4.5±2.2	0.0±0.5
108-300	SE	30	< 3.6	-0.1±0.6
109-300 (P4)	WSW	49	22.2±3.5	0.5±1.0
111-300	SW	45	< 5.0	0.0±0.4
122-300	SSE	40	21.7±2.6	0.2±1.2
126-300	SSW	46	3.5±2.2	0.1±0.3
Grand Average				2.0±0.5
DOE Order 5400.5 air DCG				**100,000**

Notes:
1. All values reported with 95% confidence interval.
2. Typical detection limit: 1 - 4 pCi/m³.

5.3.2. AIRBORNE TRITIUM

Airborne tritium in the form of HTO is monitored throughout the BNL site. Twenty monitors (not including those which monitor the Removal Action V ([RA V]) recharge basin) are located at or near the property boundary (see Figure 5-4 for locations). HTO is collected by using a pump that draws air through a column of silica gel, a water-absorbent medium which retains moisture. The absorbed water is recovered in the Analytical Services Laboratory (ASL) and analyzed using liquid scintillation counting techniques.

Table 5-3 lists the number of validated samples collected at each location, the maximum value observed and the annual average concentration. (Validated samples are those which were not rejected due to equipment malfunction or other factors, e.g., a battery failure in the sampler, or frozen or super-saturated gel.) While each location showed a maximum value at some point in the year which was above the typical detection limit of about 4 pCi/m³ (0.15 Bq/m³), the vast majority of sample results were below the MDL. These data demonstrate that there is no significant difference in ambient tritium concentrations onsite or at the site boundary. With the exception of Station S6, which is located adjacent to the former Hazardous Waste Management Facility (HWMF), all annual average concentrations were observed to be below the MDL. The maximum concentration recorded at Station S6 was 75 pCi/m³ (2.8 Bq/m³). The higher values observed at this station may be due to its proximity to the HWMF. By comparison, the DOE Order 5400.5 Derived Concentration Guide (DCG) for tritium in air is 100,000 pCi/m³ (3.7 kBq/m³). The airborne DCG is the concentration of a radionuclide in air which, if inhaled at that level for one year, would result in an effective dose equivalent of 100 mrem (1 mSv) to the exposed individual.

5.3.2.1. REMOVAL ACTION V (RA V) RECHARGE BASIN

In 1997, an interim pump-and-recharge system was constructed to control the leading edge of the plume of tritium associated with the leakage of the spent-fuel storage pool at the HFBR. Three extraction wells are used to pump groundwater containing both tritium and volatile organic compounds (VOCs) from approximately 150 feet below ground surface to carbon filtration units and ultimately to the RA V recharge basin, located 3,000 feet to the north of the plume edge. (The VOCs being treated by this system are from sources unrelated to the HFBR.) Using assumptions which later proved to be very conservative, the recharge basin was evaluated as a potential air emission source for NESHAPs compliance prior to the start of pumping operations (see the Section 5.1.6.1 of the BNL Site Environmental Report for Calendar Year 1997 for a discussion of that evaluation).

Airborne HTO monitoring in the vicinity of the RA V recharge basin continued in 1998. Two monitors are installed immediately adjacent to the basin at the northeast and southeast corners, the downwind directions of the predominant winds on site (see BNL wind rose in Figure 1-10). An additional station was placed near the National Weather Service building, approximately 0.3 km (0.2 mi) to the

east of the basin. As can be seen in Table 5-4, no tendency toward measurable airborne tritium was observed. Only eight of 116 total samples showed results greater than the MDL, and those eight were at values consistent with what was observed throughout the site. This is as expected since direct analysis of the basin water showed tritium values which were rarely above the MDL of about 350 pCi/L (13 Bq/L).

Table 5-4. Ambient Tritium Monitoring Results at RA V Recharge Basin

Location	Validated Samples	Detections	Maximum (pCi/m^3)	Average (pCi/m^3)
Northeast corner of basin	41	3	5.9+/-1.7	0.8+/-0.5
Southeast corner of basin	27	1	< 3.2	0.4+/-0.6
National Weather Service Building	48	4	3.9+/-1.4	0.3+/-0.4

Notes:
Typical MDL between 1 and 4 pCi/m^3.

REFERENCES:

New York State Department of Health. 1993.
Environmental Radiation in New York State 1993.
Albany, New York.

Water Quality

CHAPTER 6

Because facilities at Brookhaven National Laboratory (BNL) discharge or have the potential to discharge radioactive and organic or inorganic contaminants in liquid effluents, effluent monitoring is conducted to ensure that the public and environment are protected during operations and verify that all discharges comply with applicable federal, state and local standards.

At the Sewage Treatment Plant (STP) outfall, average gross alpha and beta activity was observed to be in the range typical of environmental surface waters; no elevation was detected. Improved wastewater management has led to the smallest release of tritium since such measurements began; the majority of daily samples indicated concentrations which were below the Minimum Detection Limit (MDL). The results of both independent and BNL analytical sampling for plutonium showed no detectable isotopes of plutonium in STP effluent. Average cesium-137 concentrations in STP effluent were less than one percent of drinking water standards. Though drinking water standards are not applicable to the Peconic River since it is not a direct source of potable water, these limits provide a stringent standard of comparison.

An increase in analytical capability allowed 19 inorganic parameters to be monitored daily. The results show that they were all within State Pollutant Discharge Elimination System effluent limitations. Inorganic data from upstream, downstream and at locations not affected by STP discharges show that elevated amounts of aluminum, copper, lead, iron and zinc are a result of natural geology, not influenced by STP effluent. Low pH is also due to natural causes. Organic analyses show no compounds detected above method MDL's.

In 1998, all wastewater effluents met applicable discharge standards. Monitoring of organic and inorganic contaminants showed all parameters to be within ambient water quality standards or background concentrations. Compliance is discussed extensively in Chapter 3.

6.1 SANITARY SYSTEM EFFLUENTS

In 1997, significant improvements were made in the way that sanitary wastes are treated at Brookhaven National Laboratory (BNL). Formerly, sanitary wastewater was treated by primary clarification followed by intermittent sand filtration. This process was enhanced by the addition of modular aeration and ultraviolet disinfection steps. Construction of the enhanced treatment system started in 1996 and was completed in September 1997. Present treatment includes: primary clarification to remove settleable solids and floatable materials, aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, secondary clarification, intermittent sand filtration for final effluent polishing, and ultraviolet disinfection for bacterial control prior to discharge to the Peconic River. The enhanced treatment process became fully operational in 1998 by (1) accumulation of biomass necessary to effect biological treatment, and (2) operation of the oxygen minimizer. During the aeration process, the oxygen minimizer causes the microorganisms to use nitrate bound oxygen for respiration, consequently liberating nitrogen gas and reducing the concentration of nitrogen in the sewage treatment plant (STP) discharge. Nitrogen provides nutrients for plant growth, consequently plant growth within the Peconic has been extensive. Since plants require oxygen for survival during night hours, too much plant life can leave a water system void of oxygen. By reducing the concentration of nitrogen in the STP discharge, plant growth within the river remains in balance with the nutrients provided via natural sources.

Within the BNL site, the Peconic River is an intermittent stream. Offsite flow occurs during periods of sustained precipitation, typically in the spring. Since the incidence of rain was higher than average in 1998, flow was recorded from February through September. High flows were recorded in May and early June. The STP's Peconic River outfall is a discharge point operating under a State Pollutant Discharge Elimination System (SPDES) permit. Figure 6-1 shows a schematic of the STP and its related sampling arrangements.

Real-time monitoring of the clarifier influent for radioactivity, pH, and conductivity takes place at two locations: about 1.8 km (1.1 mi.) upstream of the STP and as the

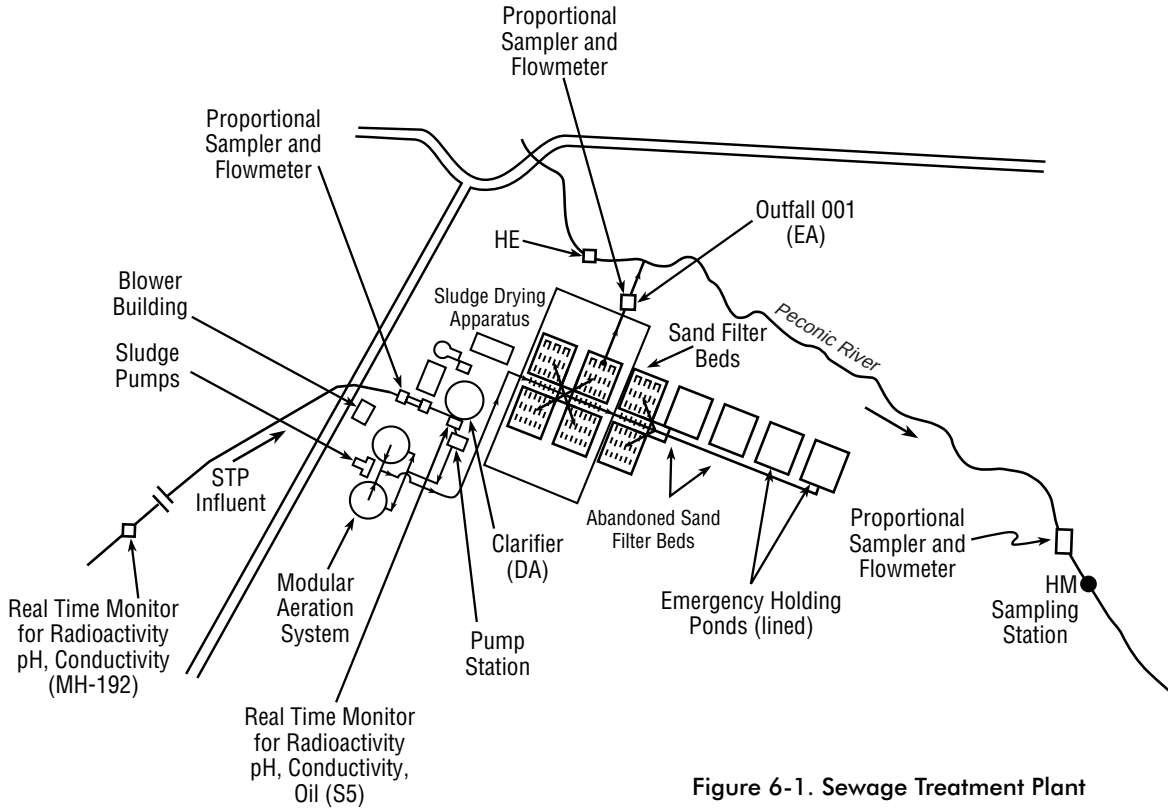

Figure 6-1. Sewage Treatment Plant

influent is about to enter the primary clarifier. The upstream station gives about 30 minutes of advanced warning to the STP operator if wastewater which may exceed BNL effluent release criteria or SPDES limits has entered the sewer system. Effluent leaving the clarifier is monitored a third time for radioactivity. Influent/effluent that does not meet BNL and/or SPDES effluent release criteria is diverted to one of two lined hold-up ponds. The total combined capacity of the two holding ponds exceeds 26.5 million liters (7 million gallons). Diversion continues until the effluent quality meets the permit limits or release criteria. The requirements for treating the effluent diverted to the holding pond are evaluated. Effluent is then reintroduced into the sanitary waste stream at a rate that ensures compliance with SPDES limits or BNL administrative release criteria.

Solids separated in the clarifiers are pumped to a digester, where they are reduced in volume by anaerobic bacteria. Periodically a fraction of the sludge is emptied into a drying bed for moisture reduction. The drying bed uses solar energy to dry the watery sludge to a semi-solid cake. The dried sludge is then containerized for offsite disposal at a Department of Energy (DOE) authorized facility.

6.1.1 SANITARY SYSTEM EFFLUENT - RADIOLOGICAL

As noted in the previous section, the STP effluent is sampled at the output of the primary clarifier (Station DA) and at the Peconic River Outfall (Station EA). At each location, samples are collected daily. The sample volume is proportional to the total water flow through the plant. These samples are analyzed for gross alpha, gross beta and tritium activity. Daily samples from these locations are also composited each month and analyzed for gamma-emitting radionuclides and strontium-90.

The Safe Drinking Water Act (SDWA) specifies that no individual may receive an annual dose greater than 4 mrem (0.04 mSv) from radionuclides present in drinking water. Although the Peconic River is not used as a direct source of potable water, the stringent drinking water standards are applied for comparison purposes. Under the SDWA, the annual average gross alpha activity limit is 15 pCi/L (0.5 Bq/L)(including radium-226, but excluding radon and uranium). SDWA also stipulates a 50 pCi/L (2 Bq/L) gross beta activity screening level, above which, nuclide-specific analysis is required. BNL goes beyond this basic screening requirement by performing nuclide-specific analysis regardless of the gross beta activity. Other specified limits are 20,000 pCi/L (740 Bq/l) for tritium and 8 pCi/L (0.3 Bq/L) for strontium-90. For all other radionuclides, DOE Order 5400.5 Derived Concentration Guides (DCGs) are used to determine the concentration of the nuclide which, if continuously ingested over a calendar year, would produce an effective dose equivalent of 4 mrem. These values are shown at the bottom of Tables 6-1 and 6-2 under “SDWA Limit”.

Gross activity measurements are used as a screening tool for detecting the presence of radioactivity without identifying the specific radionuclide(s) causing the activity. Annual average gross alpha and beta activity in the STP effluent has remained consistent with background levels for many years. This continued to be the case in 1998. Average gross alpha and beta activity at the STP Outfall was 1.6 pCi/L (0.06 Bq) and 6.5 pCi/L (0.24 Bq/L), respectively. See Table 6-1 for complete gross activity data.

Sporadically throughout the year, gamma spectroscopy analysis detected beta/gamma-emitting radionuclides in the STP influent and effluent although at levels that were close to or below the Minimum Detection Limits (MDL) of the analysis system (see Table 6-2). The presence of cesium-137 in the STP effluent is due to the continued leaching of very small amounts of cesium from the sand filter beds, deposited during historic releases to the site sanitary system. This is clear when comparing cesium detected in STP influent and effluent; detections in influent are low and infrequent, whereas detections in effluent are measurably higher on a consistent basis. Total cesium-137 released at the STP Outfall during the year was less than 1 mCi (37 MBq), and average concentrations in STP effluent were less than one percent of the drinking water standard. In fact, cesium-137 concentrations in influent and effluent have been decreasing since 1990, as shown in Figure 6-2.

Stronitum-90 was not detected in any monthly composite samples of STP effluent, though it was detected at extremely low levels

Table 6 -1. Gross Activity and Tritium Results at the Sewage Treatment Plant

STP Primary Clarifier	Flow (liters)	Tritium Maximum (pCi/L)	Tritium Average (pCi/L)	Gross Alpha Maximum (pCi/L)	Gross Alpha Average (pCi/L)	Gross Beta Maximum (pCi/L)	Gross Beta Average (pCi/L)
January	6.90E+07	1,280±224	517±140	4.9±2.5	1.6±0.7	22.6±6.1	7.4±2.0
February	5.32E+07	588±228	312±69	9.0±3.1	2.2±1.3	18.4±5.8	6.6±1.9
March	6.14E+07	624±226	206±91	5.4±2.9	1.1±0.7	14.0±5.4	7.3±1.2
April	5.46E+07	726±255	320±94	3.2±2.0	1.0±0.5	9.7±5.2	5.8±0.8
May	5.87E+07	812±242	374±116	6.1±2.6	1.7±0.8	9.5±5.7	6.4±0.8
June	6.75E+07	5,250±381	676±464	5.0±2.4	1.0±0.6	19.7±5.6	5.0±1.7
July	7.33E+07	768±223	240±98	4.1±1.9	1.2±0.6	9.4±5.2	5.2±1.4
August	8.15E+07	664±218	215±84	3.3±2.3	1.2±0.4	11.5±5.0	5.4±1.3
September	7.50E+07	301±200	127±52	3.8±1.8	1.±0.5	10.8±5.5	5.7±1.2
October	6.28E+07	< 292	16±81	3.0±1.5	1.3±0.4	10.6±5.4	6.3±1.3
November	7.33E+07	< 301	58±60	4.8±2.2	2.6±0.7	17.4±6.2	11.4±1.7
December	5.80E+07	< 307	41±54	6.7±2.4	2.2±1.0	15.7±6.3	6.4±1.8
Annual Avg.			264±54		1.5±0.2		6.5±0.5
STP Outfall							
January	4.65E+07	1,140±221	460±113	7.4±2.9	2.1±0.9	20.4±6.1	7.0±2.4
February	4.95E+07	787±239	394±91	4.2±2.4	1.4±0.7	21.0±6.2	7.5±2.1
March	5.36E+07	595±231	259±72	4.6±2.7	1.7±0.6	14.2±5.3	6.6±1.3
April	5.26E+07	474±222	240±75	3.1±1.9	0.7±0.6	9.7±5.3	5.8±1.0
May	5.60E+07	593±217	303±75	8.6±3.0	1.9±0.9	24.3±6.0	7.1±2.2
June	5.90E+07	6,350±410	747±637	5.8±2.4	1.3±0.8	15.4±5.5	6.1±1.8
July	5.33E+07	1,360±247	421±166	2.9±1.8	1.1±0.4	9.8±4.7	5.1±1.1
August	6.21E+07	364±196	174±49	4.0±2.4	1.9±0.5	13.2±5.2	6.1±1.1
September	5.45E+07	489±214	169±59	6.7±2.9	1.6±0.7	9.9±4.9	5.5±1.2
October	4.68E+07	368±195	60±59	5.1±2.7	1.4±0.7	11.4±5.0	4.2±1.4
November	3.72E+07	376±198	107±68	5.4±2.6	2.0±0.8	16.7±5.3	10.6±1.9
December	5.13E+07	360±193	76±49	12.6±3.7	2.5±1.4	13.9±5.6	7.0±1.2
Annual Avg.			289±64 pCi/L		1.6±0.2 pCi/L		6.5±0.5 pCi/L
SDWA Limit (Annual Avg.)			20,000 pCi/L		15 pCi/L		50 pCi/L
Typical MDL			350 pCi/L		3 pCi/L		8 pCi/L
Total Release (Outfall)			195 mCi		1.1 mCi		4.0 mCi

Notes:
1. All values shown with 95% confidence interval.

on two occasions in the plant influent. The largest single value recorded for a monthly composite influent sample was 0.61 ± 0.18 pCi/L (0.02 ± 0.01 Bq/L), or seven percent of the drinking water standard of 8 pCi/L (0.3 Bq/L). Because the two results are so close to the MDL, they are not considered robust. However, since strontium-90 was discharged from the STP in the 1950s and 1960s, it is possible that some residual material remains in the sanitary piping system.

Tritium detected at the STP originates with either High Flux Beam Reactor (HFBR) sanitary system releases, or small, infrequent batch releases which meet BNL discharge criteria. Previously, the onsite waste concentration process at the Waste Concentration Facility (WCF) generated tritriated distillate which constituted a third liquid source. However, this source was eliminated with the introduction of the Evaporator Facility in 1995. A plot of 1998 tritium concentrations recorded in the STP effluent is presented in Figure 6-3. A 10-year trend plot of annual average tritium concentrations measured in the Peconic is shown in Figure 6-4. Annual average concentrations have been declining since 1995.

Table 6-2. Gamma-emitting Radionuclides and Strontium-90 Detected at the Sewage Treatment Plant

STP Primary Clarifier	**Flow (L)**	**Co-60** (pCi/L)	**Cs-137** (pCi/L)	**Mn-54** (pCi/L)	**Na-22** (pCi/L)	**Sr-90** (pCi/L)
January	6.90E+07	ND	0.05±0.03	0.13±0.04	0.07±0.03	< 3.10
February	5.32E+07	ND	0.05±0.02	0.09±0.04	ND	< 1.48
March	6.14E+07	ND	0.04±0.03	0.07±0.04	ND	< 1.01
April	5.46E+07	ND	0.09±0.03	ND	ND	< 0.69
May	5.87E+07	ND	ND	ND	0.23±0.05	< 0.33
June	6.75E+07	ND	ND	ND	0.06±0.03	0.39±0.16
July	7.33E+07	ND	0.10±0.03	ND	ND	< 0.33
August	8.15E+07	ND	ND	ND	ND	< 0.22
September	7.50E+07	0.04±0.01	0.04±0.02	ND	ND	< 0.37
October	6.28E+07	ND	ND	ND	ND	< 0.33
November	7.33E+07	ND	ND	ND	ND	0.61±0.18
December	5.80E+07	ND	ND	ND	0.06±0.03	< 0.37
STP Outfall						
January	4.65E+07	ND	ND	ND	ND	<1.65
February	4.95E+07	ND	0.39±0.17	ND	ND	< 1.54
March	5.36E+07	ND	0.52±0.11	ND	ND	< 3.31
April	5.26E+07	ND	0.57±0.13	ND	ND	< 0.37
May	5.60E+07	ND	0.60±0.11	ND	0.09±0.04	< 0.34
June	5.90E+07	ND	0.88±0.16	ND	0.05±0.03	< 0.73
July	5.33E+07	ND	0.54±0.47	ND	ND	< 0.34
August	6.21E+07	ND	0.85±0.24	ND	ND	< 0.73
September	5.45E+07	ND	0.68±0.13	ND	ND	< 0.70
October	4.68E+07	ND	0.56±0.11	ND	ND	< 0.34
November	3.72E+07	ND	0.47±0.09	ND	ND	< 0.73
December	5.13E+07	ND	0.33±0.14	ND	ND	< 0.70
Total Release		0 mCi	0.3 mCi	0 mCi	0.008 mCi	0 mCi
DOE Order 5400.5 DCG		5,000 pCi/L	3,000 pCi/L	50,000 pCi/L	10,000 pCi/L	1,000 pC/L
SDWA Limit		200 pCi/L	120 pCi/L	2,000 pCi/L	400 pCi/L	8 pCi/L

Note: All concentration values shown with 95% confidence interval.

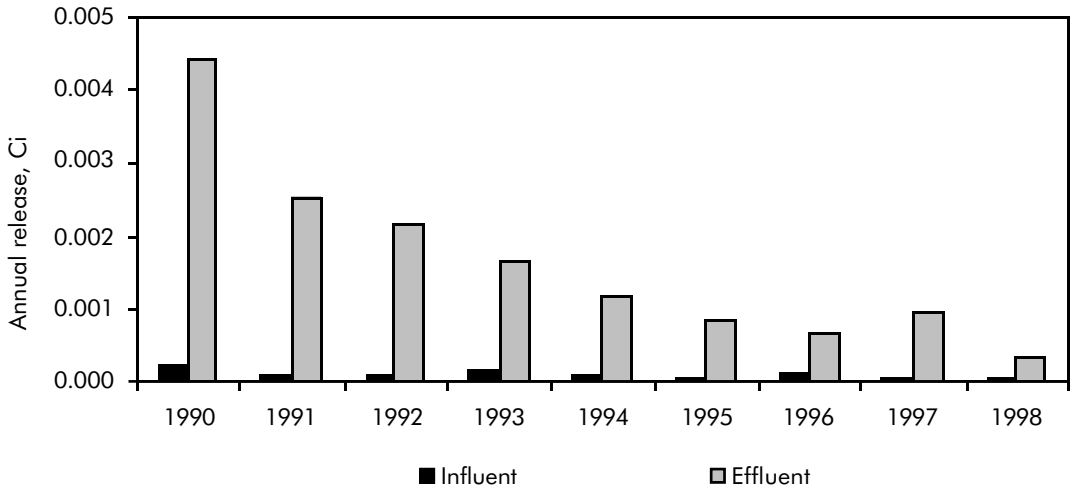

Figure 6-2. Cs-137 Trend in STP Influent and Effluent

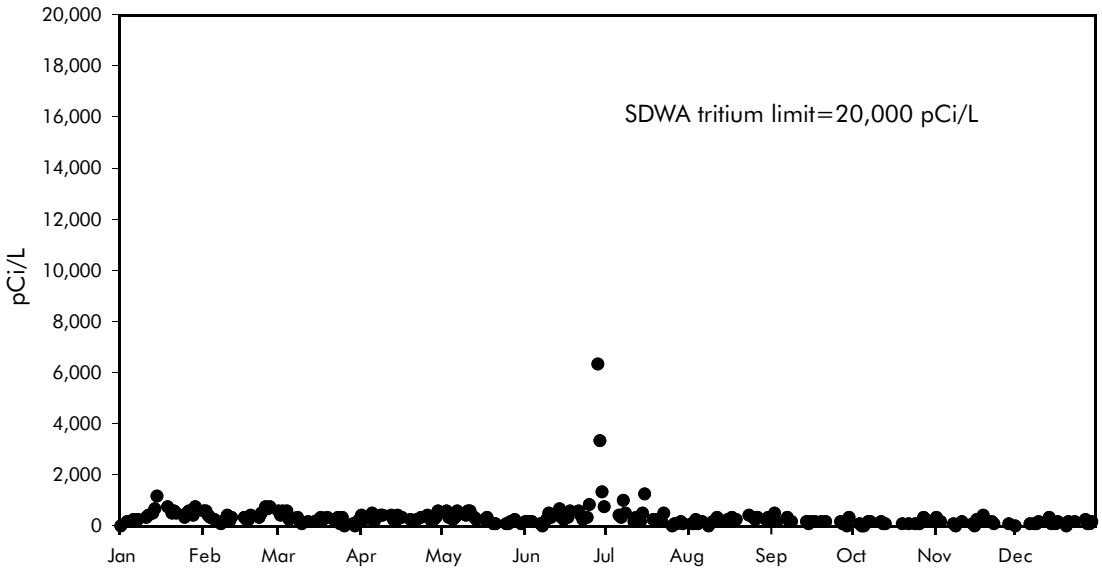

Figure 6-3. 1998 STP Effluent Tritium Concentrations

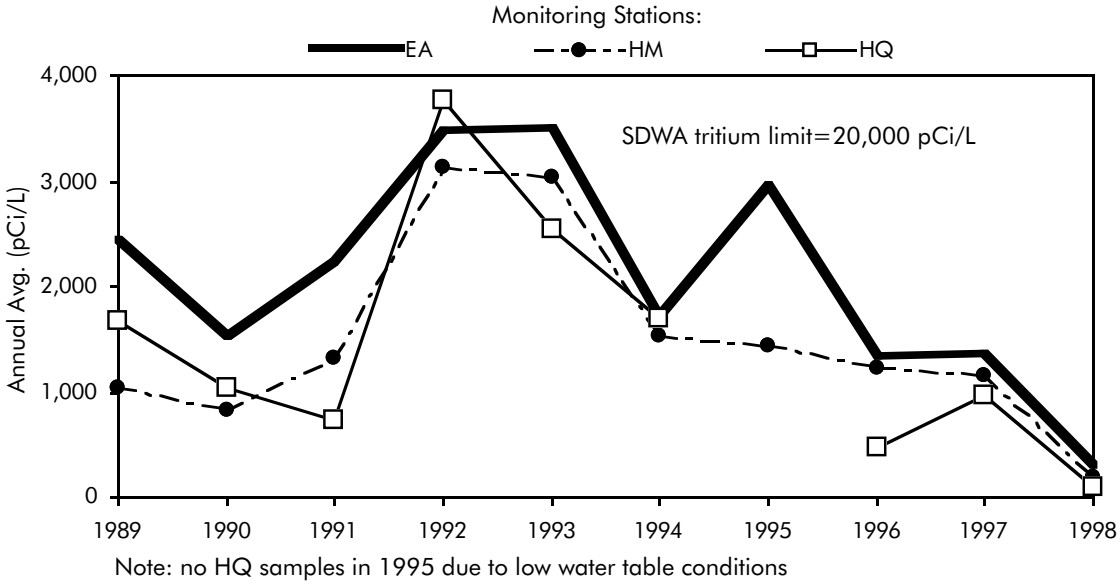

Figure 6-4. STP/Peconic Annual Average Tritum Concentrations

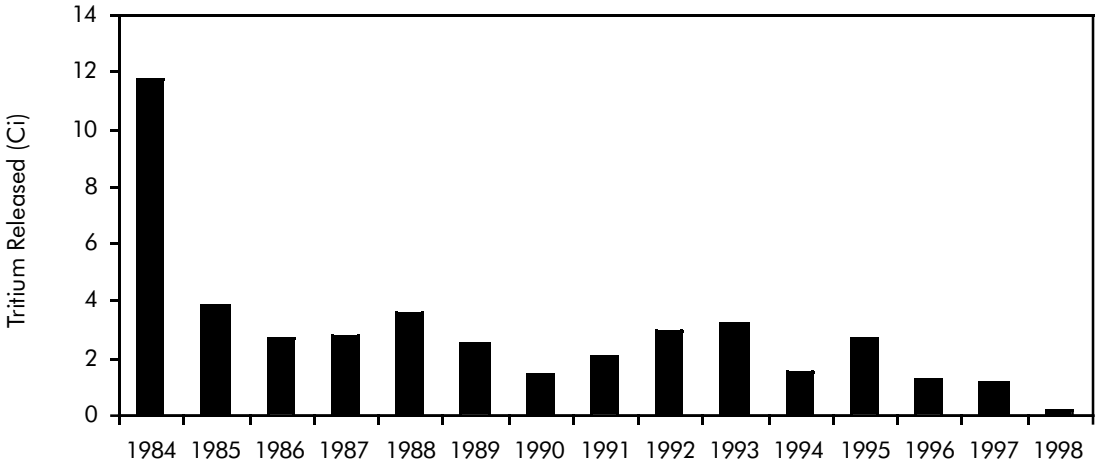

Figure 6-5. Tritium Released to the Peconic River, 15 Year Trend

In 1998, the annual average tritium concentration as measured at the Peconic River Outfall was 289 pCi/L (11 Bq/L), a value which is below the typical MDL limit of 350 pCi/L (13 Bq/L). A total source term of 0.195 Ci (7.2 GBq) of tritium was released during the year. This is the lowest annual release of tritium to the Peconic River observed since routine measurements began in 1966 (see Figure 6-5). This is attributable to HFBR facility shutdown, improved wastewater handling procedures at the HFBR and the use of the Building 802 Evaporator Facility for tritium disposal.

6.1.1.1 PLUTONIUM ANALYSIS

In an effort to address concerns over possible plutonium contamination in the STP effluent, two effluent samples were collected in June, 1998. It is important to note that there are no active facilities at BNL which could discharge this radionuclide to the sanitary system, though it was generated as a by-product in spent fuel from the Brookhaven Graphite Research Reactor (BGRR) in the 1950s and 1960s. This reactor was permanently shutdown in 1968.

One sample was processed by BNL's Analytical Services Laboratory (ASL), while another was sent to an independent commercial laboratory in South Carolina. The ASL has the analytical capability to determine total plutonium content, including the Pu-238, 239/240, and 242 isotopes. The offsite commercial laboratory analyzed the effluent sample for individual alpha-emitting Pu isotopes (including all of those listed above) as well as beta-emitting Pu-241. No plutonium isotopes were seen above either laboratory's minimum detection limits.

6.1.2 SANITARY SYSTEM EFFLUENT - NONRADIOLOGICAL

The effluent from the STP is also monitored under the environmental surveillance program. Monitoring includes water quality and inorganic (i.e., metals) parameters. Daily composite samples are collected using a flow proportional refrigerated sampling device (ISCO Model 1600). In 1998, the ASL expanded its inorganic analytical capabilities by using an Inductively Coupled Plasma/Mass Spectrometer. This instrument effectively increased the routine inorganic analyte list to nineteen parameters. The ASL then analyzes these composite samples for metals and anions. Metals analysis is conducted on a monthly composite of the daily samples, whereas anions are analyzed using a single daily sample. Grab samples are collected daily at Location EA (see Figure 6-1) and monitored for field-measured parameters including pH, conductivity, temperature, and dissolved oxygen. To monitor STP operations, daily influent and effluent logs are also maintained by the STP operators for flow, pH, temperature, and settleable solids.

Table 6-3 summarizes the water quality and metals analytical results for these samples. Comparison of the effluent data to the SPDES effluent limitations (or other applicable standard) shows that all analytical parameters were within SPDES effluent limitations. (See also compliance data in Chapter 3).

6.2 ASSESSMENTS OF PROCESS-SPECIFIC WASTEWATER

Wastewater that may potentially contain constituents above SPDES permit limits or groundwater discharge standards is held and characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate limit, and the wastewater released only if the discharge would not jeopardize the quality of the effluent.

The SPDES permit includes requirements for the quarterly sampling and analysis of process-specific wastewater discharged from the photographic developing operations in Buildings 197B, the printed-circuit-board fabrication operations conducted in Building 535B, the metal cleaning operations in Building 498, cooling tower discharges from Building 902, and miscellaneous satellite boiler blowdown. These operations were monitored for contaminants, such as inorganic elements (i.e., metals), cyanide, and volatile and semi-volatile organic compounds. All analytical results were reported in the quarterly Discharge Monitoring Reports submitted to the NYSDEC. Analyses of these waste streams show that, while several contribute contaminants to the STP in concentrations exceeding SPDES permitted levels, the ranges of concentrations of these wastes are comparable to typical STP influent levels. Consequently, these discharges have little to no impact on the STP effluent water quality.

Table 6-3. Sewage Treatment Plant (STP), Average Water Quality and Metals Data[c]

	No. of Samples	STP Influent Min.	STP Influent Max.	STP Influent Avg.	No. of Samples	STP Effluent Min.	STP Effluent Max.	STP Effluent Avg.	SPDES Limit or Ambient Water Quality Standard[b]
pH(SU)	235	5	8.2	NA	235	6.1	7.3	NA	5.8 - 9.0
Conductivity (µmhos/cm)				(b)	235	6.8	309	238	NA
Temperature (C)					235	4.4	26.8	16.4	NA
Dissolved Oxygen (mg/L)	NA	NA	NA	NA	235	5.2	14.6	9.4	NA
Chlorides (mg/L)	NA	NA	NA	NA	12	19.8	34	26	NA
Nitrate (as N)(mg/L)	NA	NA	NA	NA	12	2.1	8.2	5.6	10 (Total N)
Sulfates (mg/L)	NA	NA	NA	NA	12	9.9	19.6	15.4	250 (GA)
Aluminum (µg/L)	11	53.7	247.3	123.28	12	21.4	55.1	43.8	100 (Ionic)
Arsenic (µg/L)	11	< 3	6	< 3	12	< 3	< 3	< 3	150 (Dissolved)
Barium (µg/L)	11	25.4	102.2	44.2	12	11.6	52	19.8	1000 (GA)
Beryllium (µg/L)	11	< 0.66	5.4	< 0.66	12	< 0.66	< 0.66	< 0.66	11 (Acid Soluble)
Cadmium (µg/L)	11	< 1.1	5.4	< 1.1	12	< 1.1	< 1.1	< 1.1	1.1 (Dissolved)
Chromium (µg/L)	11	1.4	7.7	2.6	12	1.6	2.5	2	34.4 (Dissolved)
Cobalt (µg/L)	11	0.5	6.3	1.3	12	0.3	1	0.5	5 (Acid Soluble)
Copper (µg/L)	11	60	207.8	113.5	12	37.7	60.4	50.3	150 (SPDES)
Iron (µg/L)	11	521	1307	881	12	107.1	223.6	163.3	370 (SPDES)
Mercury (µg/L)	11	< 0.2	< 0.2	< 0.2	12	< 0.2	0.64	< 0.2	0.8 (SPDES)
Manganese (µg/L)	11	14.7	22.6	18.1	12	3	15.4	8.4	300 (GA)
Sodium (mg/L)	11	29.8	39.6	33.7	12	26.2	34.9	31.1	NA
Nickel (µg/L)	11	2.7	10.9	5.4	12	3.4	4.8	4	110 (SPDES)
Lead (µg/L)	11	5	25.6	11.6	12	1.3	3.5	2	19 (SPDES)
Selenium(µg/L)	11	< 5	5.6	< 5	12	< 5	< 5	< 5	4.6 (Dissolved)
Silver (µg/L)	11	< 1	5	< 1	12	< 1	2.8	2	15 SPDES
Thallium(µg/L)	11	< 0.66	5.1	< 0.66	12	< 0.66	< 0.66	< 0.66	8 (Acid Soluble)
Vanadium (µg/L)	11	< 5.5	15.2	< 5.5	12	5.5	13.2	8.7	14 (Acid Soluble
Zinc(µg/L)	11	43.7	133.2	80.7	12	18	52.4	37.8	100 (SPDES)

Notes:
NA: Not Applicable or Not Analyzed
GA: Class GA (groundwater) Ambient Water Quality Standard
a. The locations of the monitoring stations are shown on Figure 6-1.
b. Unless otherwise provided, the reference standard is Class C surface water. For Class C standards the solubility state for the metal is provided.
c. All metal analytical results were generated using total recoverable analytical techniques.

Process wastewaters that are not routinely monitored under the SPDES permit because they were not expected to be of consistent quality or because they are not generated routinely, were held for characterization before release to the sewer. Waste waters routinely evaluated, are ion-exchange column regeneration wastes, primary closed-loop cooling water systems, and other industrial wastewaters. To determine the appropriate disposal method, samples are analyzed for contaminants specific to the process. The analyses are then reviewed, and the concentrations compared to the SPDES and radiological effluent limits. If the concentrations are within limits, authorization for sewer disposal is granted; if not, alternate means of disposal are pursued. In all instances, any waste which contains hazardous levels of contaminants or elevated radiological contamination is sent to the waste management program for disposal.

6.2.1 RECHARGE BASINS

Figure 6-6 depicts the locations of BNL's recharge basins. An overall schematic of water use at the Laboratory is shown in Figure 6-7. Recharge Basins HN and HT receive once-through cooling water discharges generated at the Alternating Gradient Syncrotron (AGS) as well as cooling tower blowdown and storm water runoff.

- Recharge Basin HS receives predominantly storm water runoff and minimal cooling tower blowdown from the National Syn-

chrotron Light Source (NSLS).

- Basin HX receives Water Treatment Plant (WTP) filter backwash water.
- Basin HP receives once-through cooling water from the BMRR.
- Recharge Basin HO receives cooling water and cooling tower discharges from the AGS and HFBR, and storm water runoff. A polyelectrolyte and dispersant are added to the supply of AGS cooling- and process-water to keep the naturally occurring iron in solution. The HFBR secondary-cooling system water recirculates through mechanical cooling towers, and is treated with inorganic polyphosphate and tolytriazole to control corrosion and deposition of solids. The blowdown from this system, combined with once-through cooling water used at the Cold Neutron Facility and the Cyclotrons, is also discharged to the HO Basin. In 1998, approximately 4.1 MLD (1.1 MGD) was discharged to the HO Basin. Rates of discharge to Basin HO continued to be lower in 1998, due to the shutdown of the HFBR.
- In addition, several other recharge areas are used exclusively for discharging stormwater runoff; these include Basin HW (Outfall 008) and the Central Steam Facility (CSF) stormwater outlet.

Each of the recharge basins is a permitted point source discharge under BNL's SPDES permit. To facilitate monitoring of these discharges, each is equipped with a flow monitoring station. Weekly recordings of flow are maintained, along with records of pH, conductivity and temperature. The specifics of the SPDES compliance-monitoring program are provided in Chapter 3. To supplement the SPDES compliance sampling program, samples are also collected routinely and

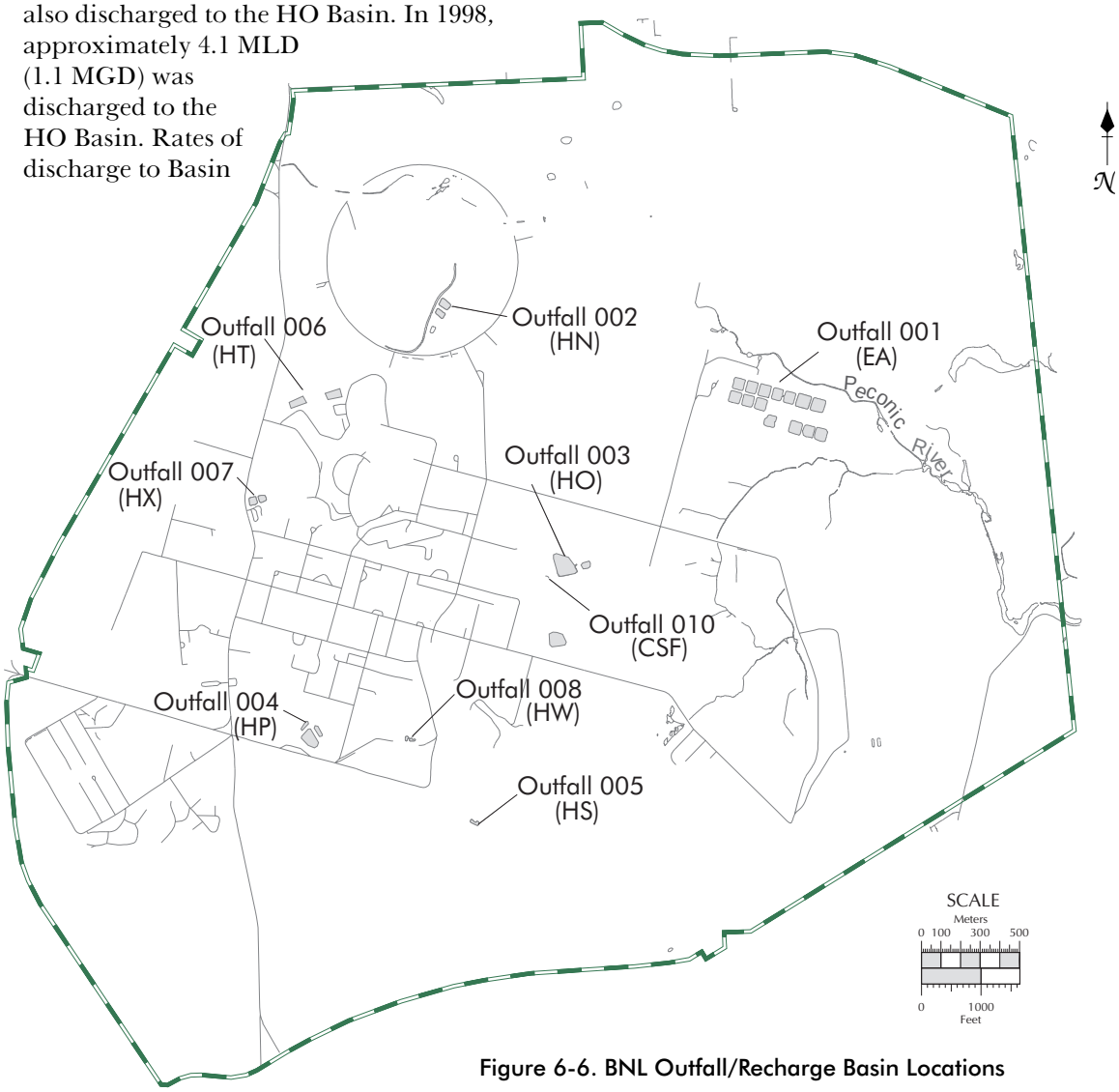

Figure 6-6. BNL Outfall/Recharge Basin Locations

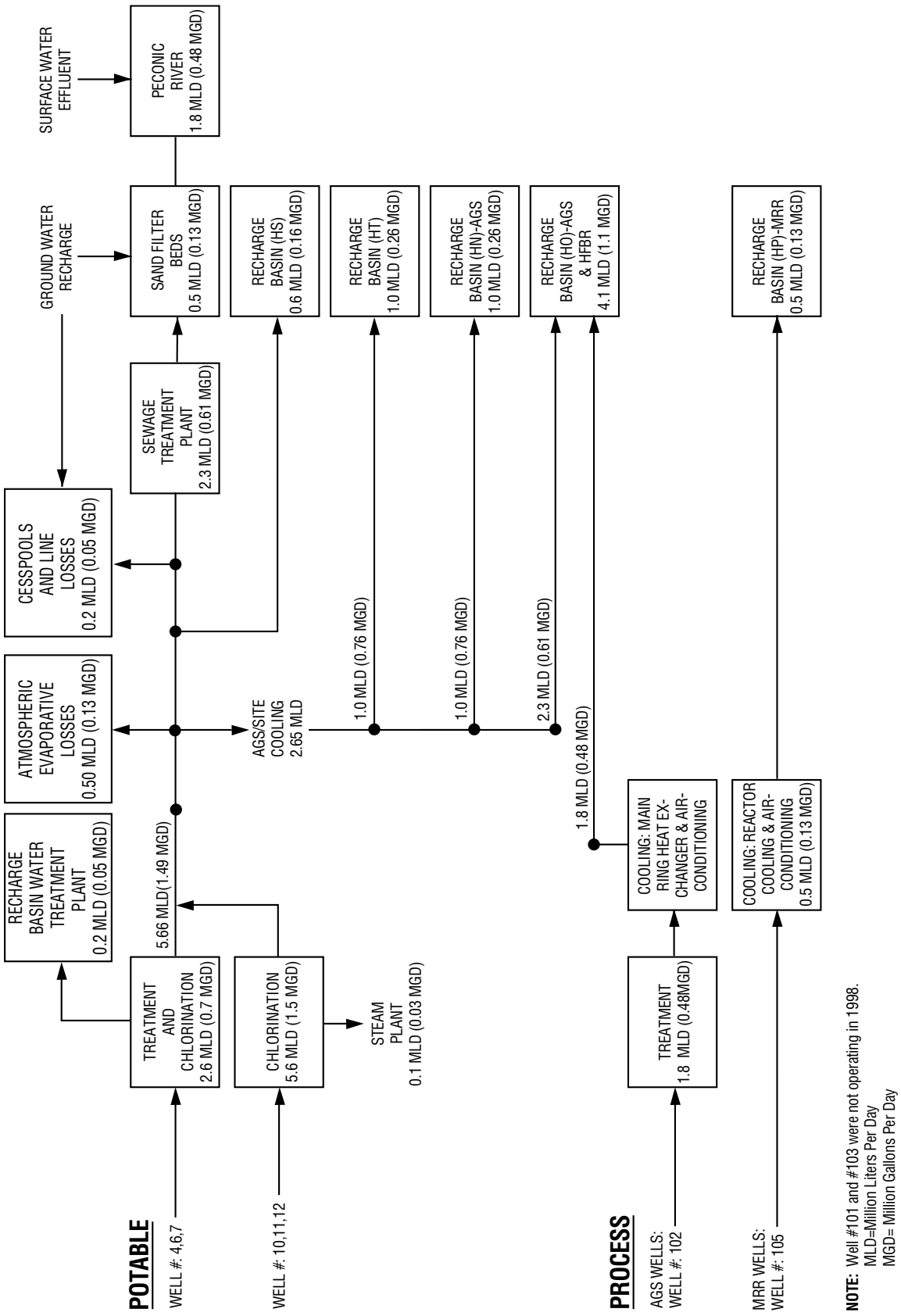

Figure 6-7. Brookhaven Nationl Laboratory Schematic of Water Use and Flow for 1998

analyzed under the environmental monitoring program for Volatile Organic Compounds (VOCs), metals and anions. During 1998, water samples were collected from Basins HN, HO, HP, HS, HT, HW, and the CSF storm water outfall.

6.2.1.1 RECHARGE BASINS - RADIOLOGICAL ANALYSES

Discharges to the recharge basins were sampled throughout the year to determine concentrations of gross activity, gamma-emitting radionuclides and tritium (if any). Radiological results for water samples collected at the recharge basins are presented in Table 6-4. As in previous years, Basin HN was found to contain trace amounts of radionuclides attributable to BNL operations. This basin receives secondary, non-contact magnet cooling water from the AGS. Secondary radiation in the vicinity of the beam line, where coolant lines run, may interact with elements in the water to produce radioactive species such as tritium. Metal corrosion products present in the system may also become activated. No elevations of gross activity levels were observed in any basin, and all average gamma-emitting radionuclide concentrations were far below applicable DCGs.

6.2.1.2 RECHARGE BASINS - NONRADIOLOGICAL ANALYSES

To determine the overall impact of these discharges on the environment, the data from samples collected from the discharges to the recharge basins were compared to groundwater discharge standards promulgated under Chapter 6 of the New York Code of Rules and Regulations (NYCRR), Part 703.6. Samples

Table 6-4. Radiological Analysis Results for Recharge Basin Samples

Basin		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Be-7 (pCi/L)	Na-24 (pCi/L)
HN	N	15	15	15	16	16
	Max.	3.3±1.9	5.4±1.4	2,540±326	25.5±13	182.0±24
	Avg.	0.8±0.7	-4.4±10.8	411±415	3.2±3.7	16.0±3
HO	N	11	11	11	11	11
	Max.	2.0±0.7	4.0±2.3	< 335	22.9±14	ND
	Avg.	0.4±0.6	-8.0±14.6	20±53	2.1±3.9	
HP	N	4	4	4	4	4
	Max.	< 1.4	< 3.7	< 304	ND	ND
	Avg.	-0.3±0.9	-19.7±34.8	64±112		
HS	N	4	4	4	4	4
	Max.	4.0±0.8	8.2±2.5	< 309	22.7±13.0	ND
	Avg.	1.4±2.2	3.8±3.7	0±28	13.7±8.3	
HTe	N	12	12	12	12	12
	Max.	5.0±0.9	6.8±1.4	< 335	ND	ND
	Avg.	0.3±1.0	-6.7±13.2	53±74		
HTw	N	11	11	11	12	12
	Max.	7.0 1.0	10.0±2.8	< 335	ND	ND
	Avg.	0.9±1.5	-7.7±14.8	62±59		
HW	N	3	3	3	3	3
	Max.	6.4±1.4	14.7±2.7	< 335	40.2±14	ND
	Avg.	3.8±2.3	6.0±9.1	57±135	19.4±19	
SDWA Limit		15	50	20,000	1,600	400

Notes:
1. All values reported with 95% confidence interval.
2. N = Number of samples collected for analysis.
3. ND = Not Detected.
4. See Section 4.7.2 for a discussion of negative radiological results.

were collected quarterly for water quality parameters, metals and VOCs and analyzed by the ASL. Field measured parameters (i.e., pH, conductivity and temperature) are routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 6-5 and 6-6, respectively. For VOCs, low concentrations of disinfection by-products were routinely detected in several discharges, as expected, including bromoform, chloroform, dibromochloromethane and dichlorobromomethane. Concentrations ranged from non-detectable to a maximum of 45 ppb. Sodium hypochlorite and bromine used as algae control agents in cooling towers were responsible for the formation of these compounds. With the exception of a single detection of 2-butanone (5 ppb) in recharge

Table 6-5. Water Quality Data for Onsite Recharge Basins

Location (a)		pH SU	Temp. C	Conductivity µmhos/cm	Chlorides mg/L	Sulfates mg/L	Nitrate as N (b) mg/L
HN	N	26	26	16	9	9	9
(RHIC Recharge)	Min.	6.9	2	47	3	2.2	<1.0
	Max.	8.2	23.4	386	181	150	4.9
	Avg.	NA	13.8	170	33.2	25.2	<1.0
HO	N	22	22	12	8	8	8
(HFBR-AGS)	Min.	6.3	4.4	35	3.1	2.2	<1.0
	Max.	7.9	22.7	190	20.5	12.8	<1.0
	Avg.	NA	14.9	123	16.5	8.9	<1.0
HP	N	8	8	5	4	4	4
(BMRR)	Min.	5.8	14.2	186	31.7	12.8	<1.0
	Max.	6.5	23	202	43.4	13.8	1.7
	Avg.	NA	17.9	192	35.1	13.3	1
HS	N	18	18	7	3	3	3
(Storm Water)	Min.	6.8	3.2	42	< 4	1.9	<1.0
	Max.	8.4	24	209	17	14.9	3.1
	Avg.	NA	12.9	118	11.7	10.8	<1.0
HT (c)	N	60	60	37	18	18	18
(LINAC)	Min.	6.8	3.4	23	1.2	0.7	<1.0
	Max.	8.3	26.3	231	20.9	21.6	5.3
	Avg.	NA	16	164	16.5	11.3	<1.0
HW	N	12	12	2	3	3	3
(Weaver Rd.)	Min.	5.8	2.7	70	< 4	4	<1.0
	Max.	8.1	25.5	93	8.1	12.5	3
	Avg.	NA	13.1	82	6.5	9.4	1.3
CSF	N	12	12	2	5	5	5
(Storm Water)	Min.	5.8	3.1	62	< 4	< 4	<1.0
	Max.	8	25.4	92	4.8	17.3	3.1
	Avg.	NA	14.5	77	< 4	7.5	<1.0
NYSDEC Effluent Standard		6.5 - 8.5	(d)	(d)	500	500	20
Typical MDL		NA	NA	10	4	4	1

Notes:
N: No. of samples
MDL: Minimum Detection Limit
NA: Not Applicable
a. The location of the recharge basins is provided on Figure 6-5.
b. The holding times specified by the USEPA were exceeded for several of these samples.
c. Recharge Basin HT has two discharge structures; consequently twice as many readings have been recorded.
d. No Class GA effluent standard specified.

Table 6-6. Metals Data for On-Site Recharge Basins

Location (a)	N		Al µg/L	As µg/L	Ba µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Hg µg/L	Mn µg/L	Ni µg/L	Na mg/L	Pb µg/L	V µg/L	Se µg/L	Zn µg/L
HN	10	Min.	9.9	< 3	19.3	< 1.1	< 0.12	1.2	20.4	69.1	< 0.2	2.7	< 1.1	3	< 1.3	< 5.5	< 5	19.2
(RHIC)		Max.	2809	< 3	56.0	< 1.1	1.8	5.3	99.2	3191	0.2	62.6	5.5	34.9	13.6	6.1	< 5	115.5
		Avg.	626	< 3	36.8	< 1.1	0.4	2.7	48.1	903	< 0.2	24	1.5	16.6	4.2	< 5.5	< 5	50.2
HO	9	Min.	4.4	< 3	< 1.8	< 1.1	< 0.12	< 1	2.8	30.1	< 0.2	2.5	< 1.1	2.7	< 1.3	< 5.5	< 5	< 4
(AGS/HFBR)		Max.	859.3	6.6	55.9	< 1.1	1.5	< 1	13.4	3059	0.21	351.2	4	18	3.6	< 5.5	33.4	61.9
		Avg.	121.5	< 3	29.6	< 1.1	0.6	< 1	6.7	828.9	< 0.2	93.9	1.1	12	< 1.3	< 5.5	< 5	17.2
	4	Min.	15.3	< 3	57.4	< 1.1	0.15	< 1	4.2	68.5	< 0.2	51.9	< 1.1	17.6	< 1.3	< 5.5	< 5	HP 10.3
(BMRR)		Max.	54.2	< 3	676.3	< 1.1	0.21	< 1	6.8	847.4	< 0.2	62.9	< 1.1	20.2	< 1.3	< 5.5	< 5	48.6
		Avg.	35.2	< 3	213.5	< 1.1	0.18	< 1	5.2	314	< 0.2	58.9	< 1.1	18.8	< 1.3	< 5.5	< 5	22.5
HS	4	Min.	84.7	< 3	21.2	< 1.1	< 0.12	2	9.4	64.7	< 0.2	2.8	< 1.1	2.9	< 1.3	< 5.5	< 5	16.5
(Storm		Max.	1719	< 3	43.2	< 1.1	0.86	6.2	49.8	1329	< 0.2	30.6	2.5	24.5	15.1	< 5.5	< 5	160.5
Water)		Avg.	547	< 3	33.3	< 1.1	0.33	3.5	22.4	478.3	< 0.2	15.9	1.7	13.9	7.2	< 5.5	< 5	71.7
HT (b)	19	Min.	8	< 3	23.3	< 1.1	< 0.12	< 1	9.7	30.2	< 0.2	< 2	< 1.1	12.8	< 1.3	< 5.5	< 5	7.6
(Linac)		Max.	250.7	< 3	66.8	< 1.1	0.23	9	92.4	381.8	0.2	9.9	1.5	34.6	5.1	102.6	< 5	55.2
		Avg.	65.6	< 3	36.7	< 1.1	< 0.12	< 1	31.2	117.7	< 0.2	3.8	< 1.1	20.8	< 1.3	< 5.5	< 5	26.1
HW	3	Min.	131.8	< 3	20.4	< 1.1	0.3	1.1	7.2	228	< 0.2	10.4	2.3	1.2	7.1	< 5.5	< 5	58.7
(Weaver Rd.)		Max.	3209	< 3	42.2	3.8	7.6	13.7	82.7	4379	0.37	61.6	10.6	5	72	18.1	< 5	274
		Avg.	1235.7	< 3	32.1	2	2.8	5.6	36.7	1676	< 0.2	30.1	5.3	2.9	29.4	6	< 5	172
CSF	5	Min.	321.1	< 3	34.4	< 1.1	0.7	< 1	4.9	691	< 0.2	15.7	6.4	1.6	21.2	7.1	< 5	37.9
(Storm		Max.	1875	< 3	72.7	2.6	5.6	13.7	51.4	7305	< 0.2	70.8	52.9	5.1	77.5	49.5	< 5	249.2
Water)		Avg.	1200.8	< 3	50.6	< 1.1	3.1	5.7	26.3	2583	< 0.2	27.1	24.8	3.1	43.6	35.2	< 5	127.1
NYSDEC Effluent Limitation or AWQS			2000	50	2000	10	5	100	1000	600	1.4	600	200	NS (c)	50	NS (c)	20	5000
Typical MDL			2.2	3	1.8	1.1	0.12	1	2	15	0.2	2	1.1	1	1.3	5.5	5	4

Notes:
N: No. of samples.
MDL: Minimum Detection Limit.
a. Locations of recharge basins are shown on Figure 6-6.
b. Recharge Basin HT is comprised of two discharge structures, hence twice as many samples are collected and analyzed.
c. No effluent standard specified.

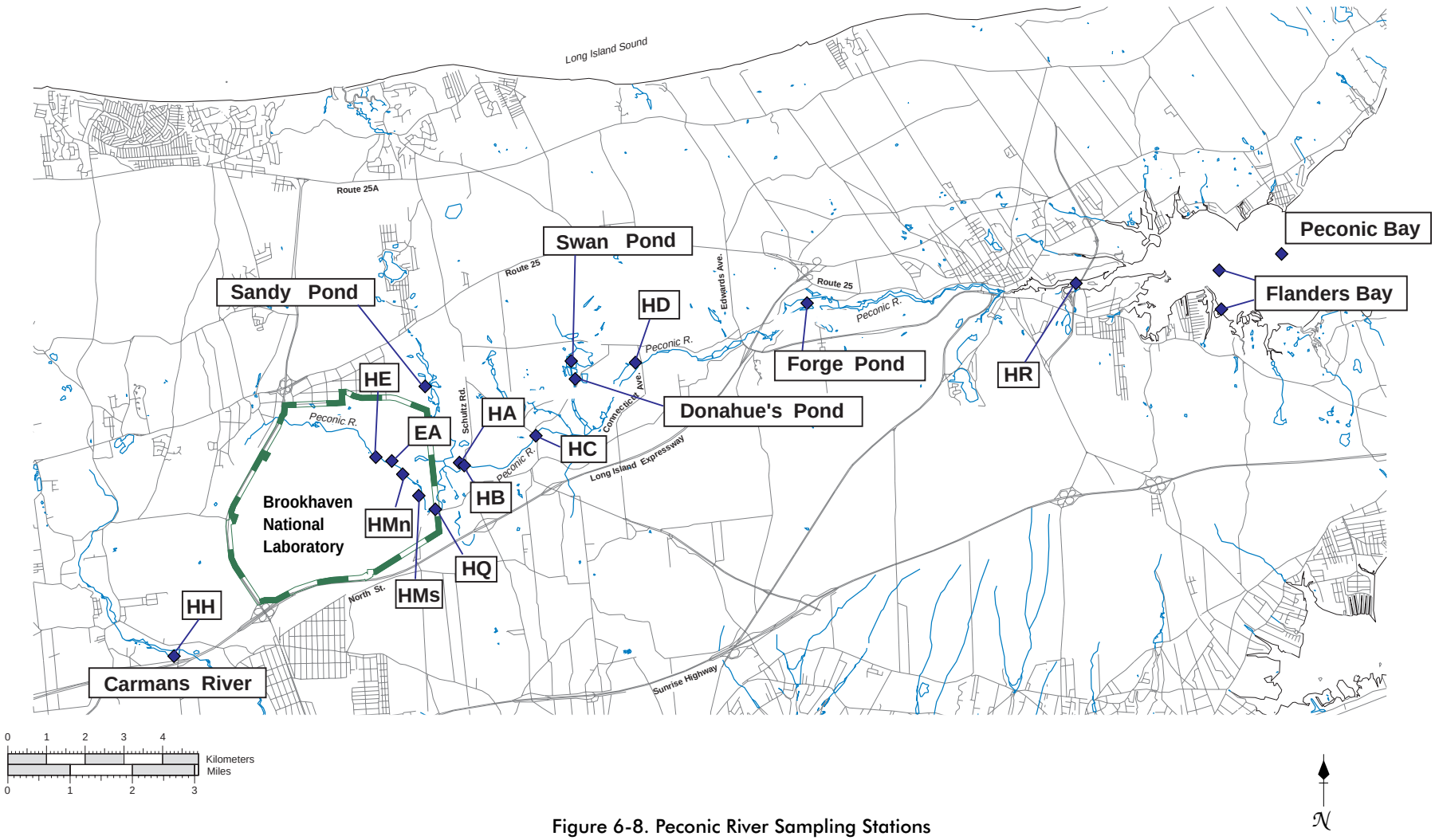

Figure 6-8. Peconic River Sampling Stations

Table 6-7: Radiological Analysis of Peconic River Water Samples

Sample Station	Geographic Location		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Sr-90 (pCi/L)
HMn	Peconic River, 0.7 km from STP, On-Site	N	148	148	150	4
		Max.	8.3±3.1	15.1±5.6	8,440±543	< 0.95
		Avg.	1.4±0.2	5.0±0.5	185±115	-0.39±0.85
HMs	Peconic River tributary, On-Site	N	7	7	7	5
		Max.	1.4±0.8	< 4.0	< 304	0.27±0.07
		Avg.	0.2±0.5	1.2±0.9	-116±65	-0.91±0.75
HQ	Peconic River, BNL site boundary	N	101	101	103	2
		Max.	4.1±2.0	13.2±5.6	822±234	< 0.68
		Avg.	1.1±0.2	4.4±0.6	94±33	-1.66±1.06
HA	Peconic River, Off-Site	N	4	4	4	4
		Max.	2.0±1.0	< 3.7	< 335	0.84 ±0.20
		Avg.	0.1±1.1	-22.4±35.6	174±55	-0.34±0.75
HB	Peconic River, Off-Site	N	4	4	4	3
		Max.	< 1.4	< 3.7	< 335	< 0.21
		Avg.	-0.2±0.8	-21.8±36.4	94±94	-0.15±0.19
HC	Peconic River, Off-Site	N	6	6	6	4
		Max.	1.4±0.9	< 3.7	< 302	< 0.11
		Avg.	0.1±0.5	-16.4±24.2	83±54	-1.64±0.99
HD	Peconic River, Off-Site	N	1	1	1	NS
		Max.	0.9±0.5	< 2.1	< 322	
HR	Peconic River, Riverhead	N	5	5	5	4
		Max.	2.5±0.8	< 3.7	< 304	0.54±0.09
		Avg.	0.6±0.9	-17.4±28.4	38±68	-1.12±0.95
HH	Carmans River (Control Location)	N	4	4	4	4
		Max.	3.7±0.8	6.5±1.5	< 335	0.46 ±0.16
		Avg.	0.9±1.7	-21.2±37.2	115±144	-0.04±0.29
SDWA Limit			15	50	20,000	8

Notes:
1. All values shown with 95% confidence interval.
2. N = Number of samples analyzed.
3. NS = Not Sampled for this analyte.
4. No gamma-emitting anthropogenic radionuclides were detected in Peconic River water samples in 1998.
5. Station HMn Sr-90 analysis results based on composite samples, all others collected as grab samples.

Samples at Station HQ (located at the eastern site boundary) were collected on a much more frequent basis than in recent years, due to increased flow of the Peconic there. Since the Peconic is a groundwater-fed river, continued elevated water table levels in 1998 served to provide frequent flow at this location. Over 100 samples were collected at HQ for gross activity and tritium analysis. Annual average gross activity values were below typical minimum detection limits. Tritium was rarely detected at HQ, reflecting the trend recorded at the STP outfall. Tritium was not detected in any quarterly Peconic River sample collected beyond the BNL site boundary.

In Peconic River samples collected at Riverhead (Location HR), gross alpha and gross beta activity values were consistent with typical background values. Neither tritium nor any man-made gamma-emitting radionuclides were detected. One out of four samples analyzed for strontium-90 showed a value above the MDL. The result for that sample was equal to 0.54 ± 0.09 pCi/L (20 ± 3 mBq/L) with a MDL of 0.13 pCi/L (5 mBq/L). Given that the other three samples showed values for strontium-90 which were negative, this value is considered suspect. Samples collected from the Carmans River control location showed a similar pattern in that one of four samples

Table 6-8. Water Quality Data for Surface Water Samples Collected Along the Peconic and Carmans Rivers

River	Sample Location[a]		pH SU	Conductivity umhos/cm	Temp. deg. C	Dissolved Oxygen mg/L	Chlorides mg/L	Sulfates mg/L	Nitrates as N mg/L
Peconic	**HE**	N	15	15	15	0	12	12	12
		Min.	4.8	69	2.6	0	19.8	9.9	2.1
		Max.	8	223	22.1	0	34	19.6	8.2
		Avg.	NA	98	11.7	0	23.9	15.4	5.6
	HMn	N	152	152	152	149	8	8	8
		Min.	5	51	2	3.6	18.8	7.9	< 1
		Max.	7.3	291	23.4	15.3	60.5	17.5	6.6
		Avg.	NA	175	12.6	8	30.3	13.3	3
	HMs	N	5	5	5	0	6	6	6
		Min.	3.8	41	5.5	0	< 4	< 4.0	< 1.0
		Max.	4.5	95	18.9	0	7.7	7.8	< 1.0
		Avg.	NA	57	12.5	0	< 4	< 4	< 1.0
	HQ	N	110	110	110	109	8	8	8
		Min.	5.1	48	1	0.3	8.9	< 4	< 1.0
		Max.	7.5	233	24.3	13.7	27.7	15.5	1.4
		Avg.	NA	134	14.2	5	18.2	8.8	< 1.0
	HA	N	5	5	5	0	4	4	4
		Min.	5.3	49	9.3	0	7.5	< 4.0	< 1.0
		Max.	6.1	77	19.2	0	11.7	6.4	< 1.0
		Avg.	NA	61	15.1	0	9	< 4	< 1.0
	HB	N	4	4	4	0	4	4	4
		Min.	5.4	44	9.5	0	6.2	< 4.0	< 1.0
		Max.	6.1	86	19	0	10.4	5.2	< 1.0
		Avg.	NA	69	14	0	8.6	< 4.0	< 1.0
	HC	N	4	4	4	0	4	4	4
		Min.	6.2	57	9.3	0	8	< 4.0	< 1.0
		Max.	6.8	68	19.2	0	11	8	< 1.0
		Avg.	NA	63.5	14.7	0	9.8	6.1	< 1.0
	HR	N	4	4	4	0	3	3	3
		Min.	6.2	90	9.1	0	12.1	8.1	<1.0
		Max.	7.5	120	20.9	0	14.6	10.2	<1.0
		Avg.	NA	104	15.5	0	13.2	9.5	<1.0
Carmans	**HH**	N	4	4	4	0	4	4	4
(Control Location)		Min.	5.5	110	10.1	0	16.5	8.6	<1.0
		Max.	7.7	191	19	0	25	11.4	1.7
		Avg.	NA	152	14.4	0	21.9	10.4	1.1
NYS AWQS (b)			6.5 - 8.5	(c)	(c)	(c)	250	250	10
Typical MDL			NA	10	NA	NA	4	4	1

Notes:
N: No. of samples
NA: Not Applicable
MDL: Minimum Detection Limit
a. The Peconic and Carmans Rivers sample locations are shown on Figure 6-7.
b. AWQS: Since there are no Class C Surface Water Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for Ground Water is provided, if specified.
c. No AWQS specified.

Table 6-9. Metals Concentration Data for Surface Water Samples Collected Along the Peconic and Carmans Rivers

River	Sample Location [a]		Ag µg/L	Al µg/L	Ba µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu ug/L	Fe µg/L	Hg µg/L	Mn µg/L	Ni µg/L	Na mg/L	Pb µg/L	V µg/L	Se µg/L	Zn µg/L
Peconic	**HE**	N	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
		Min.	< 1	123.4	21.1	< 1.1	0.5	< 1	< 2	54.7	< 0.2	59.1	< 1.1	8.2	< 1.3	< 5.5	< 5	8.2
		Max.	14	905.3	86.8	< 1.1	15.3	9.5	41.5	10460	< 0.2	514	14.1	20.3	6.6	< 5.5	< 5	258.5
		Avg.	2	434.8	34	< 1.1	3.8	1.8	11.4	3592	< 0.2	169	2.7	11.4	2.2	< 5.5	< 5	56.9
	HMn	N	12	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8
		Min.	< 1	46	11.5	< 1.1	0.3	1	17.8	166.2	< 0.2	4.7	2.5	12.1	1.4	< 5.5	< 5	12.8
		Max.	2.4	450	17.3	< 1.1	1.3	2.4	49.4	1453	< 0.2	142.9	4.3	30.6	7.8	8.1	< 5	76.4
		Avg.	1.8	202.4	13.3	< 1.1	0.6	1.7	33.8	628.3	< 0.2	36.9	3.3	23.1	2.8	< 5.5	< 5	35.4
	HMs	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
		Min.	< 1	57.8	22.2	< 1.1	0.2	< 1	< 2	179.4	< 0.2	21.7	< 1.1	1.7	< 1.3	< 5.5	< 5	< 2
		Max.	< 1	860	59.4	< 1.1	0.6	9.3	38.9	3096	< 0.2	46.1	2.8	3.6	5.6	< 5.5	< 5	61
		Avg.	< 1	613	39.4	< 1.1	0.4	1.7	7.2	723.7	< 0.2	30.3	< 1.1	3.1	1.3	< 5.5	< 5	26.4
	HQ	N	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
		Min.	< 1	16.5	9.5	< 1	0.3	< 1	12.5	113.6	< 0.2	9	2.9	8.7	< 1.3	< 5.5	< 5	4.7
		Max.	< 1	324.5	31.3	1.1	0.5	1.4	26.2	1085	0.24	84.4	4.3	34.6	1.8	6.6	< 5	117.6
		Avg.	< 1	211.5	12.7	< 1	0.4	< 1	16	424.3	< 0.2	27.8	3	18.3	< 1.3	< 5.5	< 5	28.5
	HA	N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Min.	< 1	89.9	< 1.8	< 1.1	0.2	< 1	< 2	341.1	< 0.2	34.5	< 1.1	4.6	< 1.3	< 5.5	< 5	14.7
		Max.	< 1	194.2	31.3	< 1.1	0.4	1.4	195.1	1580	< 0.2	58.5	2.4	9.1	9.4	< 5.5	< 5	111.4
		Avg.	< 1	155.2	20.9	< 1.1	0.3	< 1	50.6	1058	< 0.2	45.5	< 1.1	6.7	2.4	< 5.5	< 5	48.8
	HB	N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Min.	< 1	67.3	15.6	< 1.1	0.18	< 1	< 2	900.3	< 0.2	36.6	< 1.1	4.8	< 1.3	< 5.5	< 5	7.8
		Max.	< 1	173.4	48.1	< 1.1	0.5	< 1	37	4543	< 0.2	79.5	< 1.1	7.7	2	< 5.5	< 5	19.9
		Avg.	< 1	133.6	32.2	< 1.1	0.3	< 1	10.7	2627	< 0.2	56.7	< 1.1	6.3	< 1.3	< 5.5	< 5	13.2
	HC	N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Min.	< 1	46.5	24.5	< 1.1	< 0.1	< 1	< 2	533.9	< 0.2	32.2	< 1.1	4.9	< 1.3	< 5.5	< 5	5.5
		Max.	< 1	138.2	38.5	< 1.1	0.6	< 1	< 2	3424	< 0.2	195.8	< 1.1	8.9	< 1.3	< 5.5	< 5	15.9
		Avg.	< 1	92.8	29.7	< 1.1	0.2	< 1	< 2	1765.3	< 0.2	78	< 1.1	6.8	< 1.3	< 5.5	< 5	11.7
	HR	N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Min.	< 1	85.2	29.7	< 1.1	0.3	< 1	< 2	582.7	< 0.2	96.9	< 1.1	8.1	< 1.3	< 5.5	< 5	11.7
		Max.	< 1	515	42.1	< 1.1	0.5	< 1	3.7	2278	< 0.2	149.7	< 1.1	12.6	3.4	< 5.5	< 5	37.4
		Avg.	< 1	277.2	35.7	< 1.1	0.4	< 1	2.5	1416.7	< 0.2	123.8	< 1.1	10	2	< 5.5	< 5	11.7
Carmans	**HH**	N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
(Control Location)		Min.	< 1	33.2	14.9	< 1.1	< 0.1	< 1	< 2	297.5	< 0.2	37	< 1.1	11.2	< 1.3	< 5.5	< 5	5.4
		Max.	< 1	1746	71.6	< 1.1	0.6	< 1	5.6	1601	< 0.2	160.6	< 1.1	17.2	119.4	< 5.5	< 5	22.3
		Avg.	< 1	527.9	44.7	< 1.1	0.2	< 1	2	961.4	< 0.2	90.2	< 1.1	14.7	31	< 5.5	< 5	11.8
NYSDEC	AWQS		0.1	100	NS	1.1	5	34	4	300	0.8	NS	23	NS	0.1	14	4.6	37
Metallic State[b]			I	I		D	AS	D	D	AS	D		D		D	AS	D	D
Typical MDL			1	2.2	1.8	1.1	0.12	1	2	15	0.2	2	1.1	1	1.3	5.5	5	4

Notes:
N: No. of samples
AWQS: Ambient Water Quality Standard for Class C Surface Water
MDL: Minimum Detection Limit

a.The Peconic and Carmans River sample locations are shown on Figure 6-7.
b. The regulated state of these constituents are as follows:
I= Ionic Form
D= Dissolved Form
AS= Acid Soluble
NS=There are no AWQS specified for these elements for Class C waters.

showed a low positive value. This result is considered suspect for similar reasons.

6.3.2 PECONIC RIVER - NONRADIOLOGICAL ANALYSES

Organic and inorganic analytical data for Peconic and Carmans River samples are summarized in Tables 6-8 and 6-9. During 1998, these samples were analyzed for water quality parameters (i.e., pH, temperature, conductivity, and dissolved oxygen), anions (i.e., chlorides, sulfates, and nitrates), metals, and VOCs. There were no VOCs routinely detected in river water samples above the MDL, although trace concentrations (i.e., 2 ppb or less) were reported for acetone and methylene chloride at one or more locations. Due to the level of detection, the presence of these compounds is questionable.

Comparison of Peconic River water quality data collected upstream and downstream shows water quality parameters to be consistent throughout the river system. These data were also consistent with the Carmans River control location. Examination of the metals data shows that aluminum, copper, lead, iron and zinc were present in concentrations which exceeded ambient water quality standards at upstream, downstream and Carmans River stations. Though these elements were routinely detected in the STP discharge, the presence of these elements at upstream locations and locations not directly influenced by STP discharges is evidence of natural contributions. In several instances, the highest concentrations of these elements were detected at areas not influenced by the STP discharge. At station HE, upstream of the STP discharge, silver and cobalt were also detected above ambient water quality standards. The pH of the Peconic River, as measured upstream and downstream of the STP discharge, is frequently lower than the ambient water quality standard. Contributions of groundwater, natural decay products such as humic acids, and stormwater runoff, all of which have pH values typically less than 5.8, contribute to these observations.

Flora and Fauna

CHAPTER 7

Brookhaven National Laboratory (BNL) has a wildlife management program to protect flora and fauna and their habitats. BNL's wildlife management strategy is based on an understanding of the resources onsite, assuring compliance with applicable requirements, protecting and monitoring the ecosystem, research, and communication. Monitoring to determine whether current or historical activities have endangered wildlife is part of this program. No BNL-related radionuclides were detected in local farm-grown vegetation in 1998. Deer and fish sampling results are consistent with previous years. Deer residing on the BNL site were found to contain elevated concentrations of cesium-137. Fish from the Peconic River collected at the BNL boundary appear to show a slightly elevated radionuclide content, though at levels which continue to decrease over time.

7.1 WILDLIFE MANAGEMENT PROGRAM

The purpose of the Wildlife Management Program is to promote stewardship of the natural resources found at Brookhaven National Laboratory (BNL), and to integrate their protection with the Laboratory's mission. In 1998, BNL developed a Wildlife Management Plan that describes the program strategy, elements and planned actions (Naidu, 1998). The program elements and some of the associated actions are summarized below.

7.1.1 IDENTIFICATION AND MAPPING OF NATURAL RESOURCES

An understanding of the environmental baseline is the starting point for wildlife management planning. The Pine Barrens Commission conducted a natural resources inventory of the BNL site based on data collected from 1970 to 1990. This mapping process has identified environmentally sensitive areas, and significant wildlife communities. BNL is in the process of updating this inventory.

As noted in Chapter 1, a wide variety of vegetation, birds, reptiles, amphibians, and mammals have been found onsite at BNL. There is only one New York State (NYS) endangered species that is a regular inhabitant of BNL property—the tiger salamander *(Ambystoma tigrinum)* (see Figure 7-1). One NYS "Species of Special Concern" has also been identified, namely, the banded sunfish (Enneacanthus obesus) (see Figure 7-2).

7.1.2 HABITAT PROTECTION OR ENHANCEMENT

Actions to eliminate or minimize negative impacts on sensitive or critical species are either incorporated into BNL procedures or incorporated into specific project plans. Environmental restoration efforts remove sources that could pollute habitats. Access to critical habitats is restricted. A map of tiger salamander breeding locations is maintained and reviewed when projects are proposed to ensure that those projects do not negatively affect the breeding areas. In some cases, habitats are enhanced to improve survival or increase populations. Routine activities (e.g., road maintenance) that are not expected to impact habitats are allowed to proceed.

Efforts to protect the tiger salamander include determining when adult salamanders are migrating toward breeding locations, when juveniles and adults are migrating after breeding, and when metamorphosis has been completed. During these times, construction and/or maintenance activities by BNL are minimized. Water quality testing is conducted as part of the routine monitoring of water basins. These data are used to assess the quality of water prior to the breeding cycle. Beginning in 1999, a biennial survey of tiger salamander habitats will be conducted. The results of such surveys will pinpoint how long the breeding period lasts here and provide a window for construction activities in and around the breeding areas. The information may also identify changes in site use that are needed and possible activities that could be affecting this species.

Banded sunfish protection efforts include ensuring that adequate flow of the river is maintained within areas currently identified as sunfish habitats, ensuring that existing vegetation in the sunfish habitat is not disturbed, and evaluating all river remediation efforts for potential impacts on these habitats. The banded sunfish is shown in Figure 7-2.

During 1998, BNL participated in the American Forestry Global ReLeaf program as part of the Long Island re-vegetation program. This program was instituted in the wake of the extensive forest fires of 1995. Students, volunteers and BNL staff and their families planted over 15,000 pine seedlings in the vicinity of BNL's northern firebreaks (see Figure 7-3). Over 50 percent of the seedlings survived. The program will be repeated in 1999.

7.1.3 POPULATION MANAGEMENT

BNL also manages other populations as necessary to ensure that they are sustainable, and to control undesirable species. For example, BNL monitors populations of species of interest, such as the wild turkey. BNL is also in the process of updating information on the deer populations onsite. Since there are no natural predators onsite and hunting has never been permitted at BNL, there are no significant pressures on the population to migrate beyond their typical geographical range of approximately 1.6 kilometers (one mile). A 1992 study indicated that the population of deer onsite exceeded 700, or approximately 39 deer per km^2 (100 per mi^2). Normally a population density of 4 to 12 per km^2 (10 to 30 per mi^2) is considered an optimum sustainable level for a given area. Overpopulation can

Figure 7-1.
Tiger salamander *(Ambystoma tigrinum)*, a New York State-listed endangered species. Breeding habitats hve been found at vaious locations at BNL. The salamander was released immediately after the photograph was taken.

Figure 7-2.
Banded sunfish *(Enneacanthus obesus)*, a New York State "Special Concern" species. Photographed along with a quarter to show relative size of fish. This live specimen was returned to the water body immediately after photograph was taken.

Figure 7-3.
Student planting seedlings as part of the Global ReLeaf program in an area of the BNL site that experienced extensive damage as a result of the 1995 forest fires.

affect both animal and human health (e.g., deer ticks transmit Lyme Disease), decrease species diversity (due to selective grazing and destruction of habitat), and can also result in increased property damage and traffic accidents as animals forage into developed areas for food. Options for managing the deer population are under evaluation, and BNL will work with the regulators and the community if active management (such as culling the herd) is determined to be necessary.

7.1.4 COMPLIANCE ASSURANCE AND POTENTIAL IMPACT ASSESSMENT

BNL's National Environmental Policy Act (NEPA) program is one of the keys to ensuring that environmental impacts of a proposed action are adequately evaluated and addressed. BNL will continue to use NEPA, or NEPA equivalence under the Comprehensive Environmental Response, Compensation and Liability Act program, as the process for identifying potential environmental impacts associated with site activities (especially physical alterations). As appropriate, stakeholders such as the U.S. Environmental Protection Agency (USEPA), New York State Department of Environmental Conservation (NYSDEC), Suffolk County Department of Health Services (SCDHS), The Nature Conservancy, the Town of Brookhaven, the Citizens Advisory Board, and local environmental advocacy groups are involved in reviewing projects which have potential environmental impacts.

7.2 MONITORING

7.2.1 DEER SAMPLING

Deer in New York State typically grow to large sizes, with average weights of approximately 68 kg (150 lbs); females are slightly less at about 45 kg (100 lbs). However, deer on Long Island tend to be much smaller in size, with an average weight of less than 36 kg (80 lbs). The available meat on local deer ranges from 9 to 18 kg (20 to 40 lbs) per deer.

As in 1997, an offsite deer-sampling program was again conducted in cooperation with the NYSDEC Wildlife Branch. The NYSDEC samples provide data on deer moving beyond BNL boundaries that can be legally hunted. This program also provides control data on deer living in locations which are distant from BNL. The total number of samples obtained near the BNL site was very limited in 1998 due to a low response rate from hunters who were approached for samples at state check-points. In all, six deer were obtained onsite, while 13 were gathered from offsite locations.

BNL has been monitoring radionuclide levels in deer onsite since 1992. Onsite samples were collected primarily from deer killed in automotive incidents. Samples were analyzed for gamma-emitting radionuclides; results are shown in Table 7-1. It has been previously established that deer taken on BNL property contain concentrations of cesium-137 (half-life = 30 years) at levels above those taken from offsite (see the BNL Site Environmental Reports for 1996 and 1997 for data). This is most likely the result of deer grazing on vegetation growing in soils where elevated cesium-137 levels are known to exist. Cesium-137 in these soils can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals. Remediation of contaminated soil areas is being addressed as part of the site environmental restoration program.

The maximum onsite concentration of cesium-137 detected in all hind meat samples was 8.8 pCi/g (0.3 Bq/g), wet weight (the concentration prior to drying for analysis). The arithmetic average concentration of all samples of hind meat in which cesium-137 was detected was 4.9 pCi/g (0.2 Bq/g). This may be compared with the maximum and average hind-meat cesium-137 concentrations recorded in offsite samples of 4.3 and 1.1 pCi/g (0.2 and 0.04 Bq/g), respectively. Maximum and average cesium-137 concentrations in liver samples from deer collected onsite show a similar pattern of elevation. Figure 7-4 shows the ranges of cesium-137 concentrations in hind samples from onsite deer collected since 1996.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 9. The NYSDOH has formally assessed the potential public health risk associated with the elevated cesium-137 levels in onsite deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH, 1999).

With respect to health of the onsite deer population, the International Atomic Energy Agency (IAEA) has concluded that chronic

Table 7-1. Radiological Analysis of Deer Tissue

Location	Collect Date	Tissue	K-40 (pCi/g, wet)	Cs-137 (pCi/g, wet)
BNL				
Bell Ave. at Grove St.	02/25/98	Hind	1.86±0.32	ND
Bell Ave. at Grove St.	02/25/98	Liver	2.84±0.53	ND
BNL Observatory	04/09/98	Hind	5.26±1.58	0.24±0.15
BNL Observatory	04/09/98	Liver	3.19±2.21	ND
BNL Princeton Rd.	04/16/98	Hind	4.07±0.97	ND
BNL Princeton Rd.	04/16/98	Liver	1.77±0.43	ND
0.25 mi. S of South Gate	12/20/98	Hind	4.15±1.05	8.79±1.54
0.25 mi. S of South Gate (*)	12/20/98	Hind	2.51±0.44	7.01±1.21
RHIC	12/22/98	Hind	2.22±0.42	1.92±0.32
RHIC	12/22/98	Liver	4.72±1.15	14.59±2.88
0.25 mi. E of Main Gate	12/29/98	Hind	2.55±0.43	6.56±1.10
0.25 mi. E of Main Gate	12/29/98	Liver	2.11±0.48	1.85±0.42
Offsite				
Bridge Hampton	01/07/98	Hind	2.81±0.53	0.05±0.02
Camp Wauwepea, Ridge	01/12/98	Liver	2.23±0.39	ND
Camp Wauwepea, Ridge (*)	01/12/98	Liver	2.70±1.26	0.14±0.14
Lilco Substation	01/12/98	Hind	3.80±0.66	0.24±0.05
Intersection of Rt. 111 / Rt. 51	01/18/98	Hind	2.26±0.47	0.53±0.10
Intersection of Rt. 111 / Rt. 51 (*)	01/18/98	Hind	2.50±0.42	0.66±0.11
Ridge, 5 mi. N of Rt. 25	02/10/98	Hind	2.40±0.64	ND
Brookhaven State Park	08/18/98	Liver	2.29±0.39	ND
Wm Floyd Pkwy, N of Rt. 251	08/18/98	Hind	2.24±0.50	ND
Brookhaven State Park	08/19/98	Liver	3.34±1.42	0.41±0.18
Brookhaven State Park (*)	08/19/98	Liver	2.84±1.00	ND
Brookhaven State Park	08/19/98	Thyroid	21.23±18.14	4.30±2.87
Brookhaven State Park	08/20/98	Hind	3.12±0.74	2.14±0.40
Brookhaven State Park	08/20/98	Liver	2.15±0.58	0.27±0.06
Brookhaven State Park	08/30/98	Hind	2.63±0.60	0.99±0.18
Brookhaven State Park	08/30/98	Liver	4.44±1.22	2.16±0.45
Middle Island Conservtion Center	09/30/98	Hind	6.32±1.46	3.20±0.65
Middle Island Conservtion Center	09/30/98	Liver	0.99±0.16	0.26±0.04
Wm Floyd Pkwy, 0.25 mi. N of BNL	12/20/98	Liver	1.15±0.21	ND
Wm Floyd Pkwy, 0.25 mi. N of BNL (*)	12/20/98	Liver	1.86±0.54	0.35±0.08
Wm Floyd Pkwy, 0.5 mi. N of BNL	12/20/98	Hind	3.20±0.76	ND
BNL Hind Meat Average	7 samples		3.2±0.9	4.9±2.7
Offsite Hind Meat Average	10 samples		3.1±0.8	1.1±0.7
BNL Liver Average	5 samples		2.9±1.0	8.2±7.9
Offsite Liver Average	10 samples		2.4±0.6	0.6±0.5

Notes:
1. ND = Not Detected.
2. All values shown with 95% confidence interval.
3. (*) = duplicate analysis, a second sample from the same animal.
4. All summary statistics include duplicate analysis results.

dose rates of 100 millirad per day (1 mGy/d) to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA, 1992). A deer containing a uniform distribution of cesium-137 at the highest levels observed to date would carry a total body burden of about 0.2 uCi (0.007 MBq). Under these conditions, such an animal would receive an absorbed dose of approximately 3 millirad per day (0.03 mGy/d), or 33 times less than the threshold evaluated by the IAEA.

7.2.2 FISH SAMPLING

BNL, in collaboration with the NYSDEC Fisheries Division, maintains an ongoing program for the collection of fish from the Peconic River and surrounding fresh water bodies. In 1998, various species of fish were collected from onsite portions of the Peconic River and from offsite locations such as Donahue's Pond, Forge Pond, Swan Pond, Hempstead Lake, Lake Ronkonkoma, Lower Lake (Yaphank) and the Carmans River (see Figure 6-7 in Chapter 6 for geographic loca-

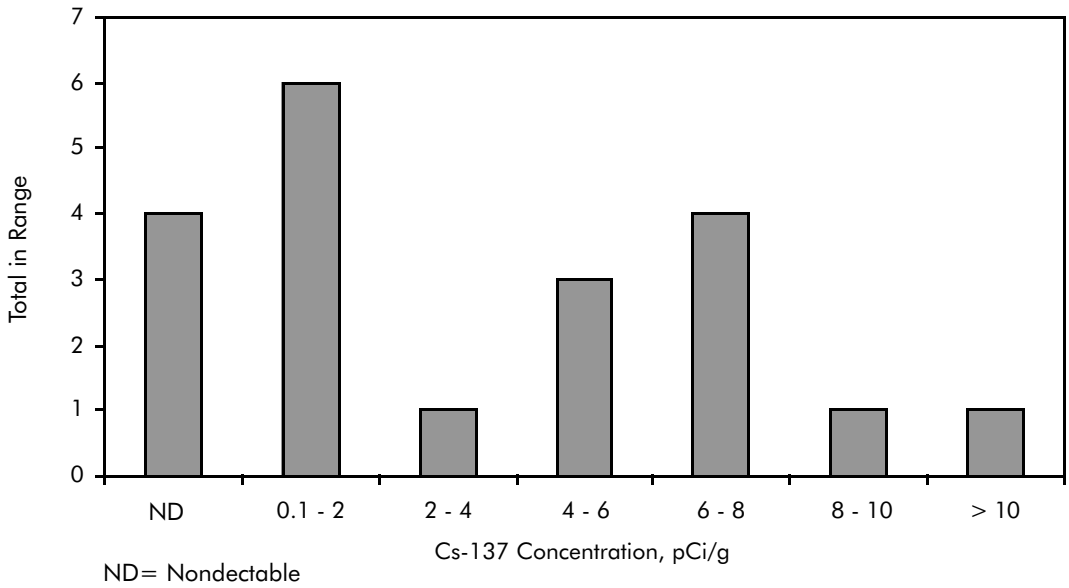

Figure 7-4. Ranges of Cs-137 concentrations detected in onsite deer samples since 1996 (hind tissue only).

Figure 7-5. BNL Staff and a Department of Environmental Conservation (DEC) Fishery Biologist use a hoop net at Swan Pond to capture fish.

tions). See Figure 7-5 for a photograph of fish sampling activities. Hempstead Lake, Lake Ronkonkoma, Lower Lake and the Carmans River are not connected to the Peconic River system and are, therefore, used as control locations to indicate environmental background conditions. Brown bullhead *(Ictalurus nebulosus)*, chain pickerel *(Esox niger)*, largemouth bass *(Micropterus salmoides)*, bluegill *(Lepomis macrochirus)*, pumpkinseed *(Lepomis gibbosus)*, creek chubsucker *(Erimyzon oblongus)*, and yellow perch *(Perca flavescens)* species were collected in 1998. Gamma spectroscopy analysis was performed on these samples. Specific information regarding the sampling point, species collected and analytical results is presented in Table 7-2. All sample results are presented as wet weight concentrations.

Note that in most cases analyses were performed separately on the flesh and skin, the viscera and bones, and the whole fish. Segregating the tissues in this way provides information regarding the localization of radionuclides in certain parts of the fish. Segregated analysis also allows for more realistic dose calculations to be performed since different radionuclides may become localized in different discrete tissues due to specific chemical characteristics. If the tissue in which a radionuclide concentrates is an inedible one, the source of intake is eliminated.

Concentrations of naturally occurring potassium-40 (a radionuclide common to soil and vegetation) were observed to be very consistent between Peconic River and control location fish, validating the comparability of the data. The only anthropogenic (man-made) radionuclide found in any fish sample, control or otherwise, was cesium-137. (Note that in 1998, the special analysis required for strontium-90 was not performed on fish samples. See Section 7.8.1 of the 1996 BNL Site Environmental Report for the most recent data.)

As discussed in Chapter 4, cesium-137 is detectable throughout the environment of the Northern Hemisphere as a result of global fallout. This is evident when examining the analytical results of control-location fish. Cesium values up to 0.43 pCi/g (16 mBq/g) were found in yellow perch flesh taken from Swan Pond. In order to account for the different feeding habits and weights of various species, it is important to compare similar

Table 7-2. Radiological Analysis of Fish from the Peconic River System and Background Locations

Fish/ Sample Type	K-40 (pCi/g, wet)	Cs-137 (pCi/g, wet)
Donahue's Pond		
Bluegill (whole)	2.94±0.83	0.14±0.06
Golden shiner (whole)	3.51±0.78	0.20±0.06
Yellow perch (flesh & skin)	3.40±0.65	0.40±0.08
Yellow perch (bone & viscera)	2.77±0.81	0.32±0.10
Chain pickerel (flesh & skin)	3.64±0.62	0.41±0.07
Chain pickerel (bone & viscera)	3.22±0.67	0.38±0.08
Brown bullhead (whole)	1.89±0.33	0.15±0.03
Brown bullhead (whole)	2.15±0.37	0.16±0.03
Forge Pond		
Largemouth bass (whole)	ND	ND
Bluegill (whole)	1.96±0.37	0.09±0.02
Bluegill (whole)	1.98±0.46	0.11±0.03
Brown bullhead (viscera & bone)	1.20±0.22	0.03±0.01
Brown bullhead (flesh & skin)	3.97±0.66	0.13±0.03
Peconic River, BNL Station HM		
Brown bullhead (whole)	2.87±0.56	0.37±0.08
Chain pickerel (whole)	3.29±0.61	0.41±0.08
Chain pickerel (flesh & skin)	4.58±1.04	0.73±0.17
Chain pickerel (bone & viscera)	1.93±0.46	0.26±0.06
Peconic River, North St.		
Brown bullhead (whole)	1.92±0.33	0.25±0.05
Brown bullhead (viscera & bone)	3.06±1.07	0.34±0.13
Brown bullhead (flesh & skin)	3.22±0.53	0.34±0.06
Creek Chub Sucker (whole)	2.27±0.43	0.42±0.08
Chain Pickerel (whole)	2.59±0.47	0.60±0.11
Peconic River, STP outfall		
Chain pickerel (whole)	3.74±0.83	0.36±0.08
Swan Pond (control)		
Yellow perch (whole)	2.41±0.46	0.23±0.05
Yellow perch (flesh & skin)	4.00±0.91	0.43±0.10
Yellow perch (bone & viscera)	2.84±0.74	0.34±0.08
Pumpkinseed (whole)	1.59±0.33	0.05±0.02
Brown bullhead (whole)	1.98±0.34	0.06±0.01
Brown bullhead (flesh & skin)	2.49±0.41	0.10±0.02
Brown bullhead (viscera & bone)	1.46±0.27	0.05±0.01
Hempstead Lake (control)		
Carp (whole)	1.69±0.30	0.02±0.01
Carp (whole)	2.03±0.36	0.03±0.01
Lake Ronkonkoma (control)		
White perch - flesh & skin	2.53±0.43	0.08±0.02
White perch - viscera & bone	2.85±0.93	ND
White perch - whole	2.24±0.38	0.08±0.02
Lower Lake, Yaphank (control)		
Yellow perch (whole)	2.38±0.48	ND
Yellow perch (flesh & skin)	4.02±0.83	ND
Yellow perch (bone & viscera)	2.52±0.68	ND
Brown bullhead (whole)	2.09±0.37	0.01±0.01
Brown bullhead (flesh & skin)	2.73±0.48	0.03±0.01
Brown bullhead (viscera & bone)	1.75±0.37	0.02±0.01

Notes:
1. ND = Not Detected.
2. All values shown with 95% confidence interval.

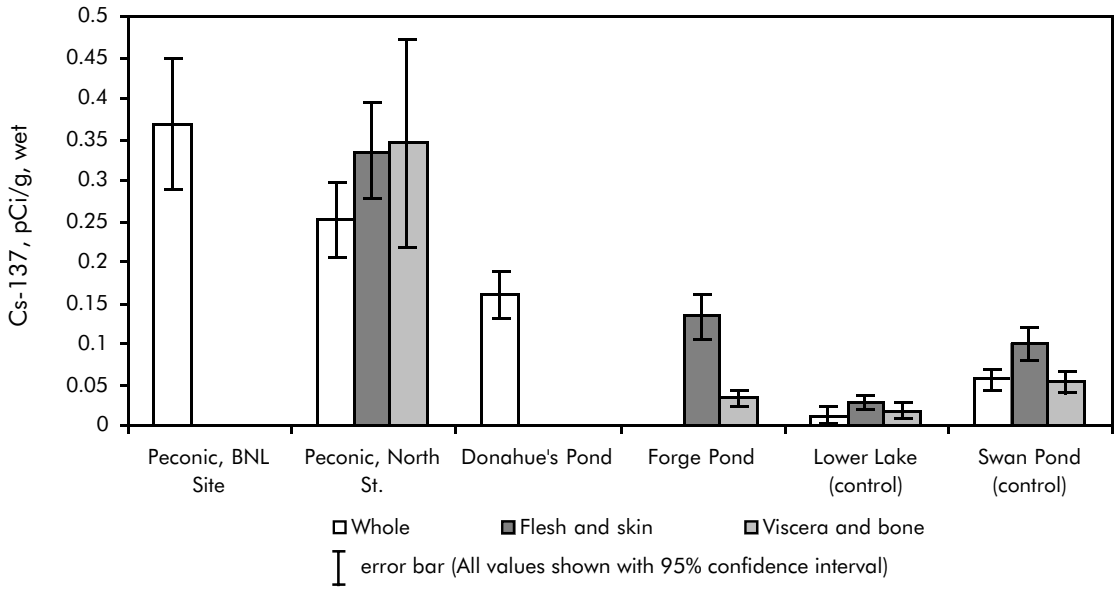

Figure 7-6. Concentration of Cs-137 in Brown Bullhead collected from Peconic River System

species to each other. A comparison of cesium-137 concentrations in brown bullheads collected from Peconic and control locations is plotted in Figure 7-6. (Each location does not show all three segregation categories since not all fish were segregated for analysis in the same manner.) It can be seen that cesium-137 concentrations in bullheads collected near the BNL Sewage Treatment Plant outfall are somewhat elevated in comparison to the control locations. The elevations become less pronounced with increasing distance from the Sewage Treatment Plant outfall (see Donahue's Pond and Forge Pond values).

Though it is clear from discharge records and sediment sampling that historical BNL operations have contributed to anthropogenic radionuclide levels in the Peconic River system, most of these nuclides (with the exception of tritium) were released between the late 1950's and early 1970's. Radionuclides in Peconic River fish have been measured since 1974 by the NYSDOH. Both the NYSDOH and BNL data indicate a continuing decrease in radionuclide concentrations in all fish species over time (NYSDOH, 1996). This is due to a lack of significant new radioactive discharges and the radioactive decay of materials discharged in the past.

7.3 VEGETATION SAMPLING

Vegetation samples were collected from several farms surrounding BNL (see Figure 7-7). Samples included typical farm vegetables such as potatoes, peppers and tomatoes. These samples were analyzed by the BNL Analytical Services Laboratory for gamma-emitting radionuclides. Direct monitoring of radioactive emissions and effluents discharged from BNL facilities indicates that no influence on local crops would reasonably be expected. The results shown in Table 7-3 confirm this, indicating only the presence of naturally occurring potassium-40 at levels which are typical of these types of samples. No radionuclides attributable to BNL operations were observed.

7.4 PECONIC RIVER SEDIMENTS

During Operable Unit V Peconic River characterization studies under the Environmental Restoration program, some sediment samples were found to contain americium-241. There are two possible explanations for the presence of this radionuclide. The first is that it may have been released directly to the BNL sanitary system at some time in the past. The second is that it is a decay product from plutonium-241. To assess these possibilities, exploratory sampling of Peconic River sediments on the BNL site and just beyond the boundary was conducted in 1998. The analytical results were ambiguous. A number of factors were responsible, including insufficient analytical sensitivity and background concentration data. To address these unresolved issues, a more comprehensive sampling plan was developed and will be executed in 1999 as

Figure 7-7.
Vegetation Sampling near the HM Monitoring Sie

Table 7-3. Radioogical Analysis Results for Local Vegetation Samples

Location	Sample Type	K-40 (pCi/g)
Lewin's Farm	Tomatoes	2.53±0.42
Lewin's Farm	Radish (Leaves)	0.99±0.19
Lewin's Farm	Bell Peppers	1.95±0.34
Lewin's Farm	Eggplant	1.25±0.21
Lewin's Farm	Turnip Stems	3.63±0.77
Lewin's Farm	Beet Root	3.93±0.65
Lewin's Farm	Potatoes	3.38±0.55
Lewin's Farm	Turnip (Leaves)	1.67±0.29
Lewin's Farm	Radishes	2.62±0.45
May's Farm	Corn Kernels (Yellow)	1.89±0.32
May's Farm	String Beans	2.45±0.41
May's Farm	Bell Peppers	0.25±0.04
May's Farm	Tomatoes	2.48±0.41
May's Farm	Zucchini	2.23±0.36
May's Farm	Eggplant	2.16±0.46

Notes:
1. All values shown with 95% confidence interval.
2. No anthropogenic radionuclides were detected in any local vegetation samples.

part of the cleanup project for Operable Unit V. The plan will address the confounding factors encountered during the 1998 sampling round. Available results will be discussed in the 1999 Site Environmental Report.

7.5 TOXICITY TESTING AT THE SEWAGE TREATMENT PLANT

Under the SPDES discharge permit, BNL conducts toxicity testing for the Sewage Treatment Plant effluent. Two species are evaluated—the fathead minnow *(Pimphales promelas)* and the water flea *(Ceriodaphnia dubia)*. Results from this testing program are presented in Chapter 3.

7.6 WILDLIFE MANAGEMENT EDUCATION, OUTREACH AND RESEARCH

BNL sponsors a variety of educational and outreach activities on natural resources. These programs are designed to provide an understanding of the ecosystem and foster interest in science. They are conducted at the Laboratory in collaboration with DOE, local agencies and local high schools and colleges. Ecological research is also conducted onsite to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning.

In 1998, a Smithtown High School student completed a follow-up study of the BNL Gamma Forest. The Gamma Forest was a research project that began in 1961, which examined the effects of long-term irradiation on a forest ecosystem. No evaluations of the area had been done since the project was terminated in 1979. In the follow-up study, an innovative method of depicting population/habitat relationships, in particular with regard to sediment chemistry and types, was developed. The student's research qualified him as a finalist in an INTEL Science Competition. Another study by a Smithtown High School student was conducted on succession communities in the woodlands at BNL as compared to those at the NYSDEC Rocky Point Preserva-

tion area and the Dwarf Pine Plains. This student was a semi-finalist in the Westinghouse Science competition.

A third study was conducted by BNL and Suffolk Community College staff to evaluate the effects of woodland clearing on forest types in the Long Island Pine Barrens. Both BNL and the NYSDEC preserve at Rocky Point were evaluated. The study focused on areas subject to extensive clearing involving removal of all vegetation and scraping of the surface deep into the subsoil. The results indicated that pitch pine *(Pinus rigida)* are "pioneer" species. Areas at both sites where disturbance was less severe experienced more traditional succession from grass to shrubs, etc. (Naidu, et al, 1997).

Finally, the 106 Rescue Group at the Westhampton Air Force Base conducted a project funded by a Department of Defense Legacy Grant which compared woodlands at BNL to the Westhampton site. Complete biological, chemical and geological surveys were carried out at both locations. The study received a Department of Defense Environment Management Award. Data from both of these studies is being incorporated into the BNL environmental database and the Wildlife Management Plan.

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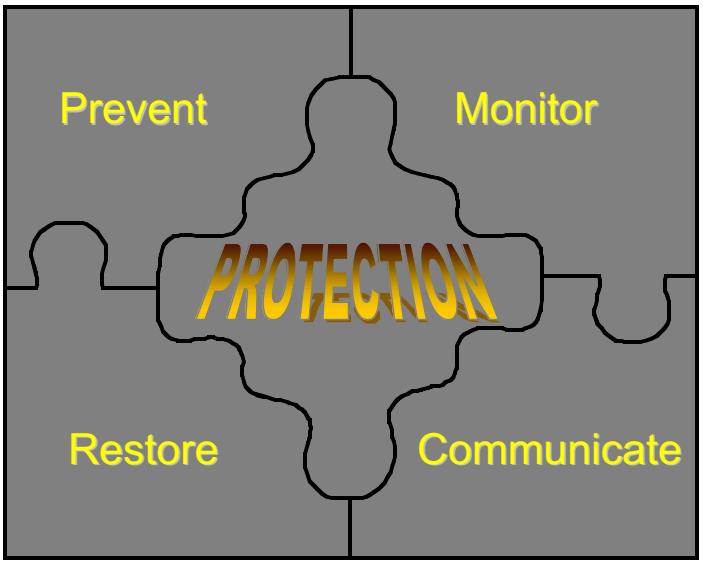
Groundwater Protection

CHAPTER 8

The Brookhaven National Laboratory (BNL) Groundwater Protection Program is made up of four elements: prevention, monitoring, restoration, and communication. In addition to implementing aggressive pollution prevention measures to protect groundwater resources, BNL has established an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. In 1998, BNL collected groundwater samples from 470 monitoring wells during 1,750 individual sampling events. Six significant volatile organic compound (VOC) plumes and six radionuclide plumes were tracked and evaluated. During 1998, four onsite groundwater remediation systems removed approximately 490 pounds of VOCs and returned approximately 2,800 million liters (740 million gallons) of treated water to the Upper Glacial aquifer.

The DOE Order 5400.1, "General Environmental Protection Program" requires development and implementation of a groundwater protection program. The primary goal of the BNL Groundwater Protection Management Program (GPMP) is to ensure that plans for groundwater protection, management, monitoring and restoration are fully defined, integrated and managed in a cost-effective manner that is consistent with federal, state and local regulations. The BNL GPMP includes policy, strategy, requirements and regulations applicable to groundwater protection (Paquette et al., 1998). As shown in the groundwater protection puzzle in center, the BNL GPMP consists of four interconnecting elements: 1) prevention, 2) monitoring, 3) restoration, and 4) communication.



BNL's Groundwater Protection Program

Prevention: BNL has initiated a three-phased project to: 1) identify past or current activities with the potential to affect environmental quality; 2) conduct a BNL-wide review of all experiments and industrial-type operations to determine the potential impacts of those activities on the environment and to integrate pollution prevention/waste minimization, resource conservation, and compliance into planning, decision-making and implementation; and 3) develop and implement an Environmental Management System (EMS). These activities are designed to prevent further pollution of the sole source aquifer underlying the BNL site, and are described in Chapter 2. In addition, as described in Chapter 3, efforts are being made to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater. Examples include upgrading underground storage tanks, closing cesspools, adding engineering controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (i.e., reducing the toxicity and volume of chemicals in storage or use).

Monitoring: BNL has an extensive groundwater monitoring network designed to evaluate groundwater contamination from historical and active operations. Groundwater monitoring is being conducted under two programs - the Environmental Monitoring Program designed to satisfy DOE and New York State (NYS) monitoring requirements for active research and support facilities, and the Environmental Restoration (ER) Program for monitoring related to BNL's obligations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These programs are coordinated to ensure completeness and to prevent any duplication of effort in the installation and abandonment of wells, and the sampling and analysis of groundwater. Furthermore, Data Quality Objectives (DQOs), plans and procedures, sampling and analysis, quality assurance, data management, and well installation, maintenance and abandonment programs are being integrated to optimize the groundwater monitoring system, and to ensure that water quality data are available for review and interpretation in a timely manner. In 1998, there were no major changes to BNL's groundwater monitoring program in terms of number of wells sampled, frequency of sampling or analytes tested for.

Restoration: BNL was added to the National Priorities List in 1989 (see Chapter 2 for discussion of the BNL's ER Program). Twenty-nine Areas of Concern (AOC) have been grouped into six Operable Units (OU). Remedial Investigation/Feasibility Studies (RI/FS) have been conducted for each OU. A primary goal of the

ER program is remediating soil and groundwater contamination, and preventing additional groundwater contamination from migration offsite. To that end, contaminant sources (e.g., contaminated soil, underground tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the Interagency Agreement (IAG) among the United States Environmental Protection Agency (USEPA), New York State Department of Environmental Conservation (NYSDEC) and DOE.

Communication: BNL has a community involvement, government and public affairs program to ensure that BNL communicates with the community in a consistent, timely and accurate manner. The majority of communications regarding groundwater protection have been associated with the ER Program. A number of communication mechanisms are in place, such as web pages, mailings, public meetings, briefings and roundtables.

8.1 GROUNDWATER MONITORING

Groundwater monitoring is an integral part of BNL's GPMP. Groundwater monitoring program elements include: installing monitoring wells; planning and scheduling; quality assurance; sample collection; sample analysis; data verification, validation and interpretation; and reporting. Monitoring wells are generally used to monitor specific facilities where degradation of the groundwater is known or suspected to have occurred, to fulfill regulatory permit requirements, to assess the quality of groundwater entering or leaving the BNL site, and to ensure that corrective measures designed to protect and restore groundwater are, in fact, working.

The groundwater beneath the BNL site is considered by NYS as Class GA groundwater. Class GA groundwater is defined as a source of potable water supply and suitable for drinking. As such, federal drinking water standards, NYS Drinking Water Standards (NYS DWS), and NYS Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater have been used as groundwater protection and remediation goals. The BNL groundwater surveillance program uses monitoring wells (which are not utilized for drinking water supply) to monitor research and support facilities where there is a potential for environmental impact, and areas where past waste handling practices or accidental spills have already degraded groundwater quality. BNL evaluates the potential impact of radiological and non-radiological levels of contamination by comparing analytical results to NYS and DOE reference levels and background water quality levels. Non-radiological analytical results from groundwater samples collected from surveillance wells are usually compared to NYSDEC AWQS. Radiological data are compared to NYS DWS (for tritium, gross beta, and strontium-90), NYS AWQS (for gross alpha and radium-226/228), and Safe Drinking Water Act (SDWA)/DOE Derived Concentration Guides (DCGs) (for determining the 4 mrem/dose for other beta/gamma-emitting radionuclides). Contaminant concentrations that are below these standards are also compared to background values to evaluate the potential effects of facility operations. The detection of low concentrations of facility-specific volatile organic compounds (VOCs) or radionuclides may provide important early indications of a contaminant release, and allow for the timely investigation into the identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 420 onsite and 50 offsite surveillance wells (Figure 8-1). Active and inactive facilities that have groundwater monitoring programs include the following: the Sewage Treatment Plant/Peconic River Area, Biology Agricultural Fields, Former Hazardous Waste Management Facility (HWMF), New Waste Management Facility (WMF), two former landfill areas, Central Steam Facility/Major Petroleum Facility (CSF/MPF), Alternating Gradient Synchrotron (AGS), Waste Concentration Facility (WCF), Supply and Materiel, and several other smaller facilities. As the result of detailed groundwater investigations conducted over the past fifteen years, as many as six significant VOC plumes and six radionuclide plumes have been identified (Figures 8-2 and 8-3). Groundwater quality is also routinely monitored at all active potable supply wells and process supply wells. In addition to groundwater quality assessments, water levels are routinely measured in over 650 onsite and offsite wells to assess variations in directions and velocities of groundwater flow.

Figure 8-1.
Locations of BNL Groundwater Monitoring Wells

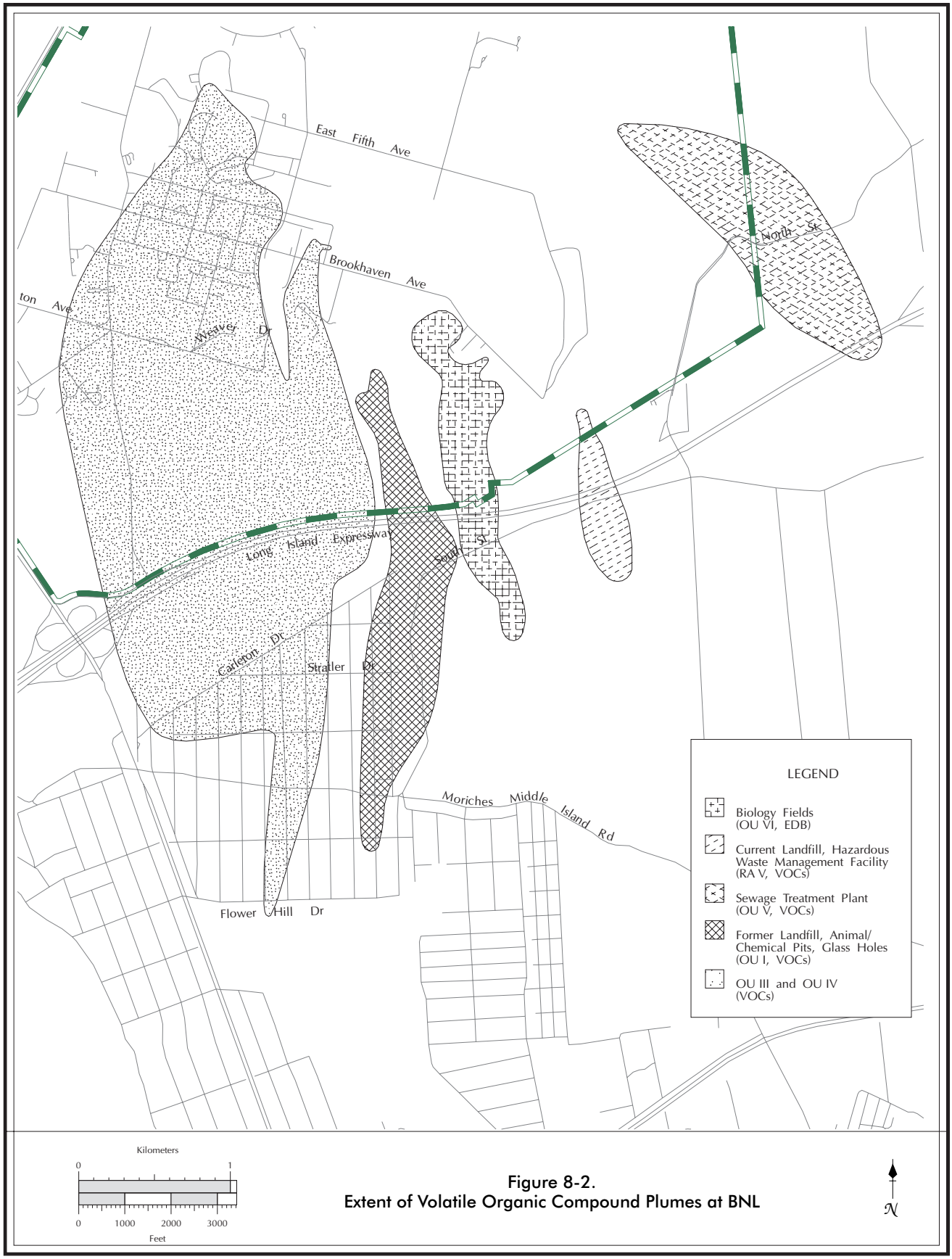


Figure 8-2.
Extent of Volatile Organic Compound Plumes at BNL

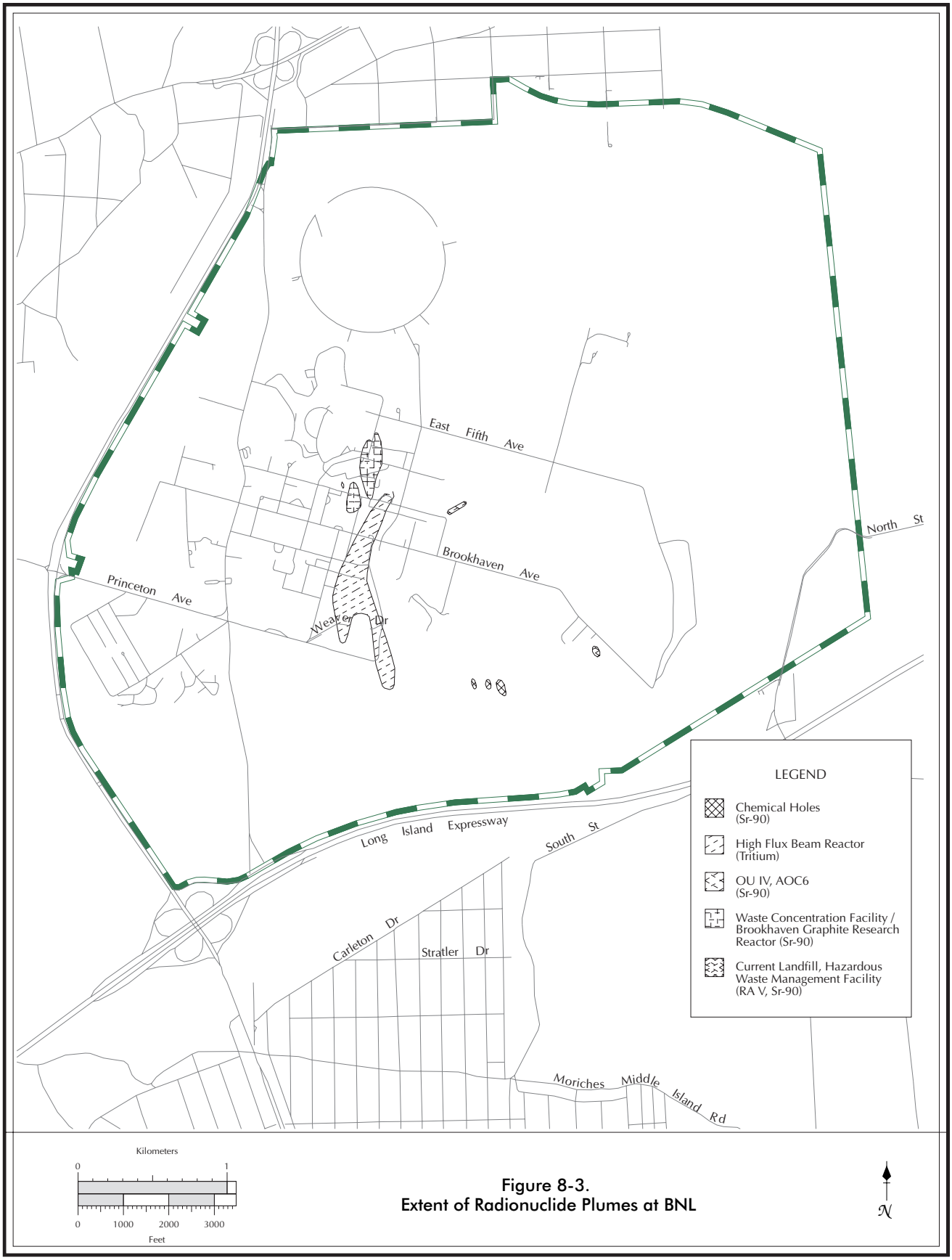


Figure 8-3.
Extent of Radionuclide Plumes at BNL

8.1.1 POTABLE AND PROCESS SUPPLY WELLS (SUPPLEMENTAL MONITORING PROGRAM)

Because of the proximity of BNL's potable supply wells to known or suspected groundwater contamination plumes and source areas, BNL conducts a supplemental potable supply well monitoring program that exceeds the monitoring required by the SDWA described in Chapter 3. This program also evaluates the quality of water obtained from process supply wells that is used to provide water for non-potable uses (secondary cooling water and biological experiments). Well water samples are typically collected quarterly and analyzed by the onsite Analytical Services Laboratory (ASL). Samples are usually analyzed for radionuclides (gross alpha, gross beta, gamma and tritium), VOCs (consisting of the primary volatile halogenated aliphatic hydrocarbons and aromatic hydrocarbons), inorganics (i.e., metals), and water quality parameters (nitrate, chlorides, and sulfates). These samples serve both as a quality control on contractor laboratory analyses of compliance samples (described in Chapter 3), and as an additional source of data used in evaluating groundwater quality.

The BNL supply well network consists of six potable supply wells (Wells 4, 6, 7, 10, 11, and 12) and five secondary cooling/process water supply wells (Wells 9, 101, 102, 103, and 105). All supply wells are screened entirely within the Upper Glacial aquifer (Figure 8-4). In 1998 Well 102 provided the secondary cooling water at the AGS, and Well 9 supplied process water to a facility where biological research is conducted with fish. Secondary-cooling water for the Brookhaven Medical Research Reactor (BMRR) was supplied exclusively from Well 105. Wells 101 and 103 were not operational during 1998, because Well 102 provided sufficient cooling water supply for AGS operations.

In 1998, samples were obtained quarterly from Potable Wells 10, 11 and 12 and analyzed for radioactivity, water quality indices, metals, and VOCs. Wells 4, 6, and 7 were sampled for field parameters, VOCs and radiological parameters. Wells 4, 6 and 7 were not sampled for water quality or metals under the surveillance program. Regulatory compliance samples were collected and analyzed in accordance with the BNL Potable Water System Sampling Plan. The results of the regulatory compliance samples were discussed in Chapter 3.

Process Supply Wells 9, 102, and 105 were analyzed for water quality, and inorganic and organic contaminants. Water chemistry analyses (e.g., pH and conductivity) were also performed for Well 102 by the AGS facility operators, as needed, to meet their operational requirements.

8.1.1.1 NON-RADIOLOGICAL ANALYSES

Tables 8-1 and 8-2 summarize the 1998 water quality and metals data for the BNL potable and process supply wells. The water quality data show that nitrates, sulfates, and chlorides are well within the limits established in the NYS DWS (Part 5 NYS Sanitary Code). The pH values in these wells ranged from 5.9 - 7.1 SU, and are typical of natural Long Island groundwater. (Note: The natural pH of groundwater at BNL has been found to range from 4.5 to 8.1 SU.) To reduce the corrosivity of the groundwater, Wells 10, 11, and 12 are equipped with metering pumps, which add sodium hydroxide to maintain the pH of the potable water effluent at approximately 8. The Water Treatment Plant (WTP) water softening process uses lime (calcium hydroxide) to reduce the corrosivity of the water obtained from Wells 4, 6 and 7.

Water samples were tested for nineteen inorganic parameters. Table 8-2 summarizes only those elements detected in one or more samples. Arsenic, beryllium, cadmium, mercury, thallium and selenium were not detected in any of the process or potable water supply wells in 1998. Lead, nickel, and manganese were not detected in any of the potable water supply wells. Aluminum, barium, cobalt, copper, iron, sodium, and zinc were detected in all potable wells at levels far below their respective NYS DWS. With the exception of well 105, the concentrations of inorganic elements in process supply wells, except iron, were within all drinking water standards. Naturally occurring iron is present in all wells located within the western sectors (e.g., Process Wells 102 and 105). In the case of potable wells, the ambient iron is removed at the WTP prior to site distribution. For the process wells, an iron sequestrant (a chemical which prevents the iron from precipitating from solution) is added.

Process Well 105 was sampled twice in 1998, in March and June. The concentrations of lead, iron and zinc in the sample collected in

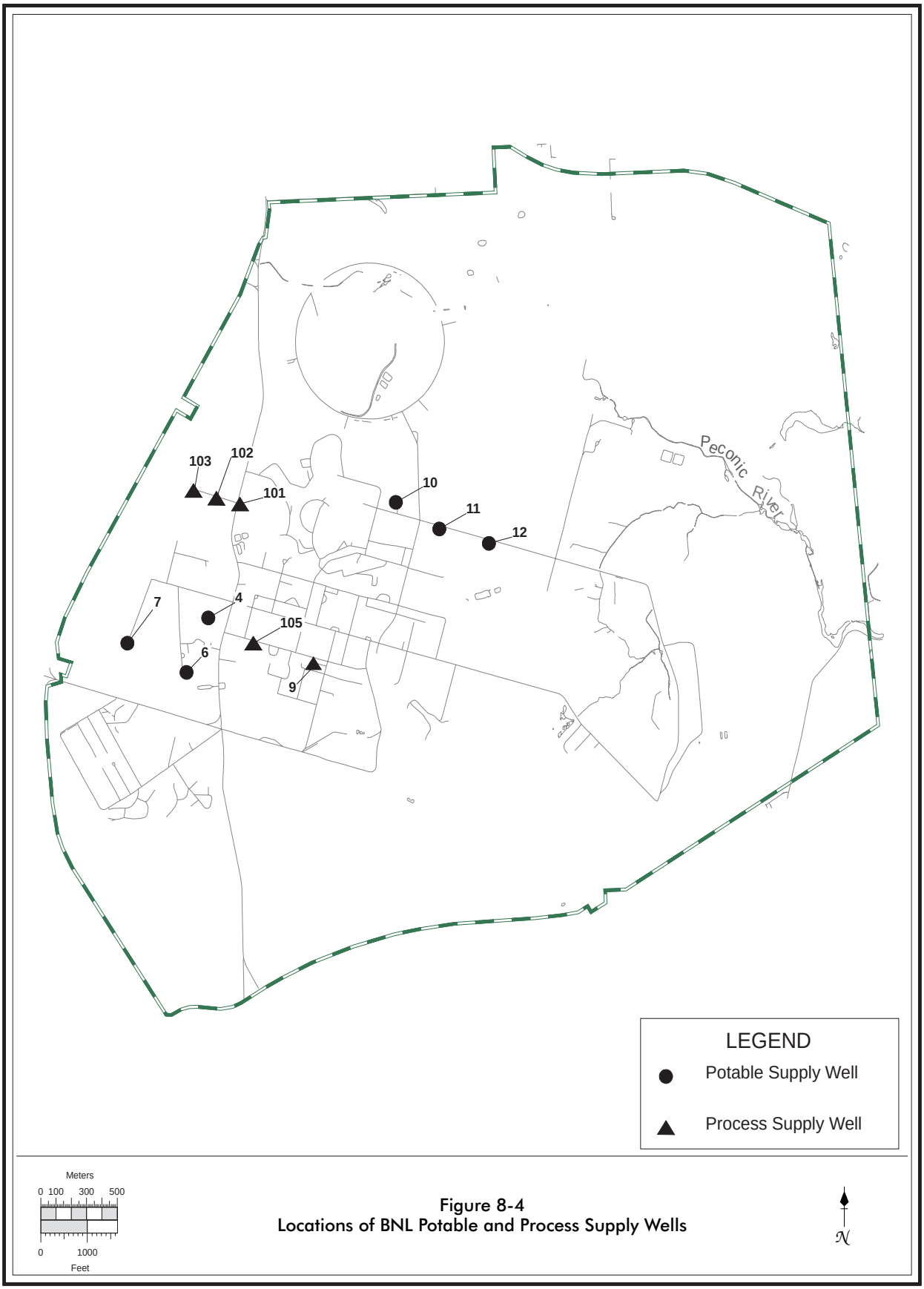


Figure 8-4
Locations of BNL Potable and Process Supply Wells

Table 8-1. Potable Water and Process Supply Wells Quality Data

Well Id. [Old Well Id.]		pH SU	Conductivity µS/cm	Chlorides mg/L	Sulfates[b] mg/L	Nitrate as N [b] mg/L
4 [FD]	N	3	3	0	0	0
	Min.	6	105			
	Max.	6.2	111			
	Avg.	NA	108			
6 [FF]	N	4	7	0	0	0
	Min.	6.1	102			
	Max.	6.2	104			
	Avg.	NA	104			
7 [FG]	N	3	3	0	0	0
	Min.	6	131			
	Max.	6.6	138			
	Avg.	NA	135			
10 [FO]	N	11	11	6	6	6
	Min.	6	93	< 4	8.7	<1.0
	Max.	7	125	17.1	11.6	< 1.0
	Avg.	NA	114	12.2	10.6	<1.0
11 [FP]	N	11	11	7	7	7
	Min.	5.9	119	17.3	11.4	<1.0
	Max.	6.7	146	20.7	13.5	<1.0
	Avg.	NA	126	19.4	12.9	<1.0
12 [FQ]	N	9	9	6	6	6
	Min.	6.2	122	16.7	10.5	<1.0
	Max.	6.8	143	21.4	13.6	<1.0
	Avg.	NA	127	17.5	11.5	<1.0
101 [FH]	N	5	0	0	0	0
	Min.	6.9				
	Max.	9				
	Avg.	NA				
102 [FI]	N	2	1	1	1	1
	Min.	6.9	135	21.2	8.9	< 1
	Max.	7.1	135	21.2	8.9	< 1
	Avg.	NA	135	21.2	8.9	< 1
103 [FJ]	N	0	0	0	0	0
	Value					
9 [FM]	N	4	4	2	2	2
	Min.	6.4	118	19.7	11.5	<1.0
	Max.	7.1	134	20.7	11.4	<1.0
	Avg.	NA	126.3	20.2	11.5	<1.0
105 [FL]	N	3	3	1	1	1
	Min.	6.2	187	33.7	13.9	<1.0
	Max.	6.4	199	33.7	13.9	<1.0
	Avg.	NA	192	33.7	13.9	<1.0
NYSDWS		(a)	(a)	250	250	10
Typical MDL		NA	10	4	4	1

Notes:
1. N: No. of samples
2. NA: Not Applicable
3. NYSDWS: New York State Drinking Water Standard
4. MDL: Minimum Detection Limit
   a. No standard specified.
   b. Holding times for nitrates and sulfates were typically exceeded.
5. Wells 101-103 show pH values for treated samples.

March exceeded typical levels by one to two orders of magnitude. Similar results were obtained in February 1997. The cause of the intermittent concentration spikes is unclear. However, this well is prone to heavy sediment (composed primarily of silt and clay minerals) build-up as evidenced by frequent clogging of the activated carbon adsorption vessels. Increases in sediment could result in elevated elemental concentrations. This theory will be

Table 8-2
Potable and Process Supply Wells Metals Data

Well Id. (# Samples)		Al µg/L	Ag µg/L	Ba µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Hg µg/L	Mn µg/L	Ni µg/L	Na mg/L	Pb µg/L	V µg/L	Se µg/L	Zn µg/L
10 [FO]	Min.	25.4	< 1	38.9	< 1.1	< 0.12	< 1	8.6	< 15	< 0.2	< 2	< 1.1	7.6	< 1.3	< 5.5	< 5	15
(6)	Max.	50	< 1	54.6	< 1.1	< 0.12	< 1	12.3	36.9	< 0.2	< 2	< 1.1	12.3	< 1.3	< 5.5	< 5	22.3
	Avg.	39.3	< 1	45.8	< 1.1	< 0.12	< 1	10.5	< 15	< 0.2	< 2	< 1.1	9.7	< 1.3	< 5.5	< 5	16.4
11 (FP)	Min.	20.2	< 1	45.7	< 1.1	< 0.12	< 1	18.5	< 15	< 0.2	< 2	< 1.1	8.9	< 1.3	< 5.5	< 5	6.7
(6)	Max.	46.6	< 1	61.1	< 1.1	0.14	< 1	36.5	20.4	< 0.2	< 2	< 1.1	12.7	< 1.3	5.5	< 5	36.5
	Avg.	39	< 1	55.5	< 1.1	< 0.12	< 1	24.7	< 15	< 0.2	< 2	< 1.1	11.9	< 1.3	< 5.5	< 5	19
12 (FQ)	Min.	25.9	< 1	33.9	< 1.1	< 0.12	< 1	9	17.9	< 0.2	< 2	< 1.1	11.6	< 1.3	< 5.5	< 5	< 4
(6)	Max.	59.3	1.3	75.5	< 1.1	0.13	< 1	38.4	36.4	< 0.2	< 2	< 1.1	13.4	< 1.3	5.5	< 5	38.4
	Avg.	37.8	< 1	50	< 1.1	< 0.12	< 1	13	32.2	< 0.2	< 2	< 1.1	13.1	< 1.3	< 5.5	< 5	11.9
9 (FM)	Min.	30.7	< 1	52.7	< 1.1	< 0.12	< 1	2.7	116	< 0.2	3.2	< 1.1	11.2	< 1.3	< 5.5	< 5	9.6
(2)	Max.	40.5	< 1	62.7	< 1.1	< 0.12	1.3	2.9	240	< 0.2	5	< 1.1	13	< 1.3	< 5.5	< 5	13.5
	Avg.	35.6	< 1	57.7	< 1.1	< 0.12	< 1	2.8	178	< 0.2	4.1	< 1.1	12.1	< 1.3	< 5.5	< 5	11
102 (FI) (1)	Value	47.2	< 1	50.9	< 1.1	1.9	1.1	113.5	3779	< 0.2	447.8	< 1.1	13.7	10.3	< 5.5	< 5	89.3
105 (FL)	Min.	30.9	< 1	62.4	< 1.1	< 0.12	< 1	17.1	629.2	< 0.2	62.2	5.2	18.1	1.9	< 5.5	< 5	202.1
(2)	Max.	40.4	< 1	62.9	< 1.1	0.2	3.9	65.6	8956	< 0.2	63.3	7.5	18.3	305.7	< 5.5	< 5	1470
	Avg.	35.7	< 1	62.6	< 1.1	< 0.12	2	41.4	4793	< 0.2	62.8	6.4	18.2	153.8	< 5.5	< 5	836.1
NYSDWS		NA	15	2000	5	NA	100	1300	300	2	300	100	NA	15	NA	50	5000
Typical MDL		2.2	1	1.8	1.1	0.12	1	2	15	0.2	2	1.1	1	1.3	5.5	5	4

Notes:
1. N: No. of samples
2. NYSDWS: New York State Drinking Water Standard
3. MDL: Minimum Detection Limit

evaluated further in 1999 by the collection of more frequent samples and the filtration of a sample aliquot prior to analysis.

Water samples are collected for VOC analyses from the wellhead before treatment (i.e., raw water) as well as post-treatment. No compounds were detected above the minimum detection limits (MDL) in treated water samples. Of the sixty compounds analyzed, 1,1,1-trichloroethane (TCA), chloroform, 1,1-dichloroethylene (DCE), 1,1-dichloroethane (DCA), and carbon tetrachloride were the only VOCs detected in raw water samples. The following observations were made:

- Only TCA exceeded NYS DWS. Chloroform and TCA were present in all wells (raw well water samples only). The concentration of TCA ranged from trace levels (i.e., < 2 µg/L) to a maximum of 11.5 µg/L in Process Well 9. Of the potable wells, only Well 11 contained TCA at concentrations exceeding the NYS DWS of 5 µg/L. The maximum concentration of TCA in this well was 5.6 µg/L. This well is equipped with carbon filtration to remove VOCs from the water prior to distribution.
- Chloroform was found in most wells, with concentrations ranging from trace levels (i.e., < 2 µg/L) to a maximum of 7 µg/L. All chloroform concentrations were equal to or below the NYS AWQS of 7 µg/L, and well below the drinking water standard of 100 µg/L.
- DCE was detected in Wells 9, 11, and 12. A maximum concentration of 3.6 µg/L was detected in Well 9, which is less than the drinking water standard of 5 µg/L.
- DCA was detected in trace concentrations. Low levels of carbon tetrachloride (up to 3.6 µg/L) and trace amounts of DCA were detected in Well 11. Both compounds were below the NYS DWS of 5 µg/L.

Process Supply Wells 9 and 105 are located within a portion of the defined OU III VOC plume. Water pumped from these wells generally contains concentrations of TCA which exceed the NYS DWS of 5 µg/L. Water from Process Well 105 is treated by carbon filtration to remove VOC contamination prior to its use in the BMRR (as once through cooling water) and subsequent discharge to Basin HP. Water from Well 9 is not treated prior to use. This water is not used for drinking and the concentrations present do not interfere with the fish experiments conducted in Building 463. No VOCs were detected in the AGS Process Supply Well 102.

8.1.1.2 RADIOLOGICAL ANALYSES

Potable and process well water was sampled and analyzed for gross alpha and gross beta activity, tritium and strontium-90; the results are listed in Table 8-3. Nuclide-specific gamma spectroscopy was also performed, supplementing the requirements of the SDWA, which does not strictly require this analysis unless gross beta activity exceeds 50 pCi/L (1.9 Bq/L). In response to employee concerns regarding the radiological content of the BNL potable water system, the total number of samples collected in 1998 was increased from previous years, to a maximum of eleven times for Wells 10, 11, and 12. These wells were in operation for the entire year and provided the majority of the drinking water for the site. Wells 4, 6 and 7 were only in operation half the year; consequently, they were sampled less frequently.

Average gross activity and tritium levels in the potable water wells were consistent with those of typical background water samples. Neither strontium-90 nor any man-made gamma-emitting radionuclides were observed above the MDL in any of the potable wells sampled. Throughout the year, Process Wells 9, 102, and 105 also showed radiological results that were consistent with background environmental values.

Compliance with the SDWA is based on the analytical results obtained from an annual composite of four quarterly samples or the average of the analyses of four quarterly samples. Compliance is demonstrated if:

- the annual average gross alpha activity is less than 15 pCi/L (0.6 Bq/L);
- gross beta activity is less than 50 pCi/L (1.9 Bq/L);
- strontium concentrations are less than 8 pCi/L (0.3 Bq/L);
- tritium concentrations are less than 20,000 pCi/L (740 Bq/L); and,
- the total effective dose equivalent for all detected radionuclides combined is less than 4 mrem in a year.

During 1998, all of these criteria were satisfied, and therefore, the BNL potable water system was in full compliance with the radiological requirements of 40 CFR 141.

Table 8-3: Potable and Process Well Radiological Analysis Results.

Well ID		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Sr-90 (pCi/L)
Potable Wells					
4 [FD]	N	4	4	4	1
	Max.	1.4±0.8	< 2.0	< 309	< 1.6
	Avg.	0.0±1.0	-21.7±37.1	0±92	
6 [FF]	N	4	4	4	1
	Max.	< 1.2	< 2.0	< 335	< 1.1
	Avg.	0.2±0.2	-8.6±15.3	-16±61	
7 [FG]	N	2	2	2	1
	Max.	< 1.1	6.9±1.6	< 335	< 1.1
	Avg.	-0.3±0.2	3.5±4.7	-66±99	
10 [FO]	N	11	11	11	3
	Max.	7.3±1.7	11.7±1.7	417±210	< 1.2
	Avg.	0.7±1.3	-5.9±15.2	113±111	0.4±0.5
11 [FP]	N	11	11	11	3
	Max.	3.7±1.2	2.0±0.7	< 320	< 1.7
	Avg.	0.3±0.7	-6.4±13.7	44±92	0.3±0.2
12 [FQ]	N	11	11	10	3
	Max.	4.7±1.0	10.1+/2.7	353±209	< 1.8
	Avg.	0.6±0.9	-5.5±15.2	48±94	0.1±0.2
Tap Water	N	223	223	235	NA
Bldgs 535/490	Max.	10.8±3.4	18.7±6.2	462±192	
(FN)	Avg.	2.6±0.3	4.7±0.5	24±16	
Process Wells					
102 [FI]	N	1	1	1	NA
	Max.	< 1.2	< 2.2	< 337	
105 [FL]	N	4	4	4	NA
	Max.	11.1±1.2	< 3.6	< 335	
	Avg.	2.7±4.8	-20.8±32.3	58±75	
9 [FM]	N	4	4	4	NA
	Max.	1.2±0.7	< 3.6	< 335	
	Avg.	0.2±0.8	-21.0±34.8	31±113	
SDWA Limit		15(a)	50(b)	20,000	8

Notes:
1. All values shown with 95% confidence interval.
2. No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 1998.
3. N = Number of samples collected.
4. NS = Not sampled for this analyte.
   a. Excluding radon and uranium.
   b. Screening level above which analysis for individual radionuclides is required.

8.1.2 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING PROGRAM

The mission of the ER groundwater monitoring program is to monitor the various contaminant plumes located onsite and offsite, as well as to monitor the progress that the groundwater treatment systems are making on plume remediation. The long-term groundwater monitoring projects coordinated under the ER monitoring program are designed to address the following issues:

1. Pre-Record of Decision (pre-ROD) Monitoring: Addresses the short-term monitoring of plumes to track their movement following the Remedial Investigation characterization and prior to remediation;
2. Post-Record of Decision (post-ROD) Monitoring: Addresses the long-term monitoring of plumes to track their movement following the initiation of remediation systems, including:

- Source Removal Effectiveness: Includes monitoring wells installed to verify that remediation projects, such as the capping of previously used landfills, are performing to specifications; and,
- Treatment System Performance: Includes monitoring the active pump-and-treat

systems to verify that they are effectively capturing and removing contaminants, and monitoring plumes undergoing passive remediation (i.e., natural attenuation) to verify that natural processes are effective in reducing contaminant concentrations.

3. Outpost Detection Monitoring: Samples wells located between the leading edge of contaminant plumes and a potential receptor, to give early warning of the arrival of the leading edge of the plume and trigger contingency remedial actions.

The groundwater monitoring information described below provides an overview of ER groundwater monitoring and remediation activities for 1998. During this period, a total of 407 groundwater surveillance wells were monitored during approximately 1,510 individual sampling events. Detailed analytical results for each sample obtained under the Sitewide Groundwater Program are provided in the 1998 ERD Sitewide Groundwater Monitoring Report (Dorsch and Wachino, 1999). Detailed information about the performance of the remediation systems and recommendations for potential adjustments to the systems are presented in the Operational Reports for the individual systems (described below).

Maps showing the main VOC and radionuclide plumes are provided as Figures 8-2 and 8-3. For each significant contaminant source area and plume described below, specific groundwater contaminant distribution maps and cross sections are also provided. These maps depict the areal extent of contamination, and were created by selecting the highest contaminant concentration observed for a given set of wells during a selected sample period. Associated cross sections show the vertical distribution/extent of contamination, as well as the hydrogeology. Each cross section is generally oriented through the highest areas of contaminant concentration of a given plume. The cross section transect lines are identified on the corresponding plume map. No significant change in contaminant concentrations occurred during the year, therefore a single representative round of monitoring was chosen for each plume.

8.1.2.1 BACKGROUND MONITORING

Ambient (or background) groundwater quality for the BNL site is monitored through a network of 13 wells located in the northern portion of the site and in offsite areas to the north. The site background wells provide information on the chemical and radiological composition of groundwater that has not been affected by activities at BNL. These background data are a valuable reference for comparison with groundwater quality data from areas that have been affected. This well network can also provide warning of any contaminants originating from potential sources of contamination that may be located upgradient of the BNL site.

There were no significant detections of VOCs in background wells. The highest concentration detected was tetrachloroethylene (PCE) at 2.6 micrograms per liter (µg/L) in offsite Well 000-119. This well is screened in the middle Upper Glacial aquifer, and is located immediately north of the northwest corner of the site. Low concentrations of VOCs have been detected in previous years in wells 17-03, 17-04, 18-03 and 18-04. Radionuclide concentrations were consistent with background levels.

8.1.2.2 OPERABLE UNIT 1

8.1.2.2.1 FORMER LANDFILL, ANIMAL/CHEMICAL PITS AND GLASS HOLES

The Former Landfill area initially was used by the United States Army during World Wars I and II, then BNL used the southeast corner of the landfill from 1947 through 1966 to dispose of construction and demolition debris, sewage sludge, chemical and low-level radioactive waste, used equipment, and animal carcasses. From 1960 through 1966, BNL waste, glassware containing chemical and radioactive waste, and animal carcasses containing radioactive tracers were disposed of in shallow pits in an area directly east of the Former Landfill. From 1966 through 1981, BNL continued to dispose of used glassware in shallow pits located directly north of these chemical/animal pits.

A network of eight monitoring wells is used to monitor the Former Landfill area. The monitoring program for the Former Landfill is designed in accordance with post-closure operation and maintenance (O&M) requirements specified in 6 NYCRR Part 360, "Solid Waste Management Facilities." These requirements specify that the well network be moni-

tored quarterly for a minimum of five years, after which time BNL may petition the NYSDEC to modify the frequency and types of analyses based on supporting data. The objective of this program is to monitor radiological and non-radiological contamination in the shallow Upper Glacial aquifer immediately downgradient of the landfill. The program was initiated following the capping of the Former Landfill in November 1996, and will verify whether the cap effectively prevents the continued leaching of contaminants from the landfill and document anticipated long-term improvements to groundwater quality. In addition to these wells, BNL established a separate network of 24 wells to monitor the Animal/Chemical Pits/Glass Holes areas, and the downgradient portions of the Former Landfill plume. The downgradient portions of these plumes are currently being monitored as part of the OU I/IV Pre-ROD Monitoring Program.

Volatile Organic Compounds: The primary chemical contaminants observed in the Former Landfill - Animal/Chemical Pits and Glass Holes plume are carbon tetrachloride, TCA, DCE, TCE, and chloroform. These constituents are typically observed at concentrations of less than 100 µg/L, total concentration VOCs (TVOC) (Note: a TVOC concentration is a summation of all individual VOC values for a given groundwater analysis.) The NYS AWQS for carbon tetrachloride, TCA, DCE, and TCE is 5 µg/L, whereas the standard for chloroform is 7 µg/L. The Former Landfill - Animal/Chemical Pits and Glass Holes plume extends approximately 3,500 meters (11,500 feet) from the source areas, south to the approximate vicinity of Crestwood Drive (see Figure 8-5). The plume is approximately 460 meters (1,500 feet) at its maximum width, as defined by the 5-µg/L contour. The higher concentration segment of the plume (>50 µg/L) is approximately 300 meters (1,000 feet) in width.

The vertical distribution of VOC contamination is shown on Figure 8-6. In general, the VOCs are found in the shallow sections of the Upper Glacial aquifer in the vicinity of the Former Landfill, Animal/Chemical Pits and Glass Holes, in the mid-Upper Glacial aquifer at the southern site boundary, and in the deep Upper Glacial aquifer offsite to the south. The area of the plume showing the highest TVOC concentration is offsite in the vicinity of Stratler Drive in North Shirley, New York. This area of the plume is composed primarily of carbon tetrachloride, with a TVOC concentration of 428 µg/L in Well 000-154 during October 1998. A zone of VOC contamination, consisting primarily of TCA, DCA and DCE, was detected in the upper Magothy aquifer (greater than 90 meters [300 feet] below land surface) in an area south of the Long Island Expressway and north of North Street during the OU III RI/FS. Additional characterization and the installation of permanent wells to monitor this contamination will be addressed in 2000.

Radionuclides: Strontium-90 has been routinely detected in groundwater in the Animal/Chemical Pits, Former Landfill and Glass Holes Area at concentrations above the DWS of 8 pCi/L, specifically in Wells 97-64, 106-16 and 106-13. The high levels of strontium-90 contamination (as defined by the DWS of 8 pCi/L) are in close proximity to the individual source areas (Figure 8-7). The highest strontium-90 concentrations have been detected in Well 106-16, where a maximum concentration of 554 pCi/L (20 Bq/L) was observed in July 1998. In 1997, trace amounts of strontium-90 were detected in temporary wells installed as far south as the onsite BNL Middle Road. Based upon these results, additional downgradient monitoring wells were installed during 1998. Monitoring wells are now located in advance of the leading edge of this plume and are sampled on a quarterly basis. Strontium-90 concentration trends plots for Wells 97-64 and 106-16 are presented in Figure 8-7.

8.1.2.2.2 CURRENT LANDFILL

The Current Landfill operated from 1967 through 1990, when it was closed in accordance with the 6 NYCRR Part 360, "Long Island Landfill Law." It was used to dispose of putrescible waste, sludge containing precipitated iron from the WTP, and anaerobic digester sludge from the Sewage Treatment Plant (STP). The latter contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill. As a result, the Current Landfill is a source of groundwater contamination. Permanent closure (capping) of this landfill

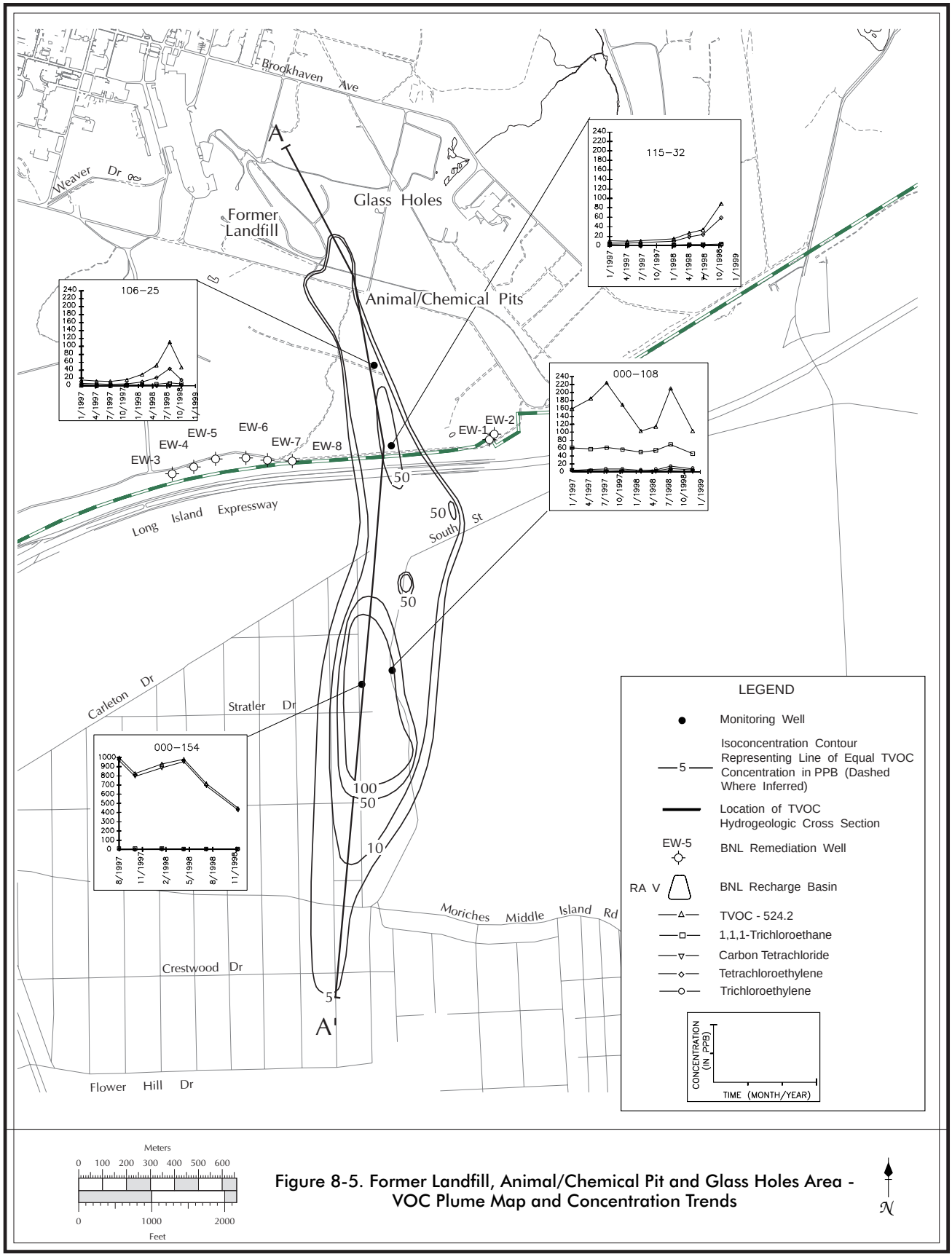


Figure 8-5. Former Landfill, Animal/Chemical Pit and Glass Holes Area - VOC Plume Map and Concentration Trends

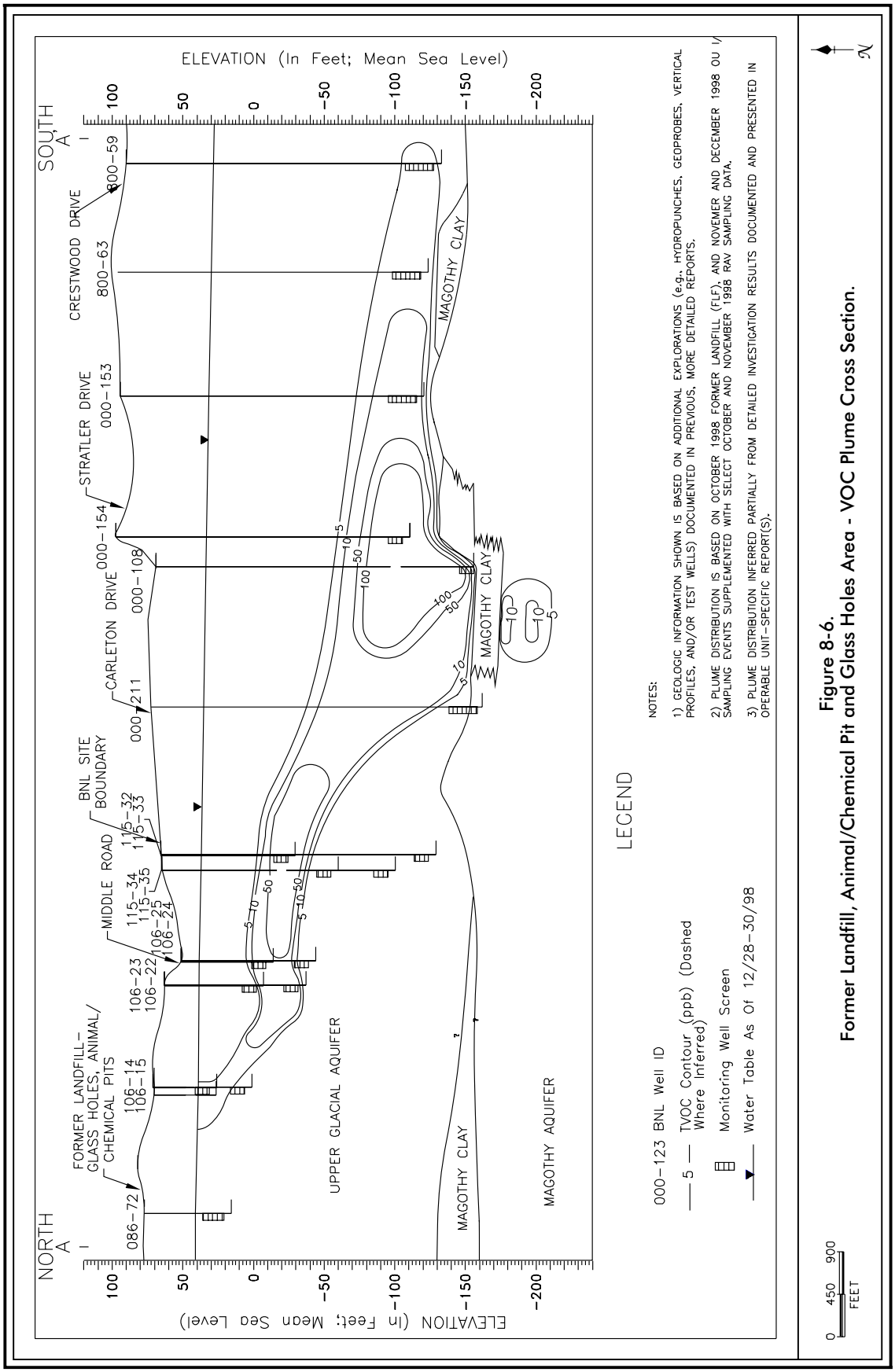


Figure 8-6.
Former Landfill, Animal/Chemical Pit and Glass Holes Area - VOC Plume Cross Section.

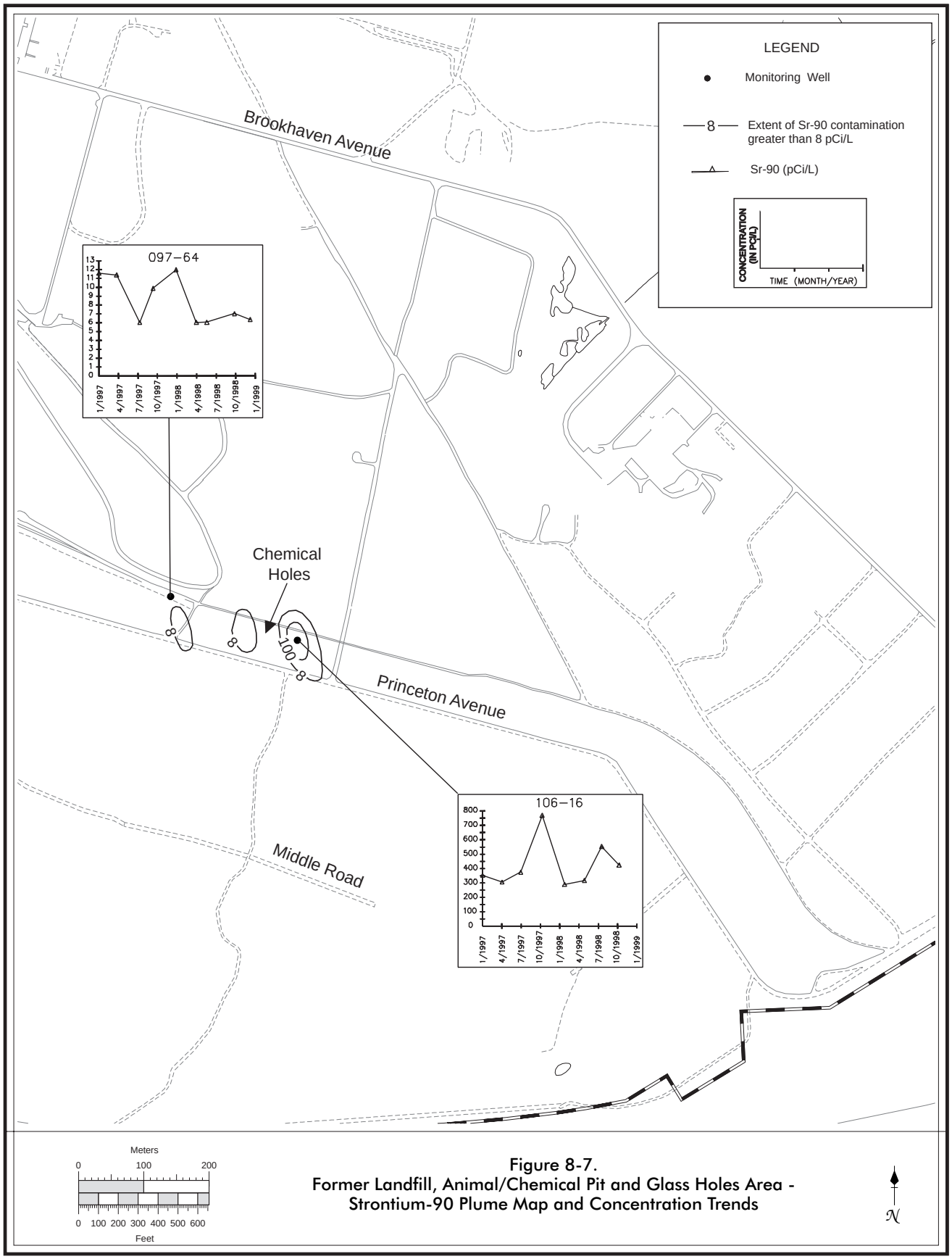


Figure 8-7.
Former Landfill, Animal/Chemical Pit and Glass Holes Area - Strontium-90 Plume Map and Concentration Trends

was completed in November 1995 as part of the ER Program.

The Current Landfill post-closure monitoring program consists of a network of 11 monitoring wells situated adjacent to the landfill in both upgradient and downgradient locations. These wells are monitored quarterly, and are used to determine the cap's effectiveness in preventing the continued leaching of contaminants from the landfill, and to document the anticipated long-term improvements to groundwater quality. The monitoring well network was designed in accordance with NYS specified post-closure O&M requirements.

Volatile Organic Compounds: During 1998, VOCs were routinely detected in wells located downgradient of the Current Landfill including chloroethane, benzene, and DCA. Chloroethane was detected at concentrations exceeding the NYS AWQS of 5 µg/L in monitoring Wells 87-11, 87-23, 87-27, 88-22, 88-109, and 88-110, with a maximum concentration of 289 µg/L detected in Well 88-109. Benzene was found in monitoring wells 87-11, 87-23, 87-27, 88-22, 88-109, and 088-110 at concentrations exceeding the NYS AWQS of 0.7 µg/L, with a maximum concentration of 2.7 µg/L. DCA was detected in Wells 88-22, 88-109 and 88-110, with a maximum concentration of 59 µg/L found in Well 88-109.

Radionuclides: Tritium was occasionally detected in downgradient Wells 87-11, 87-23, 87-27, 88-21, 88-22, 88-109, and 88-110, with concentrations ranging from slightly above the typical MDL of 400 pCi/L to as high as 3,098 pCi/L (115 Bq/L).

8.1.2.2.3 FORMER HAZARDOUS WASTE MANAGEMENT FACILITY (HWMF) PLUME AND DOWNGRADIENT SECTION OF CURRENT LANDFILL PLUME

Groundwater contamination originating from the Former HWMF and the downgradient section of the Current Landfill plume is being monitored under the Removal Action V (RA V) Program. Until 1997, the Former HWMF was BNL's central RCRA receiving facility for processing, neutralizing, and storing hazardous and radioactive wastes before offsite disposal. As the result of past waste handling and storage practices, the soil and groundwater at the Former HWMF are contaminated with both chemicals and radionuclides at concentrations that exceed NYS AWQS.

The Current Landfill and Former HWMF plumes become commingled south of the HWMF due, at least partially, to the pumping and recharge effects of the Former Spray Aeration System, which operated from 1985 to 1990 in a effort to treat VOC contaminated groundwater originating from the HWMF. The Current Landfill/HWMF plume is currently being remediated using a groundwater extraction and treatment system consisting of two wells screened in the deep portion of the Upper Glacial Aquifer at the site boundary (see RA V Treatment System described in section 8.1.2.7). This system provides hydraulic containment of those onsite portions of the plume that have TVOC concentrations greater than 50 µg/L.

The RA V monitoring program uses a network of 51 monitoring wells located in areas downgradient of the Current Landfill and HWMF. This monitoring program is specifically designed to address the following issues on groundwater contamination and plume remediation:

- Monitoring of VOC and radiological contamination of groundwater in the shallow zone of the Upper Glacial aquifer at, and immediately adjacent to, the HWMF;
- Monitoring of VOC and radiological contaminant plumes located south of the Current Landfill and HWMF that have been commingled due, in part, to the effects of the former Spray Aeration Groundwater Remediation System, which was located to the south of the HWMF; and,
- Evaluating the effectiveness of the RA V groundwater pump-and-treat system that was initiated in December 1996 at the southern site boundary using wells EW-1 and EW-2. The monitoring program will characterize the effects of this treatment system on the contaminant plume, and provide data necessary to make decisions on the future operations of the system.

Readers are referred to the RA V Groundwater Treatment Annual Operations Report 1998 (BNL, 1999c) for a detailed description of the remediation system and its effects on the VOC plume. A detailed discussion of the groundwater monitoring results for the Current Landfill area is included in the 1998 Environmental Monitoring Report, Current And Former

Landfill Areas (BNL 1999a).

Volatile Organic Compounds: The primary VOCs found onsite in this plume include chloroethane, TCA, and DCA, whereas the compounds detected offsite consist of TCA, DCE, TCE, and chloroform. The Current Landfill and HWMF plume (as defined by the 5 µg/L contour) extends approximately 2,210 meters (7,250 feet) from the Current Landfill and HWMF areas south, to an area approximately 457 meters (1,500 feet) south of North Street (Figure 8-8). The plume is approximately 420 meters (1,375 feet) wide at its maximum width. The width of the higher concentration portions of the plume (>50 µg/L) is approximately 152 meters (500 feet). The vertical distribution of VOCs is shown on Figure 8-9. Chloroethane, TCA, and DCA are shown in the shallow Upper Glacial aquifer near the source areas and in the deep Upper Glacial aquifer at the site boundary and offsite. TCA, DCE, TCE and chloroform are found in the middle to deep Upper Glacial aquifer offsite south of North Street.

There are three areas of the plume displaying VOC concentrations of >200 µg/L. These areas are located immediately downgradient of the Current Landfill/HWMF, immediately south of the southern boundary extraction system, and offsite south of North Street. When comparing the configuration of the plume from 1997 to 1998, the continued operation of the RA V groundwater treatment system at the site boundary appears to be shrinking the width of the plume in this area (see Dorsch and Wachino, 1999).

Historical VOC concentration trends for key wells along the Current Landfill/HWMF Plume are provided in Figure 8-8. Onsite, source area Wells 88-109 and 88-22 displayed decreasing VOC concentration trends. Wells 098-59 and 115-36, located between the source areas and the site boundary, displayed fluctuating or slightly increasing VOC concentration trends. Well 115-14, located in close proximity to the extraction system has maintained a low and steady VOC concentration trend. VOC concentrations have trended upward in 1998 for offsite Wells 115-42 and 000-124 whereas Well 000-138 has displayed a slight downward trend in VOC concentrations. The VOCs detected in Well 115-42 are probably the result of contamination being pulled back by the southern boundary extraction system.

Radionuclides: Tritium was detected below DWS in a number of Current Landfill/HWMF wells during Only Well 88-26 (located inside the Former HWMF) had tritium concentrations that exceeded the 20,000 pCi/L, NYS DWS, with a concentration of 34,832 pCi/L (1,289 Bq/L) in May 1998. Tritium concentrations in samples from this well were below the DWS during the other three quarters of 1998. This well has historically shown concentrations above the DWS. Tritium concentration trend plots for key Current Landfill/HWMF wells are provided in Figure 8-10. Offsite Well 000-137 showed slightly increasing tritium concentrations during 1998; however the concentrations were well below the NYS DWS.

Strontium-90 was detected in two wells (88-26 and 98-30) in the Current Landfill and Former HWMF areas during 1998 at concentrations exceeding the DWS. Figure 8-11 provides a strontium-90 plume distribution map and concentration trend data for key wells.

8.1.2.3 OPERABLE UNIT III

The monitoring well network established to monitor the OU III VOC and radionuclide source areas and resulting contaminant plumes is composed of approximately 180 monitoring wells positioned from the north-central portion of the site to the southern site boundary and offsite. The OU III groundwater-monitoring program is specifically designed to address the following groundwater contamination issues and plume remediation:

- Monitor VOC plumes with identified or suspected sources in the AGS Complex, Paint Shop, former Building 96 area, and the Supply and Materiel area. These plumes extend from the north-central portion of the site to south of the site boundary and then into North Shirley. The plumes become deeper as the distance from the source areas increases. Plumes at the southern site boundary and offsite are in the deep portion of the Upper Glacial aquifer and the upper portion of the Magothy aquifer.
- Monitor the tritium plume associated with the High Flux Beam Reactor (HFBR), and strontium-90 plumes associated with the WCF and the formerly operated Brookhaven Graphite Research Reactor (BGRR).
- Evaluate the effectiveness of the OU III south boundary groundwater pump-and-treat

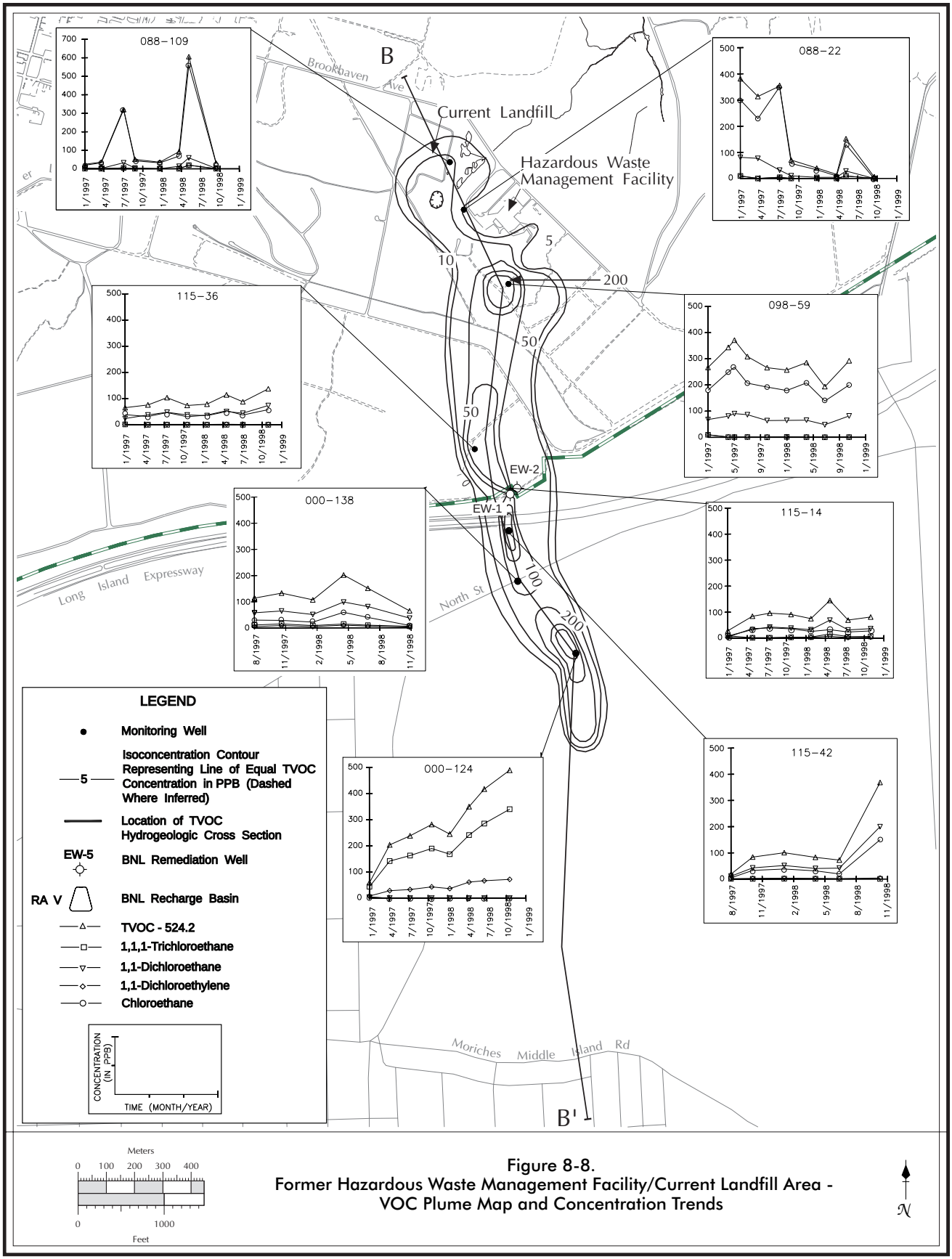


Figure 8-8.
Former Hazardous Waste Management Facility/Current Landfill Area - VOC Plume Map and Concentration Trends

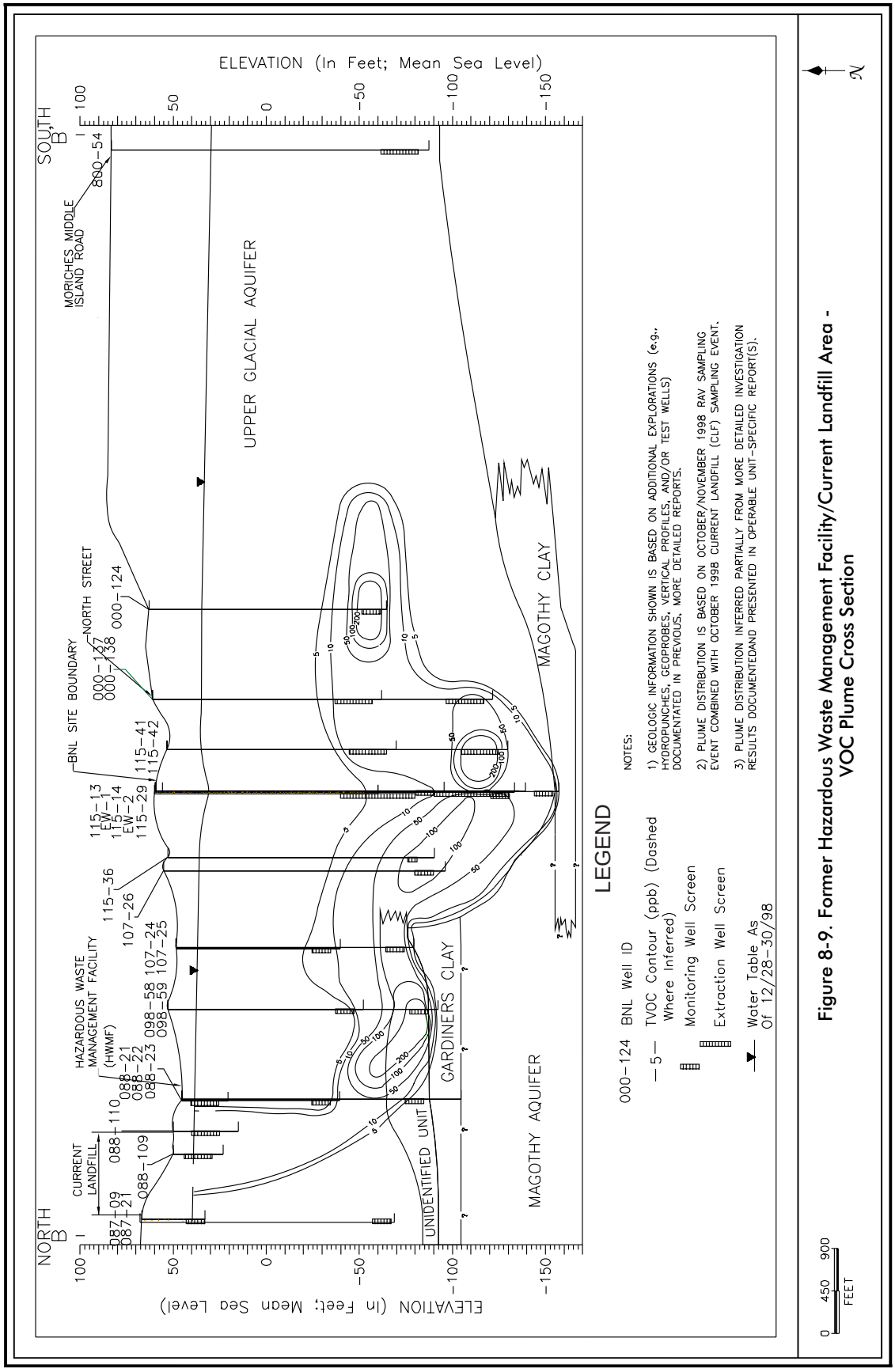


Figure 8-9. Former Hazardous Waste Management Facility/Current Landfill Area - VOC Plume Cross Section

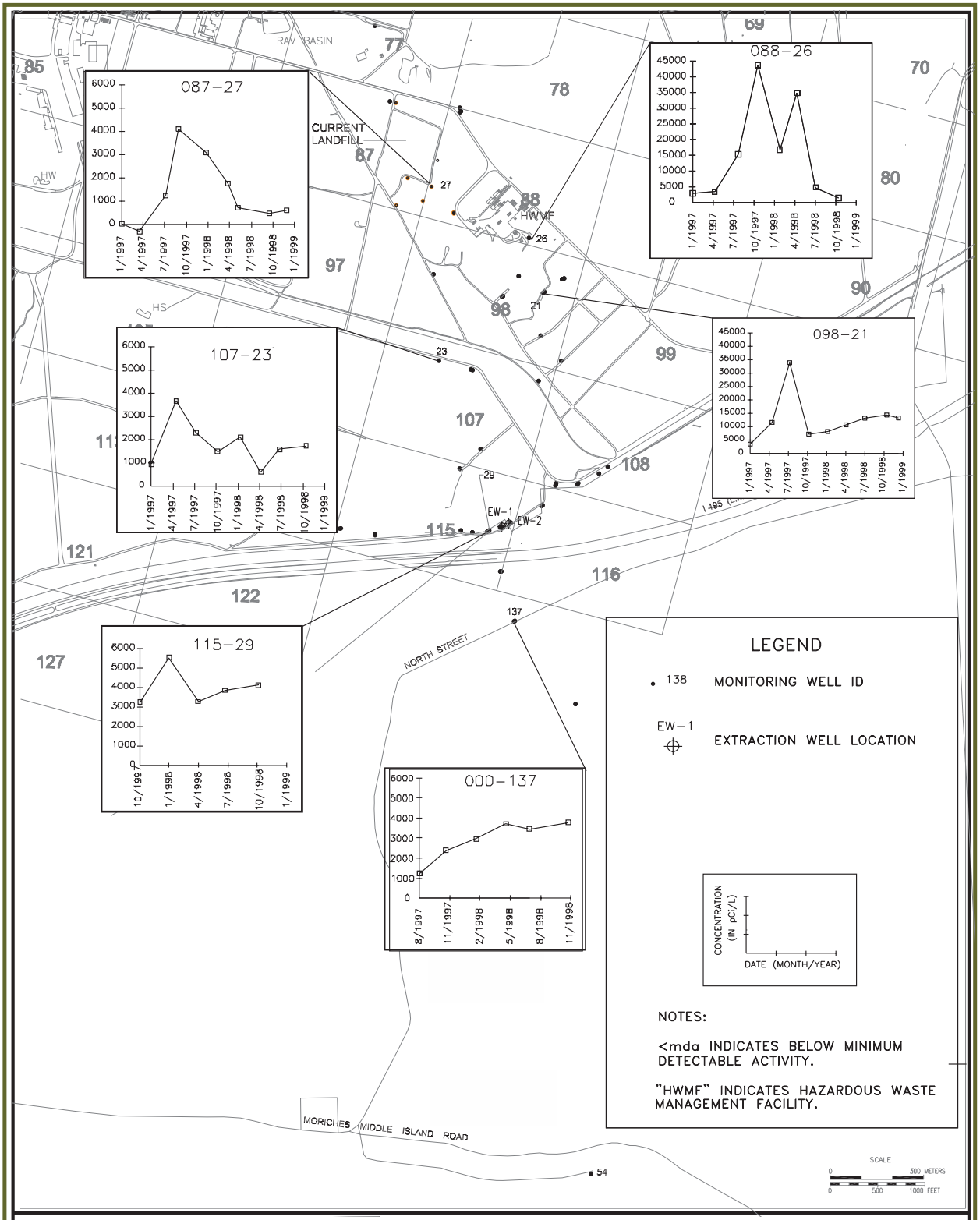


Figure 8-10.
Former Hazardous Waste Management Facility/Current Landfill Area - Tritium Concentration Trends

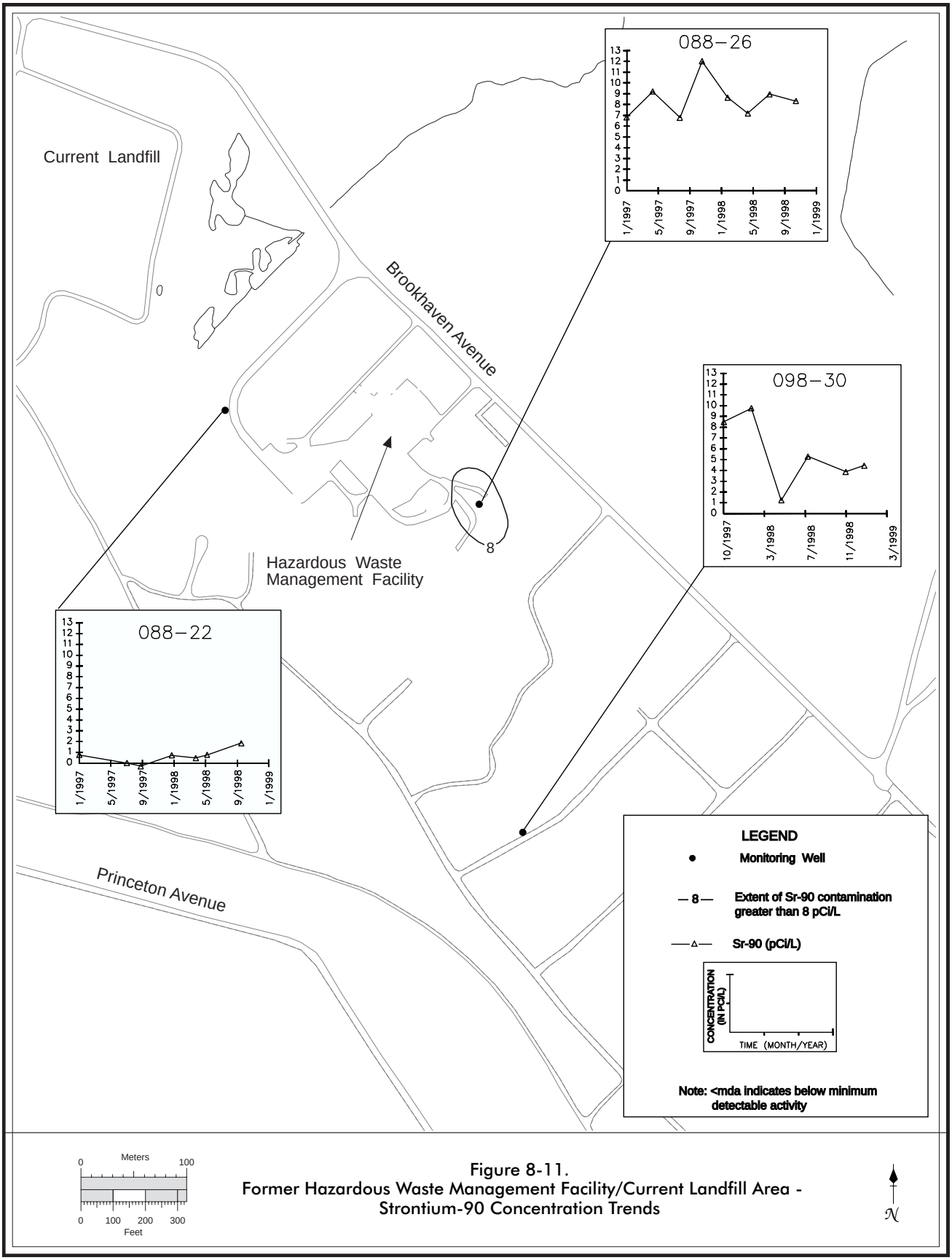


Figure 8-11.
Former Hazardous Waste Management Facility/Current Landfill Area - Strontium-90 Concentration Trends

system initiated in June 1997 (extraction wells EW-3 through EW-8). This monitoring program characterizes the effects of this pumping on the contaminant plume, and will provide data that are necessary for making decisions on the future operations of the extraction wells.

- Monitor the offsite segment of the plume and "outpost" wells located to the south (downgradient) of the defined extent of the offsite VOC plume to provide data on any possible future downgradient migration of the plume. Outpost wells are also situated in the southwestern portion of BNL, directly upgradient of the Suffolk County Water Authority (SCWA) Parr Village Well Field on William Floyd Parkway. These wells are used to verify groundwater quality south of the BNL apartment areas, and they would also provide an early warning if contaminants from BNL were to migrate toward the SCWA well field.

Volatile Organic Compounds: The OU III VOC "plume" is composed of multiple commingled plumes, some of which can be traced directly to their source areas. This commingling is partially due to the significant periodic changes in groundwater flow patterns created by historical and ongoing groundwater pumping and recharge effects. Some identified sources that were evaluated during the OU III RI/FS include spill areas within the AGS Complex, former Building 96 area (a former vehicle maintenance and drum storage area) and Building 208, located within the Supply and Materiel area. Figure 8-12 depicts the OU III VOC contamination plume. (Please note that the OU IV plume is also depicted on Figure 8-12.) The primary OU III VOCs detected in onsite monitoring wells include carbon tetrachloride, TCA, and PCE; carbon tetrachloride is the primary VOC detected in offsite wells. The OU III plume extends from the AGS Complex in the north-central part of the site southward approximately 5,180 meters (17,000 feet) to the vicinity of Flower Hill Drive in North Shirley. The plume is about 1,525 meters (5,000 feet) wide at its maximum, as defined by the 5 µg/L isoconcentration contour on Figure 8-12. The width of the high concentration portion of the plume (portions >50 µg/L) is approximately 550 meters (1,800 feet) at the site boundary. The area defined by the 5 µg/L isoconcentration line should not be interpreted to mean that there is continuous VOC contamination from the western 5 µg/L line eastward to the central core of the OU III plume. In actuality, the plume includes many areas with <5 µg/L concentrations.

Portions of the plume displaying the highest VOC concentrations include the vicinity of Building 96 (primarily PCE with lower concentrations of TCA), with TVOC concentrations ranging from 1,000 to >18,000 µg/L) and continuing south to Carleton Drive with TVOC concentrations of >500 µg/L. In the vicinity of Well 000-130, located offsite on Carleton Drive, TVOC concentrations are greater than 7,000 µg/L (consisting primarily of carbon tetrachloride). As shown in Figure 8-13, this high level carbon tetrachloride contamination is located in the upper portion of the Magothy aquifer. Groundwater characterization to define the extent of carbon tetrachloride contamination in the Magothy aquifer and the installation of additional monitoring wells is planned for 2000.

An underground storage tank (UST), located in the vicinity of the corner of Rowland Street and Rochester Street was excavated and removed in April 1998. The UST had been used at the former Chemistry Department Complex in the 1950s, and contained carbon tetrachloride. Monitoring Well 85-06 was destroyed as a result of this effort, and replaced by new well 85-98. Historically, samples collected from Well 85-06 have shown low level concentrations of carbon tetrachloride (<20 µg/L). However, sampling of the new well in June 1998 revealed carbon tetrachloride contamination approaching 100,000 µg/L. It now appears that the contamination was caused by the inadvertent release of residual carbon tetrachloride from the tank during the removal process. Subsequent groundwater characterization efforts during the summer and fall of 1998 successfully characterized the extent of the carbon tetrachloride plume, and remediation of this area is planned for in 1999. A summary of the data from this groundwater characterization project can be found in Summary Report for the Carbon Tetrachloride Investigation (BNL, 1999b).

Trend plots showing changes in VOC concentrations over time are depicted for key OU III monitoring wells in Figure 8-14 and 8-15. Wells located in the vicinity of known source areas in the central onsite portion of OU III have

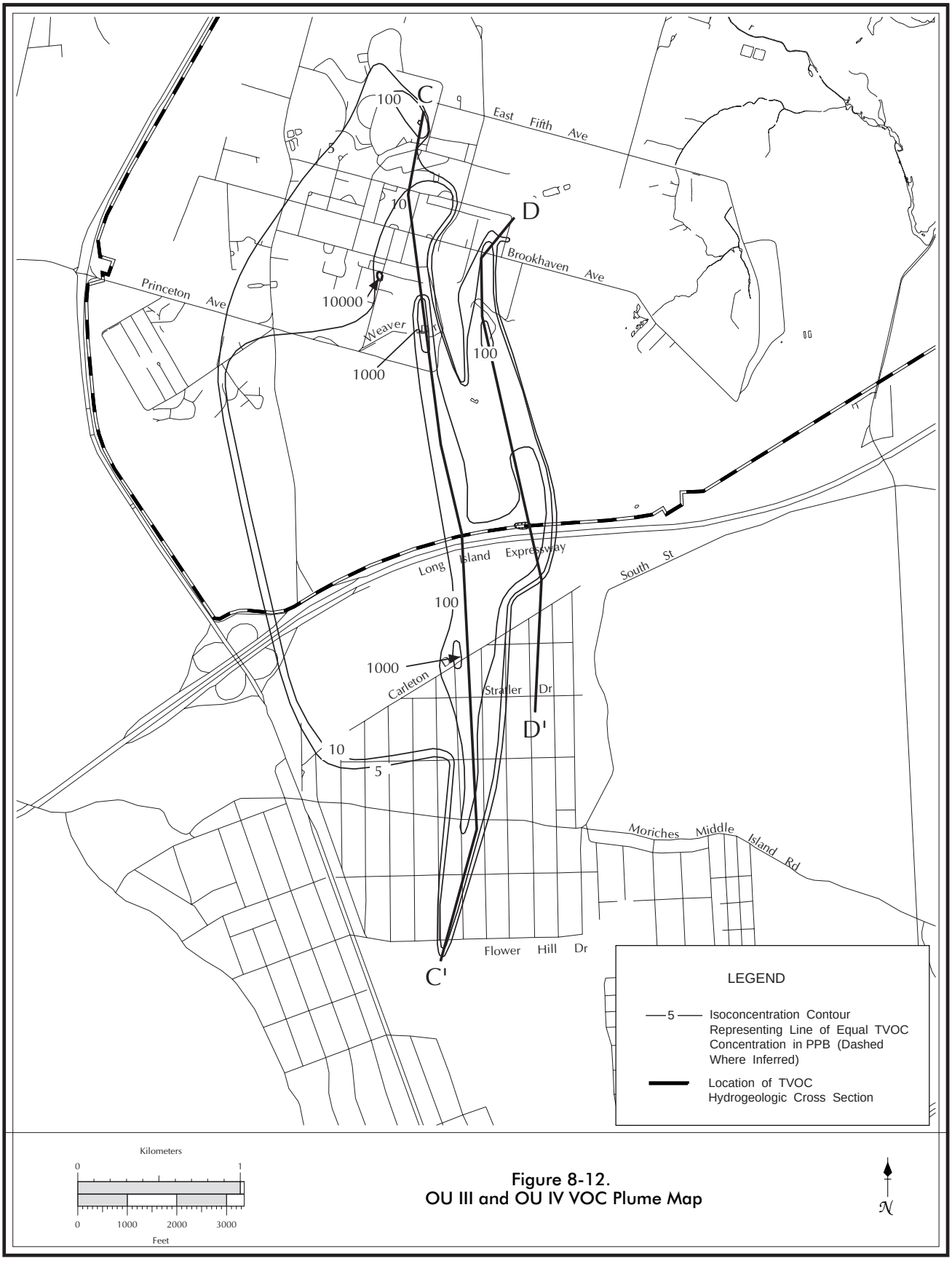


Figure 8-12.
OU III and OU IV VOC Plume Map

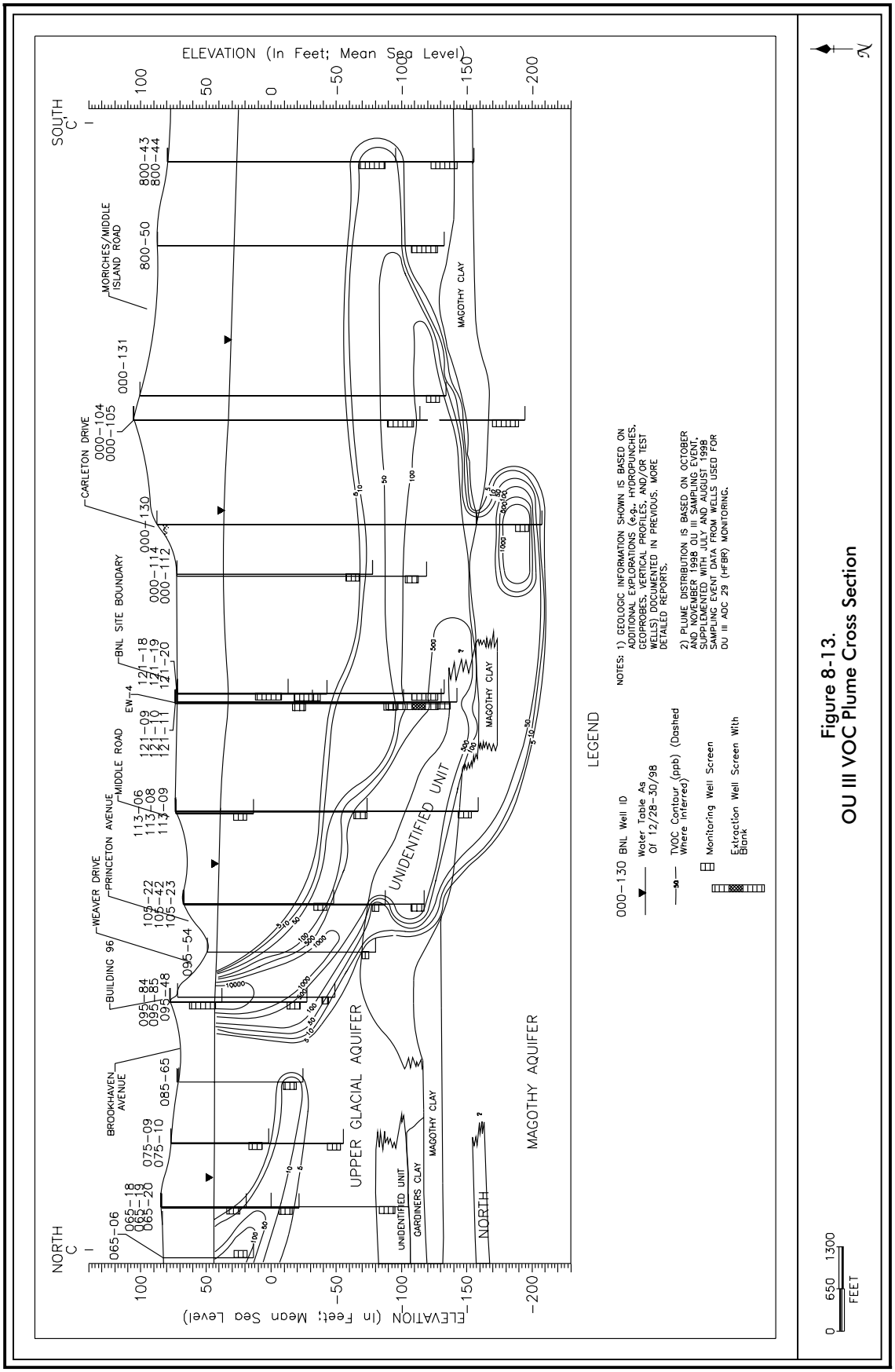


Figure 8-13.
OU III VOC Plume Cross Section

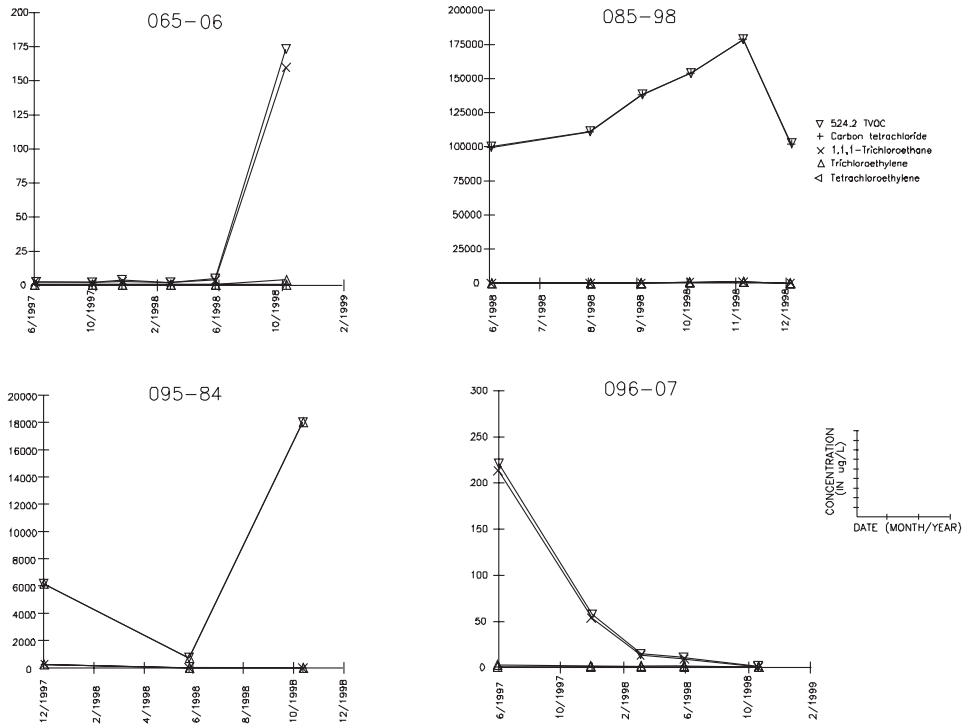


Figure 8-14. Time-vs.-VOC concentration trend plots for key wells in the OU III VOC Plume (central area): Well 65-06 located downgradient of the AGS area; Well 85-98 located downgradient of a carbon tetrachloride spill area; Well 95-84 located in the former Building 96 area; and Well 96-07 located downgradient of the Supply and Materiel Building 208.

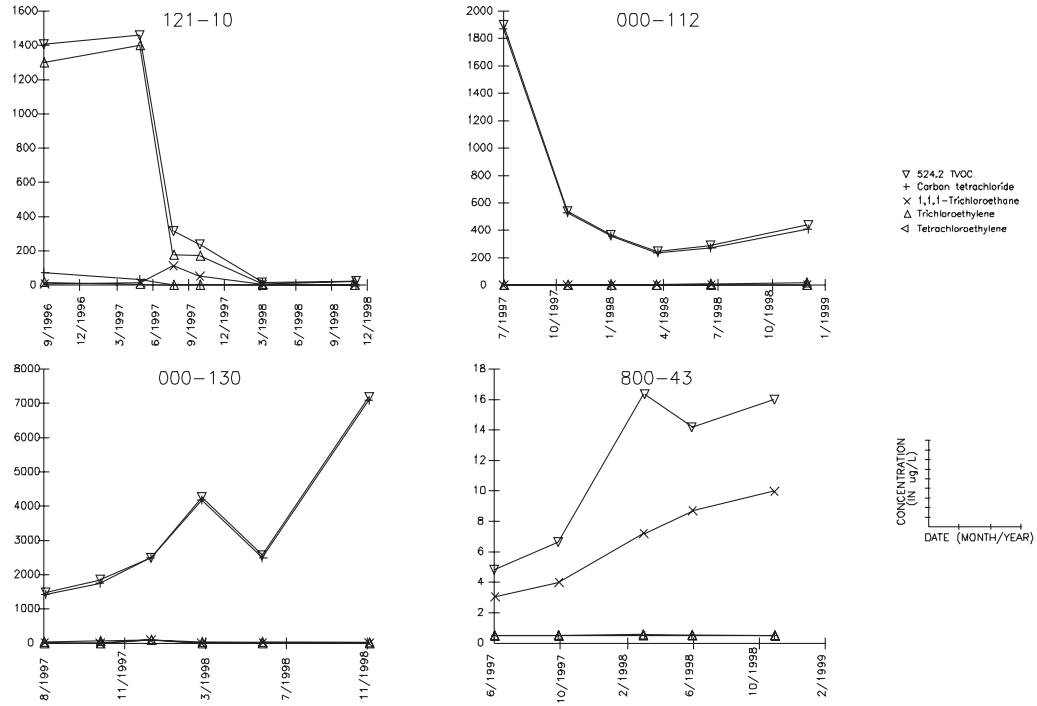


Figure 8-15. Time-vs.-VOC concentration trend plots for key wells in the OU VOC Plume (southern boundary and off-site areas): Well 121-10 located at the BNL southern boundary; Well 000-112 located off-site near the Brookhaven Industrial Park; Well 000-130 located on Carleton Drive; and Well 800-43 located near Flower Hill Drive near the leading edge of the OU III plume.

shown significant increases in concentrations during 1998. For example, VOC concentrations in Well 65-06 (primarily TCA), which is located downgradient of the AGS research complex, increased from typical concentrations ranging from 5 to 20 µg/L in 1997 and the first three-quarters of 1998 to >170 µg/L during the last quarter of 1998. (Characterization of the extent of VOC contamination in the AGS area will be augmented with data obtained from new Facility Monitoring Program wells to be installed in 1999.) Additionally, TCA concentrations decreased in Supply and Materiel area monitoring Well 96-07. Historically, TCA concentrations have exceeded 100 µg/L. However, during 1998 concentrations dropped to <5 µg/L. Wells located near the southern boundary extraction system are displaying significantly decreasing concentration trends (in Wells 121-10, 122-19 and 122-22), which can be attributed to the effect of the remediation system. The 1998 OU III Pump and Treat System Annual Report (BNL 1998a) provides detailed evaluations of VOC concentration trends and recommendations for changes to the system operations.

8.1.2.3.1 HFBR TRITIUM PLUME

Following the January 1997 discovery of tritium in wells south of the HFBR, it was determined that the HFBR's spent fuel pool was leaking tritiated water at a rate of approximately six to nine gallons per day. (Note: To prevent additional leakage, the HFBR's spent-fuel pool was completely emptied by December 1997.) As the result of an extensive groundwater investigation, it was determined that the tritium plume remains completely onsite . The extent of the tritium plume (as defined by the 1,000-pCi/L contour) was found to extend from the HFBR to a location immediately north of Weaver Drive on the BNL site, a distance of approximately 1,220 meters (4,000 feet) (see Figure 8-16). The plume is approximately 305 meters (1,000 feet) at its maximum width. However, the portion of the plume with concentrations exceeding the DWS of 20,000 pCi/L is approximately 60 meters (200 feet) wide. The area of the plume containing the highest concentrations extends in a narrow band from the HFBR south to the vicinity of Rowland Street. Tritium is detected in the shallow Upper Glacial aquifer in the vicinity of the HFBR and in the deep Upper Glacial aquifer just to the north of Weaver Drive.

During 1998, the HFBR tritium plume was monitored using 88 monitoring wells that were sampled on a quarterly basis. The highest tritium concentrations continue to be found in wells located directly downgradient of the HFBR. For example, Well 75-43, located approximately 100 feet downgradient of the HFBR, displayed a tritium concentration of 1,920,000 pCi/L (71,040 Bq/L) in December of 1998 (see trend plots for key HFBR tritium plume wells on Figure 8-16). Although several wells located south of Brookhaven Avenue (e.g., Wells 85-67 and 095-48) showed increasing tritium concentrations throughout the year, the majority of the HFBR tritium plume wells displayed decreasing or fluctuating tritium concentration trends. The fluctuation in tritium concentrations for these wells is likely due to the effects of lateral movement of the plume resulting from periodic changes in groundwater flow directions caused by onsite pumping and recharge effects. Additional groundwater characterization work, including the enhancement of the HFBR tritium-plume monitoring well network, is planned for 1999.

8.1.2.3.2 WASTE CONCENTRATION FACILITY AND BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)/PILE FAN SUMP AREAS

Groundwater quality in the areas surrounding the WCF, former BGRR and its associated Pile Fan Sump has been affected by strontium-90 contamination. A groundwater characterization effort utilizing temporary wells was undertaken in 1997 to better define the extent of strontium-90 contamination in the areas of the WCF, the BGRR, and the Pile Fan Sump. As a result of this investigation, strontium-90 was found to occur at concentrations up to 432 pCi/L (16 Bq/L) in the Pile Fan Sump area, and up to 53 pCi/L (2 Bq/L) in wells located downgradient of the BGRR. Strontium-90 concentrations up to 146 pCi/L (5 Bq/L) have been detected in wells located downgradient of the WCF. The distribution of strontium-90 contamination using the 1997 characterization data is shown on Figure 8-17. Current plans call for the installation of new monitoring wells in the spring of 1999 to allow for better long-term monitoring of the strontium-90 plumes.

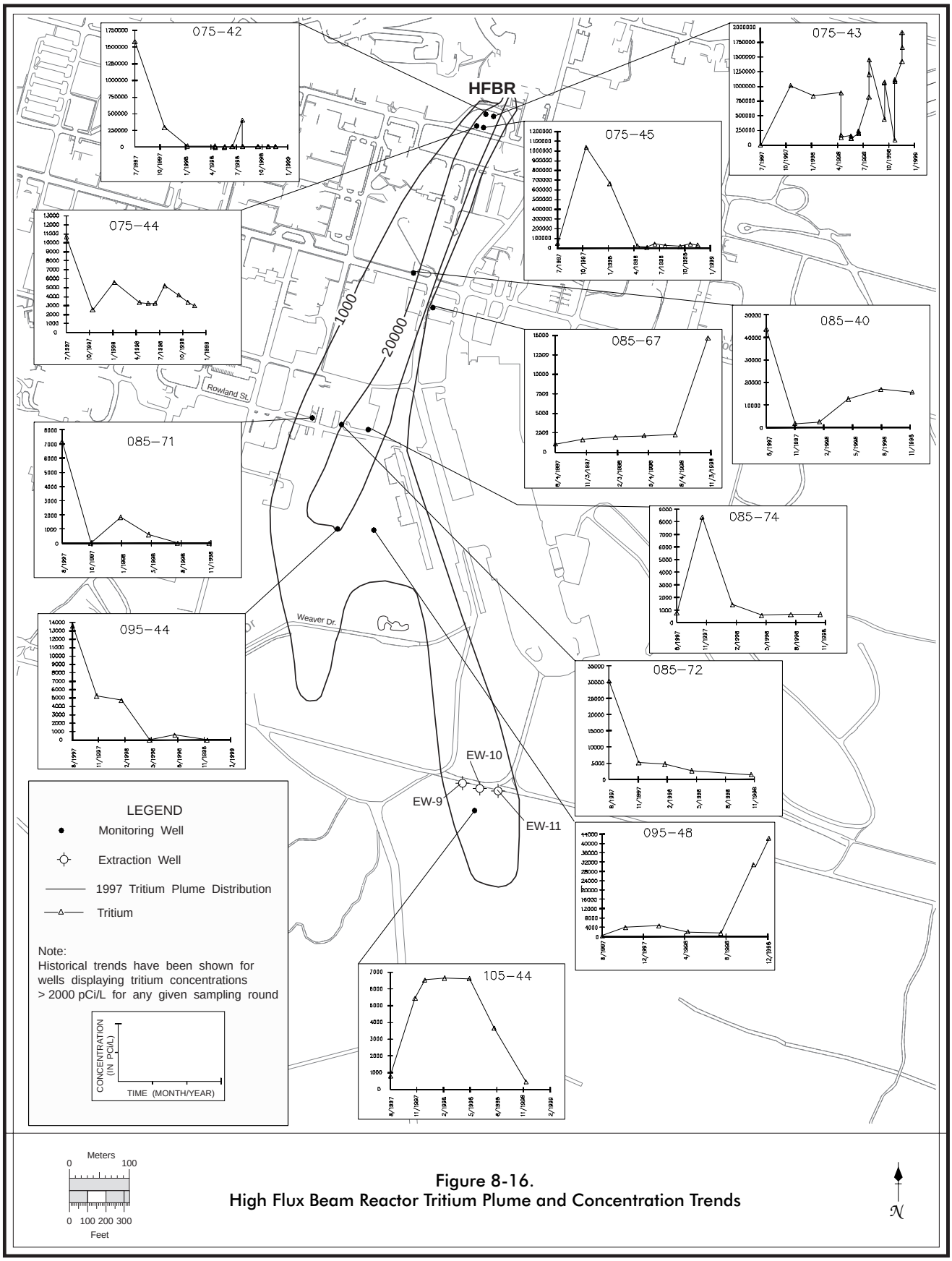


Figure 8-16.
High Flux Beam Reactor Tritium Plume and Concentration Trends

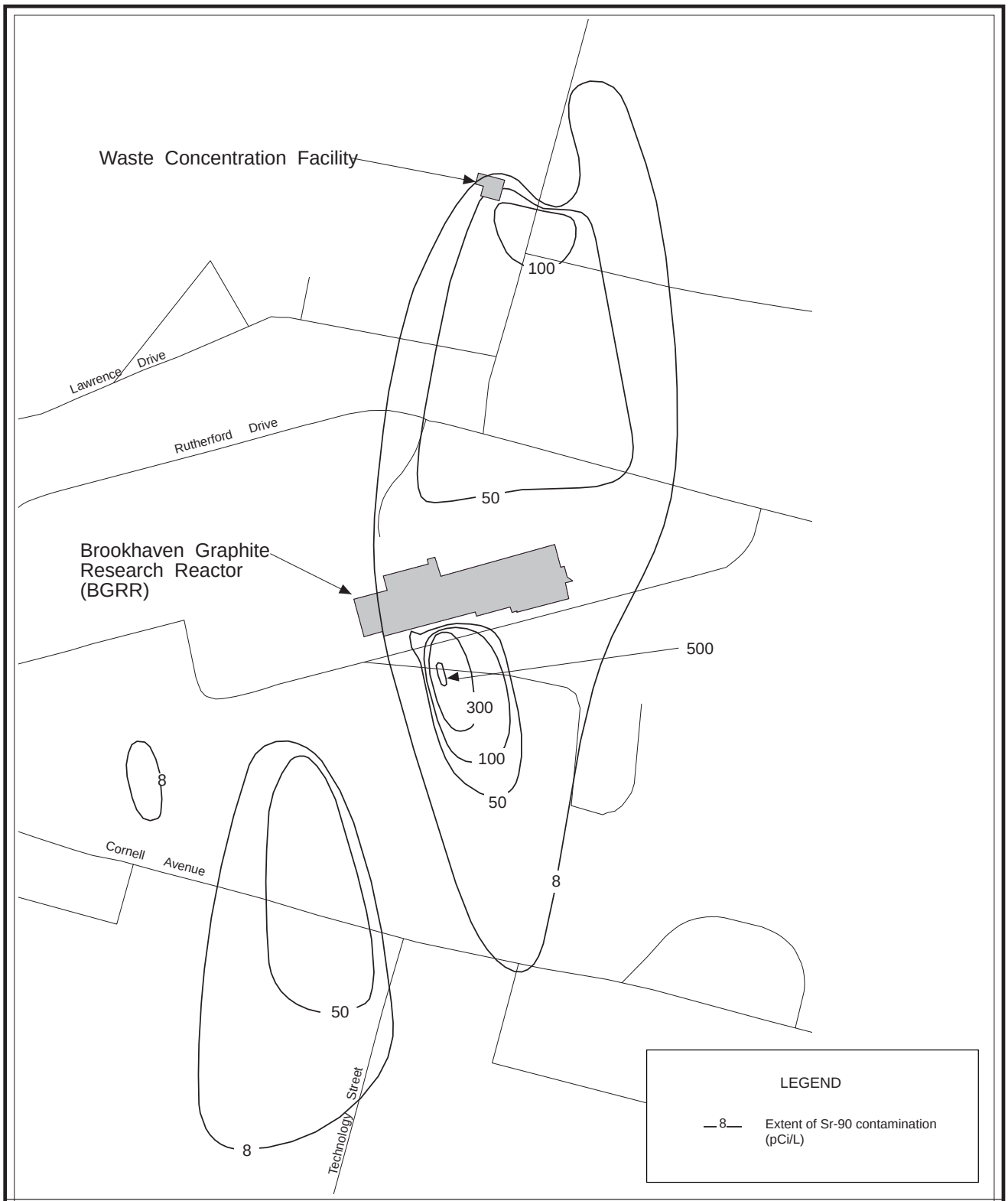


Figure 8-17.
Waste Concentration Facility and Brookhaven Graphite Research Reactor areas - Strontium-90 Plumes

8.1.2.4 OPERABLE UNIT IV

The OU IV area contains two significant source areas, the 1977 fuel oil/solvent spill site (AOC 5) and the Building 650 Sump Outfall area (AOC 6).

8.1.2.4.1 1977 OIL-SOLVENT SPILL SITE AND DOWNGRADIENT AREAS

In 1977, a 87,000 to 95,000 liter (23,000 to 25,000 gallons) mixture of Number 6 fuel oil and mineral spirits was released from a ruptured pipe used to transfer the contents from an underground storage tank to aboveground storage tanks at the CSF. In addition, several small spills of Number 6 fuel oil from the CSF fuel unloading area were documented between 1988 and 1993, and it is suspected that small volumes of solvents, such as PCE, have been released to the ground in the vicinity of the CSF. Eighteen wells are used to monitor this area. VOC contamination originating from the CSF area is currently monitored under two programs: the OU IV 1977 spill area cleanup program (AOC 5); and the OU I/IV Program which monitors the downgradient (south of Brookhaven Avenue) component of the OU IV plume.

The primary chemical contaminants found in the OU IV plume near the 1977 spill site are TCA, PCE, DCE, TCE, toluene, ethylbenzene, and xylenes. However, monitoring data suggest that there may have been additional historical solvent spills in the vicinity of the CSF (primarily PCE). The toluene/ethylbenzene/xylene component of the plume is highly localized to the 1977 spill area, and DCE is not prevalent in monitoring wells north of the Middle Road area. The OU IV plume extends from the 1977 Waste Oil Solvent Spill area in the north to an offsite area between the southern site boundary and Carleton Drive (a total distance of approximately 2,290 meters [7,500 feet]). The areal extent of the VOC plume is depicted on Figure 8-12. The plume is approximately 275 meters (900 feet) in width, as defined by the 5-µg/L contour. The width of the higher concentration segments of the plume (>50 µg/L) is approximately 700 feet. The area of the plume containing the highest VOC concentrations is in the 122 grid at the southern site boundary (consisting primarily TCA, DCE and TCE with TVOC concentrations up to 254 µg/L). The vertical distribution of VOC contamination is shown on Figure 8-18. In general, VOCs are present in the shallow Upper Glacial aquifer near the source area and in the deep portion of the Upper Glacial aquifer at the southern site boundary and just offsite. In addition, TVOC concentrations were 32 µg/L in upper Magothy aquifer Well 106-19. This deep contamination will be addressed as part of the additional characterization planned for the Magothy aquifer during 2000.

An air sparging/soil vapor extraction (AS/SVE) remediation system has been in operation since November 1997, to remediate VOC and semi-VOC contamination of soils and groundwater near the spill site (see Section 8.1.2.7). During 1998, significant decreases in VOC concentrations were observed wells located near the 1977 spill site. For example, TVOC concentrations in Well 76-04 declined from >1,000 µg/L in the first quarter to non-detectable levels during the fourth quarter of 1998 (see Figure 8-19). However, at this time it is not clear whether the reduction in VOC concentrations is due to the AS/SVE System, shifting of the plume due to AS operation or a combination of both.

The effectiveness of the OU III southern boundary extraction system is demonstrated by the reduction in TVOC concentrations in southern boundary Wells 122-04, 122-19 and 122-22 (Figure 8-19). The continued elevated concentrations detected in south boundary Well 114-07 will be addressed by the installation of a seventh remediation well located east of the existing six OU III, south boundary, extraction wells during 1999.

8.1.2.4.2 BUILDING 650 SUMP OUTFALL

Soil and groundwater contamination at the Building 650 Sump Outfall is due to the historical discharge of radionuclides to the Building 650 sump. Historically, strontium-90 has been detected at concentrations above the DWS in a number of the wells located downgradient of the Building 650 Sump Outfall. The strontium-90 plume distribution, based on October-November 1998 data, is shown on Figure 8-20. During 1998, strontium-90 was detected at concentrations exceeding the DWS in Wells 76-13, 76-24, 76-168 and 076-169, with concentrations ranging between 9 pCi/L (0.3 Bq/L) and 27 pCi/L (1 Bq/L).

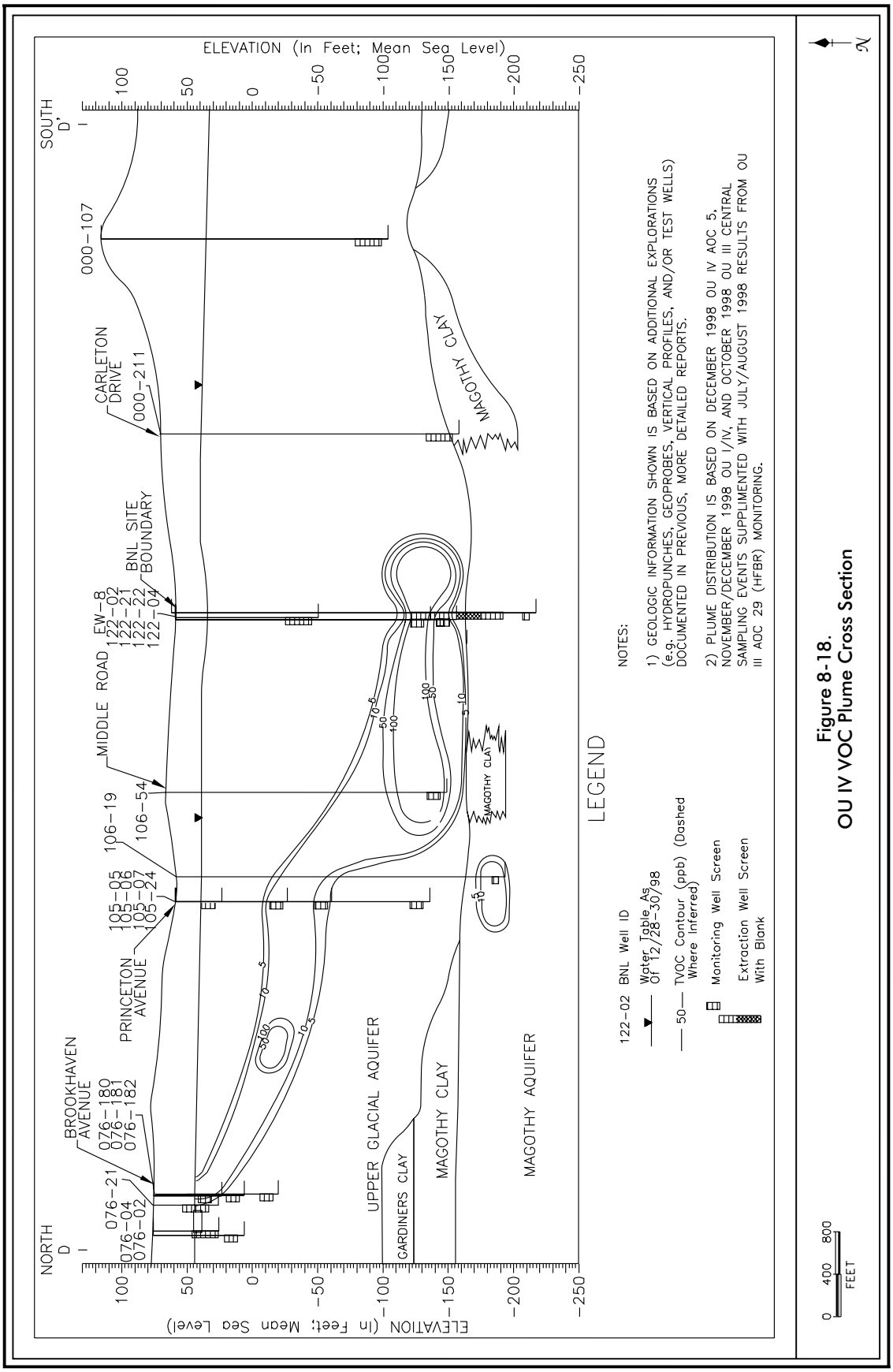


Figure 8-18.
OU IV VOC Plume Cross Section

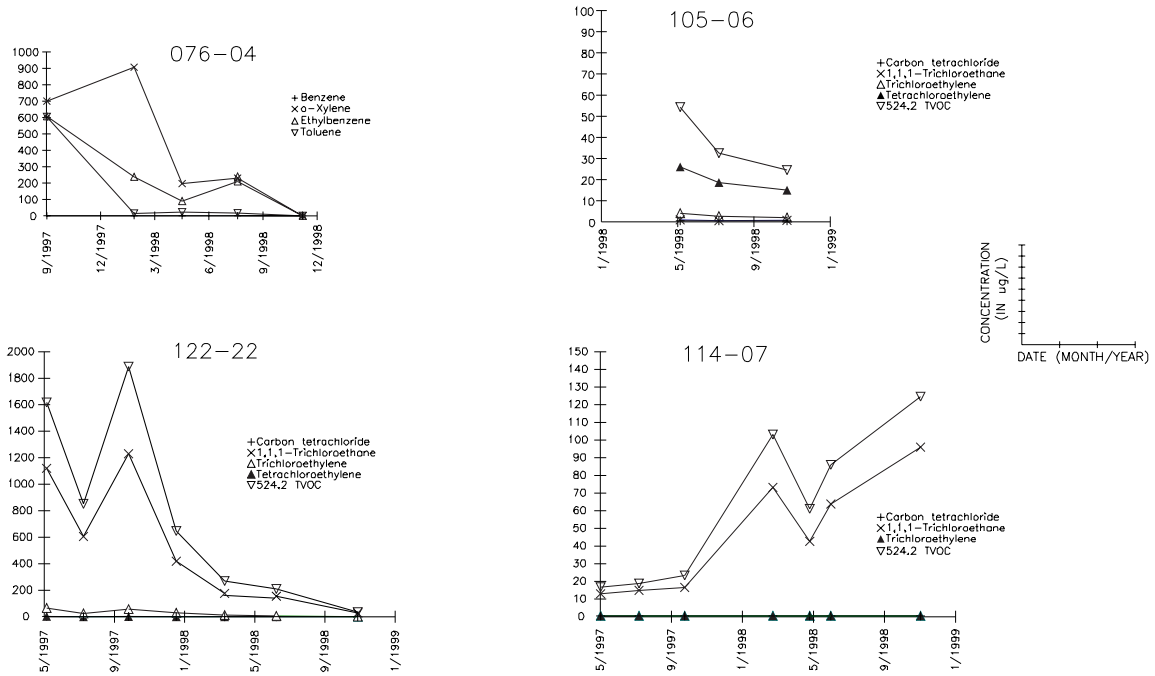


Figure 8-19. Time-vs.-VOC concentration trend plots for key wells in the OU IV VOC Plume: Well 76-04 located near the 1977 oil/solvent spill area; Well 105-06 located on East Princeton Avenue; and Wells 122-22 and 114-07 located along the southern boundary.

8.1.2.5 OPERABLE UNIT V

8.1.2.5.1 EASTERN PLUME

The OU V monitoring program uses 34 monitoring wells located downgradient of the STP. These wells monitor VOC and tritium contamination resulting from historical releases at the STP. Surveillance of present groundwater quality at the STP is performed as part of the BNL Environmental Monitoring Program (see Section 8.1.3.2.1).

Volatile Organic Compounds, Metals and Pesticides: The primary chemical contaminants that are found in the STP plume are TCE and TCA. The STP VOC plume (as defined by the 5 µg/L contour) extends from an area approximately 460 meters (1,500 feet) downgradient of the STP to the Long Island Expressway (LIE) offsite, a distance of approximately 2,290 meters (7,500 feet) (Figure 8-21). The plume is approximately 600 meters (2,000 feet) in width. Maximum VOC concentrations (approximately 30 µg/L) are observed in wells located at the site boundary, in the vicinity of North Street. The vertical distribution of VOCs is shown on Figure 8-22. VOCs are present in the deep Upper Glacial aquifer near the southeastern site boundary and offsite in the vicinity of the LIE. VOC concentration trend plots for key wells are also shown on Figure 8-21.

A number of key OU V wells were also analyzed for metals during 1998. None of the inorganic contaminants of concern identified in soils and sediments during the OU V RI/FS, including mercury and hexavalent chromium, were detected in groundwater samples. In addition, offsite wells were sampled and analyzed for pesticides and PCBs. Analytical data indicate the presence of 4,4''-DDD (dichlorodiphenyldichloroethane) and 4,4''-DDT (Dichlorodiphenyltrichloroethane) in Well 600-19 at concentrations of 0.043 and 0.06 µg/L, respectively. 4,4''-DDT was also detected in well 600-21 at a concentration of 0.013 µg/L. The NYS AWQS for these compounds is non-detect.

Radionuclides: Detectable, but below NYS DWS levels of tritium were found in site boundary Wells 50-02 and 61-05, with maximum observed concentrations of 3,079 p Ci/L (114 Bq/L) and 2,185 pCi/L (81 Bq/L), respectively. Tritium concentration trends for Wells 50-02, 61-05, 000-123, and 600-015 are provided on Figure 8-23. Tritium was not detected in any of the STP offsite monitoring wells during 1998.

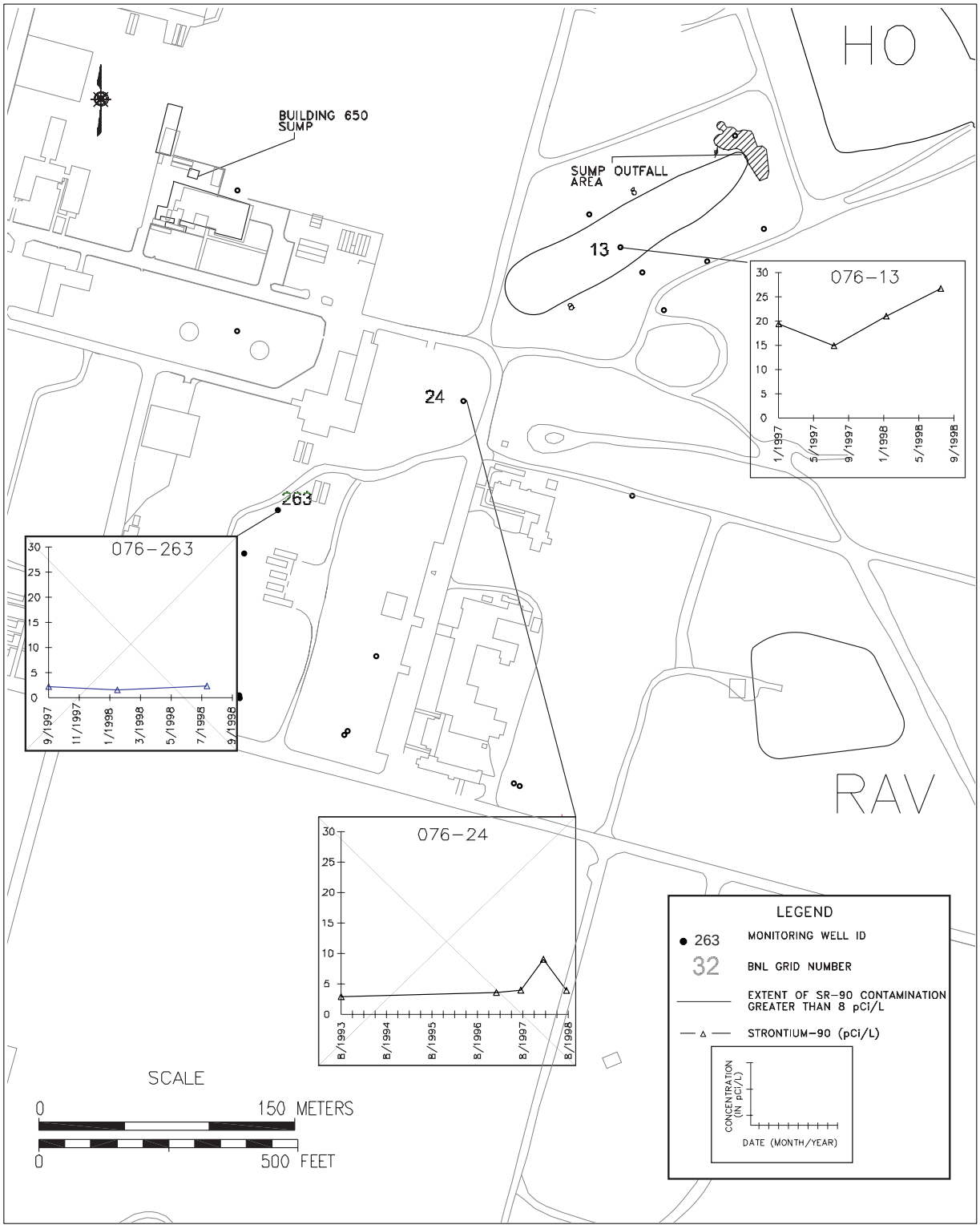


Figure 8-20.
OU IV AOC 6 - Strontium-90 Plume and Concentration Trends

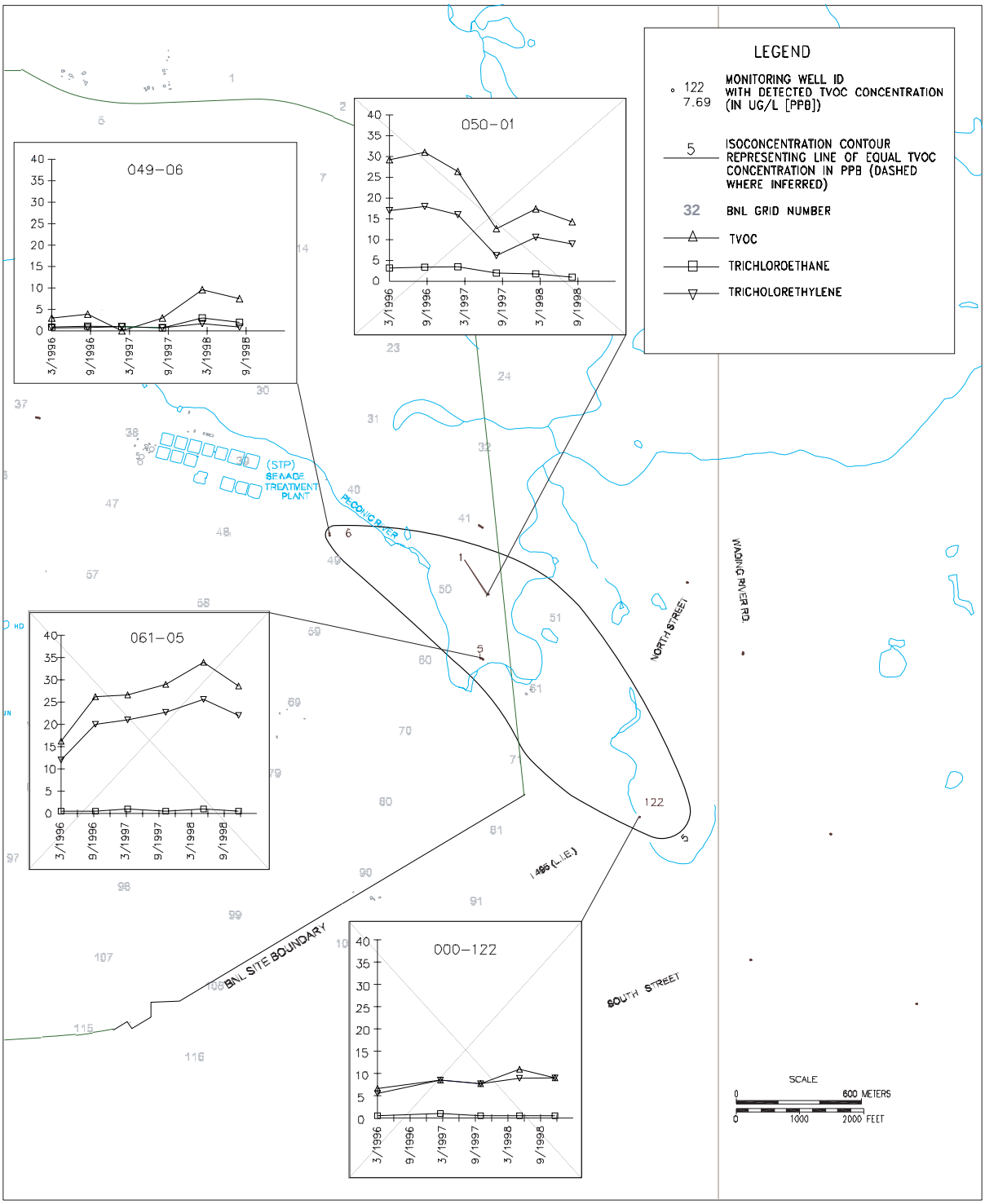


Figure 8-21.
OU V VOC Plume Map

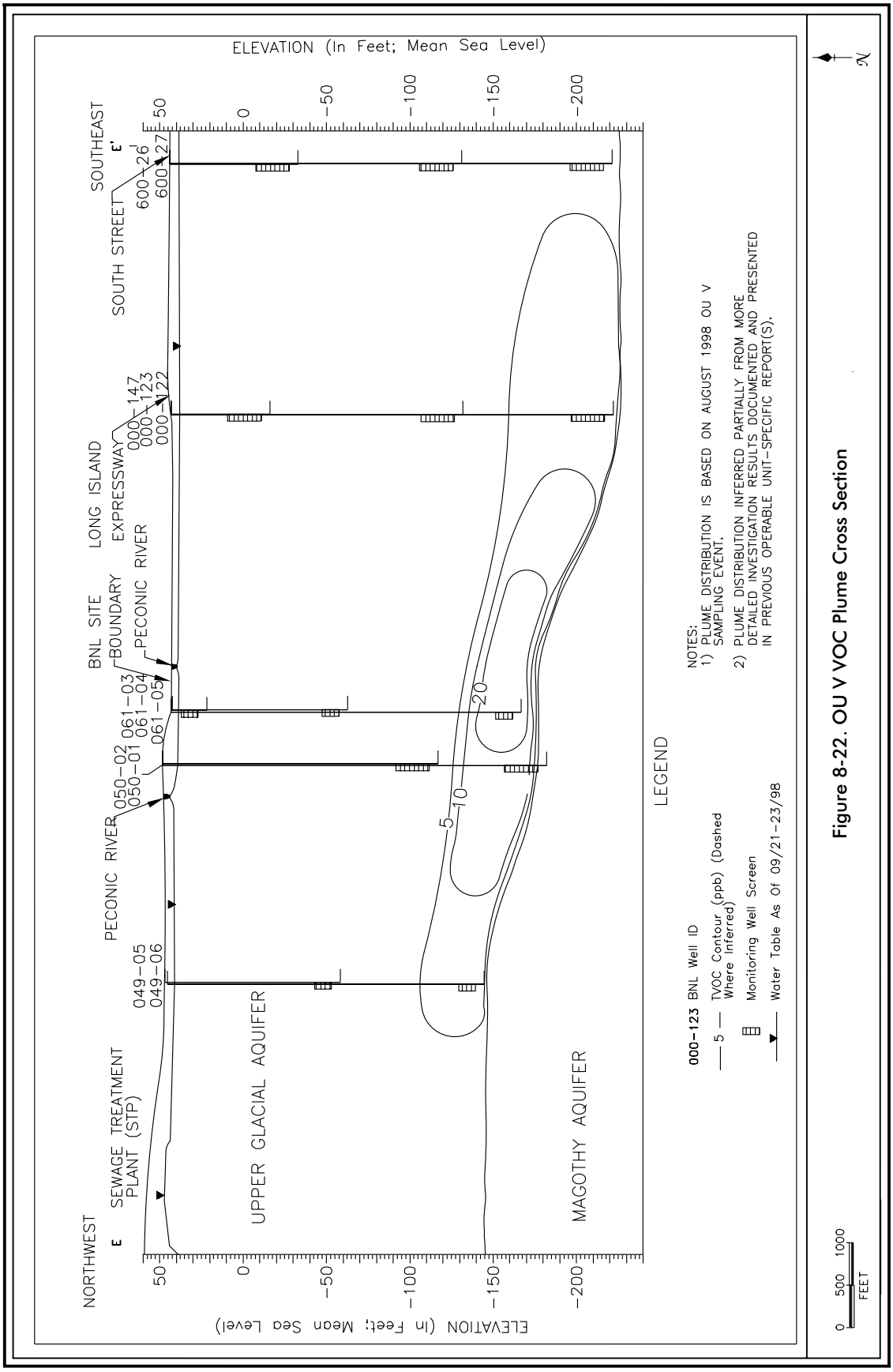


Figure 8-22. OU V VOC Plume Cross Section

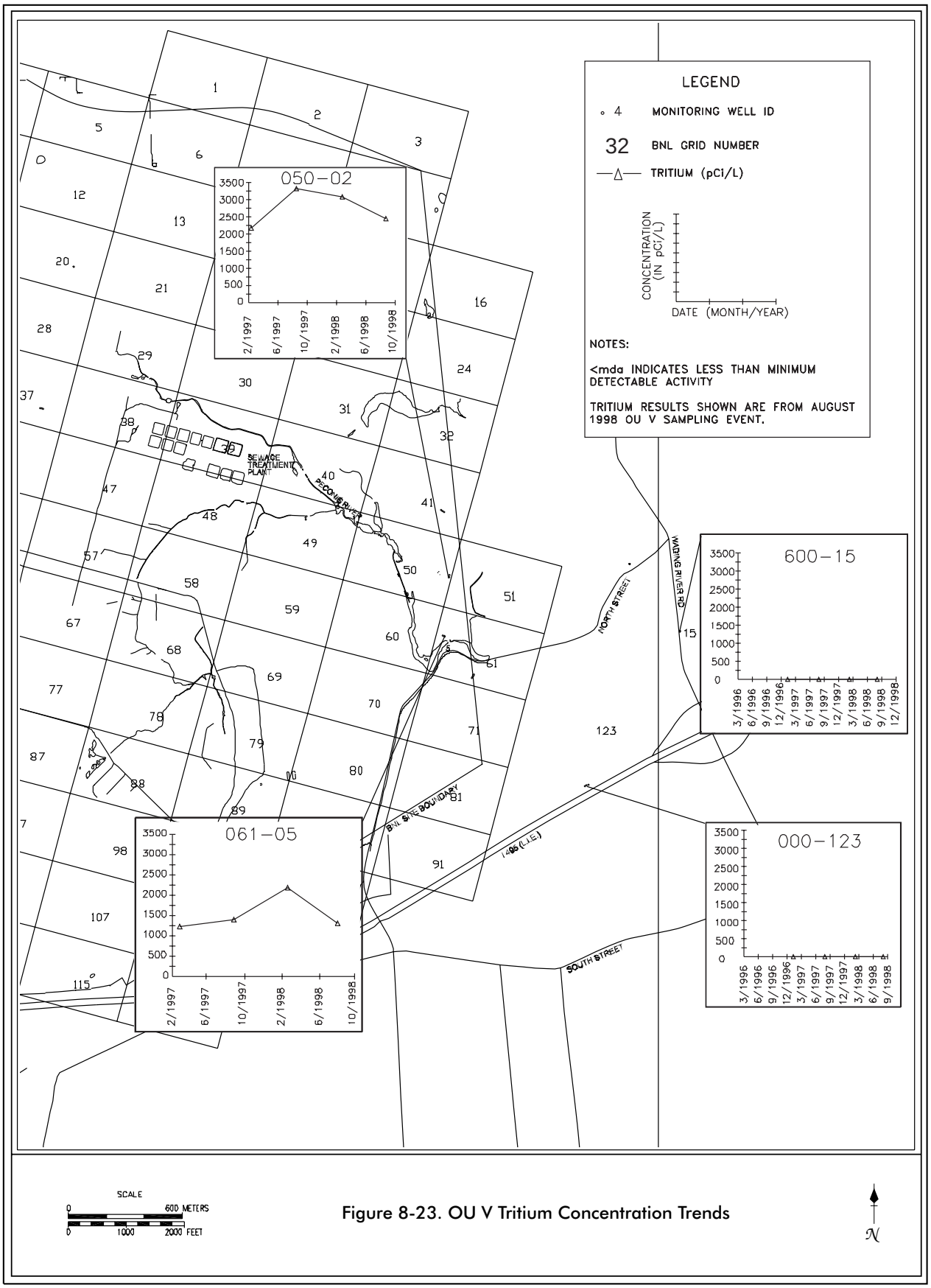


Figure 8-23. OU V Tritium Concentration Trends

8.1.2.6 OPERABLE UNIT VI

8.1.2.6.1 BIOLOGY FIELDS

Ethylene dibromide (EDB) was used as a fumigant in the BNL Biology Department's agricultural fields located in the southeast portion of the site. Available records indicate that the application of EDB in this area took place in the 1970s. An EDB contaminant plume (as defined by the 0.05 µg/L contour, which is the NYS DWS) extends from BNL's southeastern site boundary to south of North Street, a distance of approximately 1,160 meters (3,800 feet) (Figure 8-24). The highest EDB concentration was observed in offsite Well 000-175 (4.4 µg/L), which is located south of North Street. At its widest point, the plume is approximately 305 meters (1,000 feet) wide. The vertical distribution of EDB is shown on Figure 8-25. Additional offsite characterization work undertaken by BNL during 1998 resulted in the detection of EDB further downgradient than previously identified during the OU VI Focused FS. The additional characterization work resulted in defining the leading edge of the plume, and allowed for the installation of outpost wells positioned downgradient of the plume's leading edge (Well 000-178).

8.1.2.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of BNL's ER Program is remediating soil and groundwater contamination and preventing additional contamination from migrating off the BNL site. To that end, four groundwater treatment systems are operating at BNL, and a fifth system will be operational in 1999. Figure 8-26 shows the locations of these four systems. The following is a brief description of the groundwater treatment systems that were operational during 1998 and a summary of their performance:

South Boundary Remediation System for OU III: Construction of the OU III pump-and-treat system was completed in June 1997. The system uses six wells to extract VOC contaminated groundwater that originated from a number of sources located in the developed central portion of the BNL site. The water is pumped approximately 1.6 km (one mile) north to an air-stripping tower located near the Medical Department complex (Figure 8-26), where air from a powerful blower separates the VOCs from the water. The removal efficiency is close to 100 percent (see Table 8-4). No VOCs were detected above the MDL in treated water samples. The clean water is discharged to a nearby recharge basin, and the VOCs stripped from the water are released into the air at concentrations below state and federal emissions standards. The system processes approximately 2,270 liters (600 gallons) of water per minute.

During 1998, approximately 405 pounds of VOCs were removed from the groundwater, and 1,268,000,000 liters (335,000,000 gallons) of treated groundwater was returned to the aquifer.

South Boundary Remediation System for OU I (RA V): This pump-and-treat system was completed in December 1996. The system uses two extraction wells to remove contaminated groundwater that originated from the Current Landfill (now closed and capped) and the former HWMF. The water is pumped approximately 1.6 km (one mile) north to an air stripper system (Figure 8-26). This system processes more than 2,650 liters (700 gallons) of water per minute. Like the OU III treatment system, the RA V system removes close to 100 percent of the chemical contamination (Table 8-5). No VOCs were detected above the MDL in treated water samples. The clean water is discharged to a nearby recharge basin, and the VOCs stripped from the water are released into the air at concentrations below state and federal emissions standards.

During 1998, approximately 46 pounds of VOCs were removed from the groundwater, and 1,294,000,000 liters (342,000,000 gallons) of treated groundwater returned to the aquifer.

HFBR Tritium Plume Remediation System (OU III): This groundwater pump and recharge system was constructed as an interim remedial action after the HFBR tritium plume was discovered, and has operated since May 1997. Three groundwater extraction wells were installed approximately 3,500 feet south of the HFBR. For most of 1998, the tritiated groundwater (generally <2,000 pCi/L) was pumped from the aquifer at a rate of about 450 liters (120 gallons) per minute and piped north to a treatment facility adjacent to the RA V treatment system (see Figure 8-26). However, by the fourth quarter of 1998 BNL received regulatory approval to reduce the pumping rate to 190 liters (50 gallons) per minute in an effort to optimize the remediation system. Because the tritiated water also contains VOCs that origi-

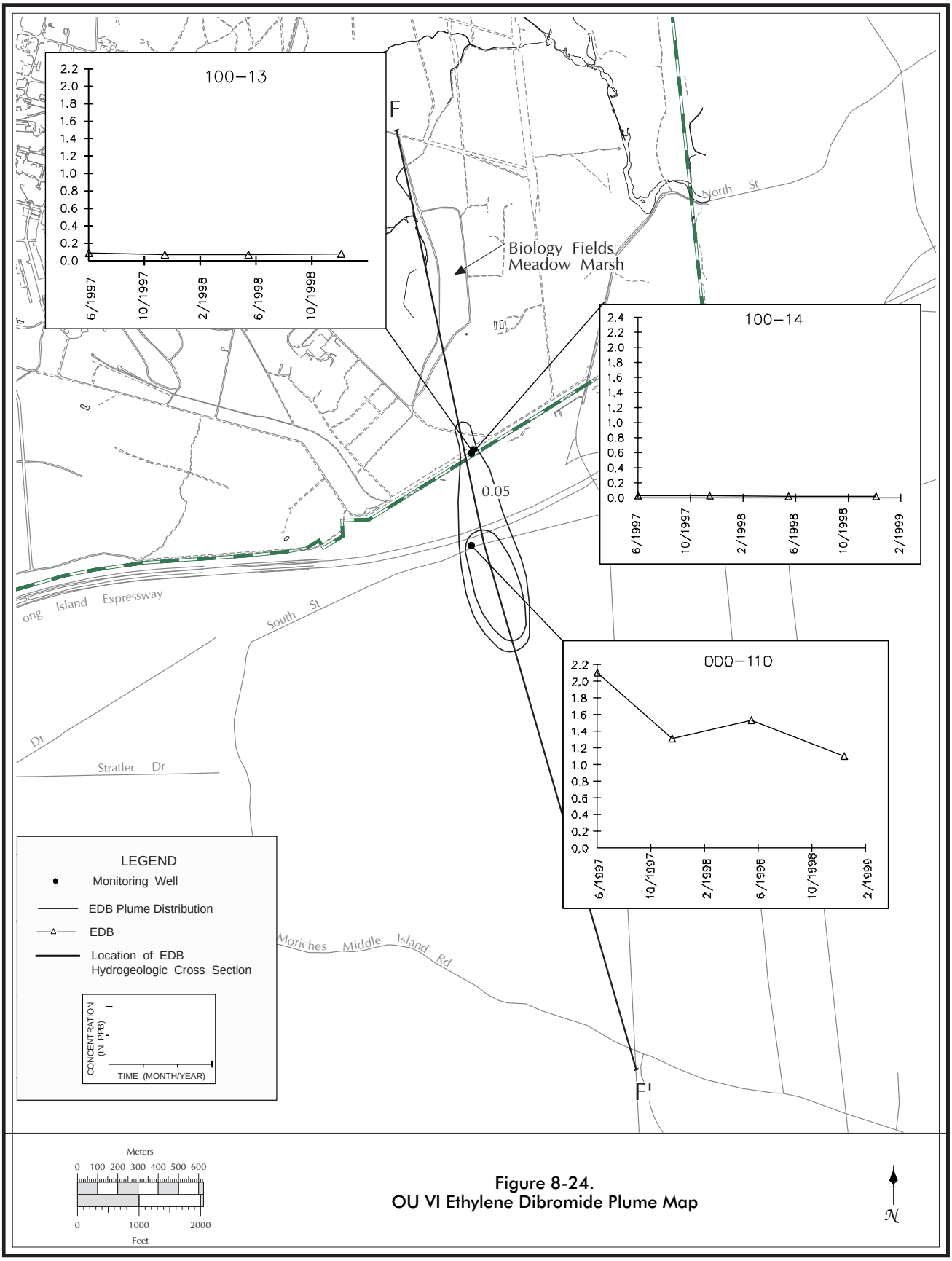


Figure 8-24.
OU VI Ethylene Dibromide Plume Map

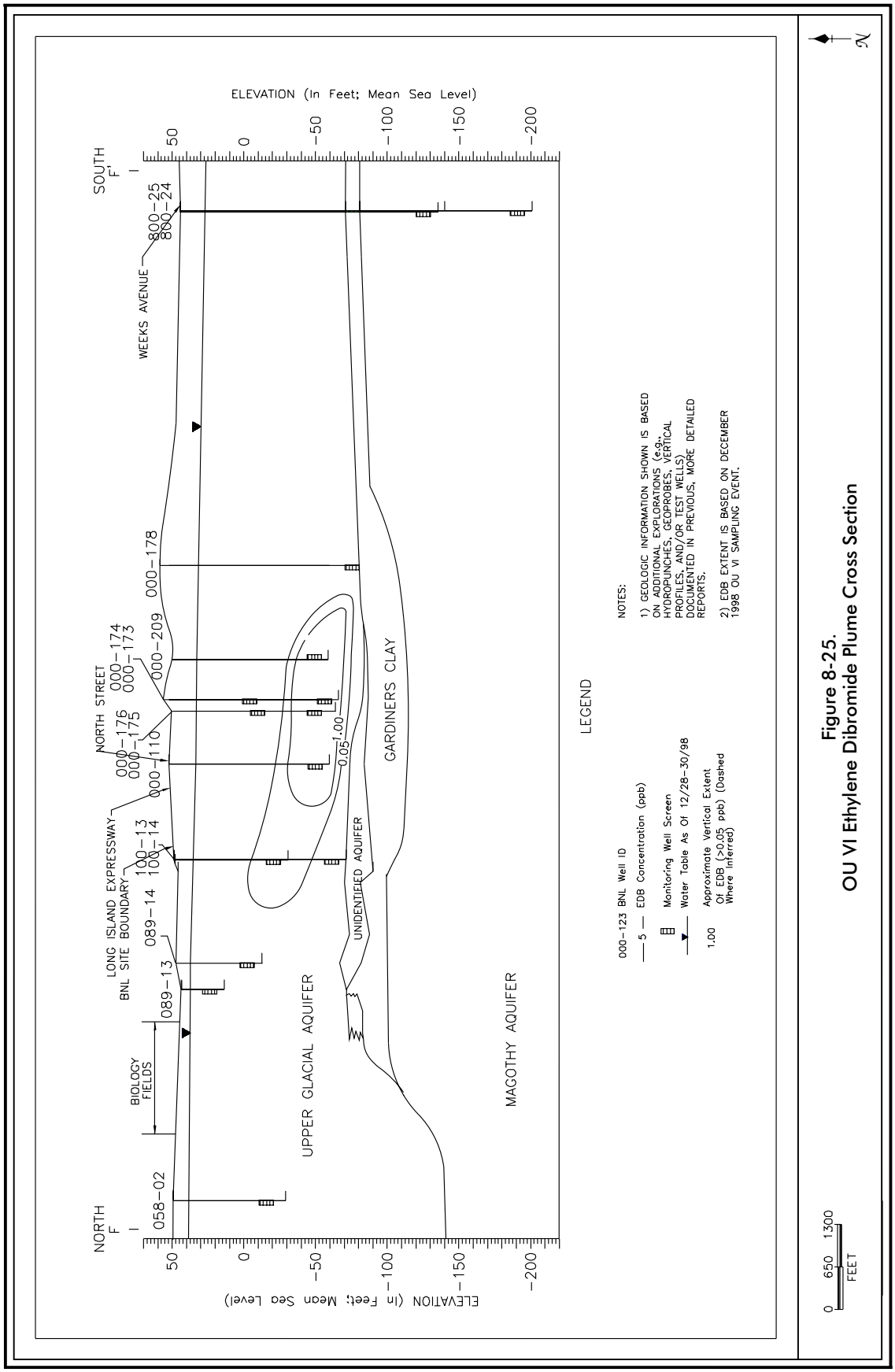


Figure 8-25.
OU VI Ethylene Dibromide Plume Cross Section

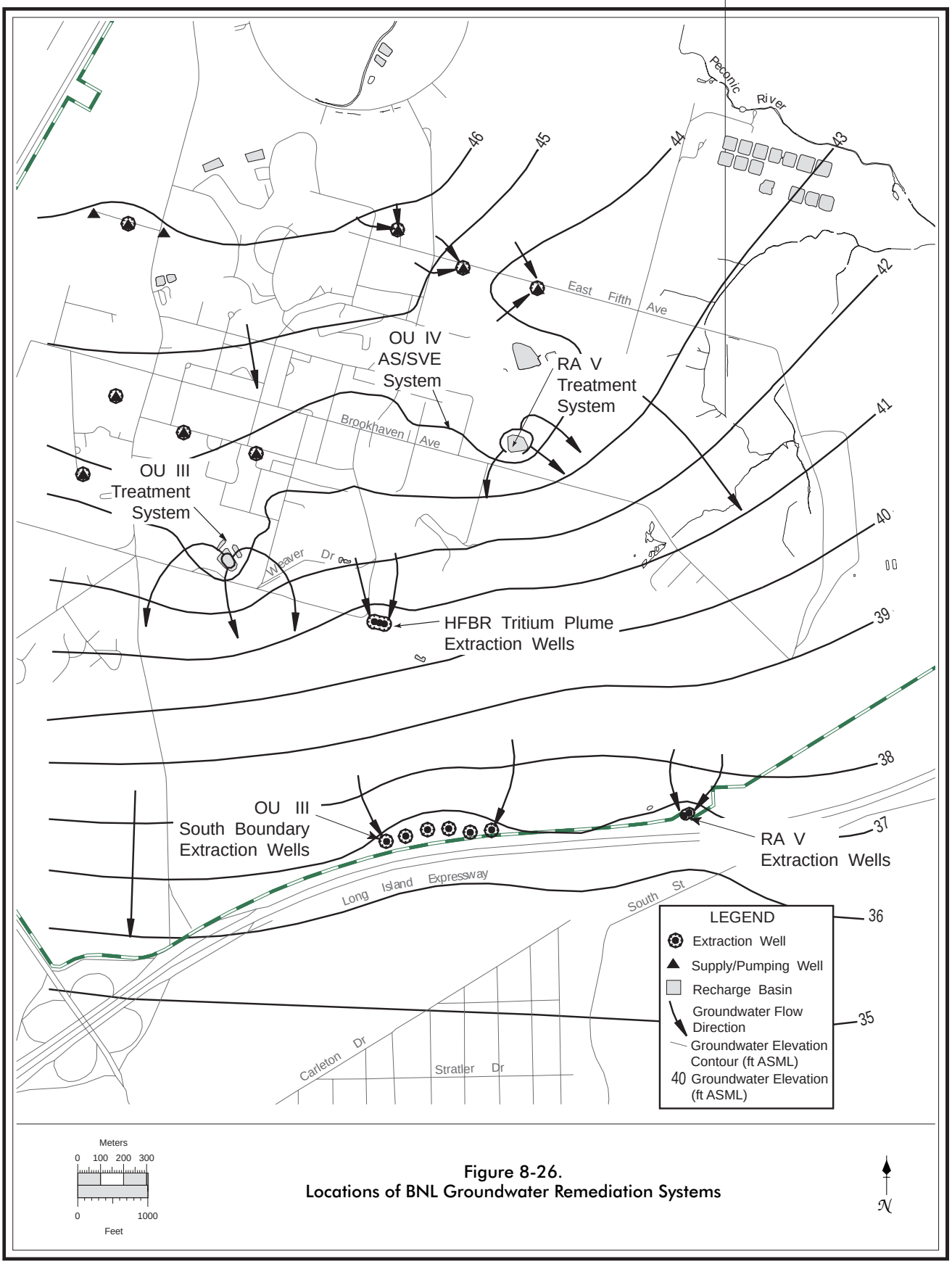


Figure 8-26.
Locations of BNL Groundwater Remediation Systems

Table 8-4. OU III South Boundary Groundwater Remediation System
Comparison of Monthly Average Influent and Effluent VOC Concentrations [a]

Month (# Samples)	VOC Removal (lbs.)		Carbon Tetrachloride	1,1 - Dichloroethylene	Tetrachloroethylene	Trichloroethylene	1,1,1 -Trichloroethane
			µg/L				
January (2)	39	Influent	8	33	43	6	86
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
February (2)	34	Influent	7	36	42	7	87
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
March (2)	45	Influent	7	35	45	7	85
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
April (2)	45	Influent	8	38	46	7	90
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
May (2)	28	Influent	6	19	36	4	58
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
June (2)	28	Influent	5	22	33	<5	60
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
July (2)	33	Influent	6	25	35	5	63
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
August (2)	22	Influent	3	18	19	4	45
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
September (2)	29	Influent	5	21	31	4	61
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
October (2)	32	Influent	3	25	44	2	61
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
November (2)	22	Influent	6	15	41	4	42
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5
December (2)	46	Influent	7	33	58	5	75
		Effluent	<0.5	<0.5	<0.5	<0.5	<0.5

Notes:
1. NYSAWQS: New York State Ambient Water Standard
2. MDL: Minimum Detection Limit
a. Other compounds detected (typically <3 µg/L).

Table 8-5. Removal Action V Groundwater Remediation System
Comparison of Monthly Average Influent and Effluent VOC Concentrations (a)

Month (# Samples)	VOC Removal (lbs)		Chloroethane	1,1 - Dichloroethane	Chloroform	1,1,1 Trichloroethane
			µg/L			
January (1)	4	Influent	3	10	<1	3
		Effluent	<0.5	<0.5	<0.5	<0.5
February (1)	3	Influent	3	9	<1	<0.5
		Effluent	<0.5	<0.5	<0.5	<0.5
March (1)	4	Influent	4	8	<1	3
		Effluent	<0.5	<0.5	<0.5	<0.5
April (1)	3	Influent	5	11	1	4
		Effluent	<0.5	<0.5	<0.5	<0.5
May (1)	7	Influent	3	7	<1	3
		Effluent	<0.5	<0.5	<0.5	<0.5
June (1)	3	Influent	2	8	1	3
		Effluent	<0.5	<0.5	<0.5	<0.5
July (1)	3	Influent	2	7	<1	3
		Effluent	<0.5	<0.5	<0.5	<0.5
August (1)	4	Influent	2	7	<1	2
		Effluent	<0.5	<0.5	<0.5	<0.5
September (1)	4	Influent	2	6	<1	2
		Effluent	<0.5	<0.5	<0.5	<0.5
October (1)	4	Influent	1	7	1	2
		Effluent	<0.5	<0.5	<0.5	<0.5
November (1)	3	Influent	2	7	<1	2
		Effluent	<0.5	<0.5	<0.5	<0.5
December (1)	4	Influent	3	11	2	3
		Effluent	<0.5	<0.5	<0.5	<0.5
NYSAWQS			5	5	7	5
MDL			0.5	0.5	0.5	0.5

Notes:
MDL = Minimum detection limit.
a. Trace amounts of several other compounds were occasionally detected (typically <3 µg/L).

nated from another source(s), the water is treated by passing it through a granular carbon filter to remove the VOCs before discharging the water to the RA V recharge basin. No VOCs were detected above the MDL treated water samples, and tritium concentrations in samples collected at the influent to the treatment system were <900 pCi/L (<33 Bq/L) (see Table 8-6). This interim remediation system is designed to prevent the further southward migration of the HFBR tritium plume while long-term remediation options are evaluated as part of the OU III FS.

During 1998, the granular activated carbon filters removed approximately 20 pounds of VOCs, and 238,000,000 liters (63,000,000 gallons) of treated water were recharged to the aquifer system.

Air Sparging/Soil Vapor Extraction System for OU IV: This remediation system, which has operated since November 1997, combines two technologies to remove VOC and semi-VOC contaminants from soil and groundwater located near the BNL CSF (Figure 8-26). The system uses air sparging and soil vapor extraction which forces pressurized air into the groundwater to "bubble" or strip these volatile compounds out of the water and soil and into a vapor phase. Powerful vacuum pumps then recover the resulting vapors and pipe them to a nearby treatment facility where the VOC vapors are removed by a granular carbon filter

Table 8-6. HFBR Tritium Plume and Recharge System
Monthly Average Influent Tritium Concentrations and a
Comparison of Monthly Average Influent and Effluent VOC Concentrations (a)

Month (# Samples)	**VOC Removal** (lbs)		**Tritium** (pCi/L)	**Tetrachloroethylene** (µg/L)	**1,1,1 - TCA** (µg/L)
January	2	Influent	<700	27	10
(3)		Effluent	-	<0.5	<0.5
February	2	Influent	<900	26	9
(1)		Effluent	-	<0.5	<0.5
March	2	Influent	<800	30	10
(2)		Effluent	-	<0.5	<0.5
April	2	Influent	<800	29	11
(2)		Effluent	-	<0.5	<0.5
May	2	Influent	<600	21	9
(2)		Effluent	-	<0.5	<0.5
June	2	Influent	<500	35	10
(2)		Effluent	-	<0.5	<0.5
July	1	Influent	<500	21	6
(3)		Effluent	-	<0.5	<0.5
August	1	Influent	<500	13	5
(2)		Effluent	-	<0.5	<0.5
September	1	Influent	<500	17	7
(2)		Effluent	-	<0.5	<0.5
October	1.5	Influent	<500	23	8
(2)		Effluent	-	<0.5	<0.5
November	2(a)	Influent	NS	NS	NS
(0)		Effluent	-	-	-
December	2	Influent	<500	30	11
(1)		Effluent	-	<0.5	<0.5
SDWA/NYSAWQS		20,000	5	5	
Typical MDL			700	0.5	0.5

Notes:
1. MDL = Minimum detection limit.
a. Other compounds detected (typically <3 µg/L).
b. Estimated.

system before the air is released into the atmosphere.

During 1998, approximately 18.5 pounds of contaminants were removed from the soil and groundwater through the treatment of 6.88 x 10^8 cubic feet of air collected in the soil vapor extraction system.

Offsite Groundwater Treatment System for OU III: A fifth groundwater remediation system is expected to be operational in the summer of 1999. The system will be constructed south of the BNL site to remove VOC contamination that has migrated to an industrial area located between the Long Island Expressway and the residential areas of North Shirley. This remediation system will consists of a series of innovative "in-well stripping" wells that use the same air stripping treatment concept as the OU III south boundary systems, but all treatment and recharge will occur within the well. Within each well, contaminated water will be pumped from a deep well screen to a treatment system located near the top of the well, where VOCs will be stripped from the water. The treated water will then be routed to a shallower screened section of the same well where it will re-enter the aquifer, and the VOC vapors will be captured by a granular carbon filter.

8.1.3 ENVIRONMENTAL MONITORING PROGRAM (NON-CERCLA)

As noted above, BNL's Environmental Monitoring Program includes monitoring at active waste processing and temporary storage facilities to comply with RCRA, waste-treatment facilities, operational monitoring around accelerators, and in other areas of

known or suspected soil and groundwater contamination. In September 1998, BNL finalized a Groundwater Monitoring Improvements Plan (Paquette, 1998) which identified active research and support facilities requiring improved groundwater monitoring programs. As a result of this evaluation, over 80 new groundwater monitoring wells will be installed on a prioritized basis in 1999. During 1998, a total of 63 groundwater surveillance wells were monitored during approximately 235 individual sampling events. All wells sampled during 1998 are listed in Appendix D.

8.1.3.1 RESEARCH FACILITIES

8.1.3.1.1 ALTERNATING GRADIENT SYNCHROTRON AND BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP) AREAS

Activated soils have been created at the AGS and BLIP facilities as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. Radionuclides, such as tritium and sodium-22, have been produced by the interaction of these secondary particles and soils that surround these experimental areas. Furthermore, historical surface spills and discharges of solvents to cesspools and recharge basins near the AGS have contaminated soils and groundwater with VOCs. Groundwater quality in the AGS/Linac and BLIP areas is monitored using 19 shallow to deep Upper Glacial aquifer wells that are sampled on a quarterly basis.

Volatile Organic Compounds: Groundwater samples collected from two AGS area wells had TCA at concentrations that exceeded NYS AWQS. Wells 54-07 and 64-03 showed maximum TCA concentrations of 114 µg/L and 7.7 µg/L, respectively. The TCA in Well 64-03 may have originated from cesspools associated with Buildings 914 and 919, whereas the TCA in Well 54-07 may have originated from the Bubble Chamber spill areas. The contents of the Building 914/919 cesspools were characterized as part of the ER Program (Cesspools Removal Project EE/CA), and were found to contain VOCs at levels above NYS Soil Cleanup Guidelines (BNL, 1994). No VOCs were detected in Linac or BLIP area wells.

Radionuclides: In February 1998, above normal levels of tritium (14,100 pCi/L; 522 Bq/L) and sodium-22 (44 pCi/L; 2 Bq/L) were detected in Well 64-02, which located downgradient of the BLIP and AGS Booster facilities (Table 8-7). Although the initial tritium and sodium-22 values were below the DWS of 20,000 pCi/L and 400 pCi/L, respectively, BNL conducted a groundwater investigation and inspection of the facilities located upgradient of Well 64-02. As a result of this investigation, activated soils surrounding the BLIP facility's beam target vessel were identified as the source of the contamination. Tritium and sodium-22 concentrations (52,400 pCi/L [1,939 Bq/L] and 151 pCi/L [6 Bq/L], respectively) were observed in a temporary well installed approximately 6 meters (20 feet) south of the BLIP building. Tritium concentrations diminished to less than the 20,000 pCi/L DWS in wells installed approximately 30 meters (100 feet) downgradient of BLIP. Details on the characterization effort are contained in the Monitoring Well 064-02 Tritium Investigation Report (BNL, 1998b). Corrective actions were taken (e.g., connecting roof drains, sealing paved areas, and construction of a cement cap) to prevent rainwater from infiltrating the activated soils, and thereby "washing out" the tritium and sodium-22 from the soils and into the groundwater. Six new groundwater monitoring wells will be installed in 1999 to verify that these corrective measures are working.

8.1.3.1.2 BROOKHAVEN MEDICAL RESEARCH REACTOR

During a 1997 investigation to evaluate groundwater quality near the BMRR, a tritium plume with a maximum concentration of approximately one-half the DWS was identified. The maximum tritium concentration was 11,800 pCi/L (437 Bq/L) in wells installed directly downgradient (within 10 meters) of the facility. The tritium is believed to have originated from the historical discharge of small amounts of BMRR primary cooling water to a basement floor drain and sump system that may have leaked. The last discharge of primary water to the floor drain system occurred in 1987. However, the floor drains continued to be used for secondary (non-radioactive) cooling water until 1997, which may have promoted the movement of residual tritium from the soils surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any future releases to the underlying soils.

During 1998, four rounds of groundwater

Table 8-7. Radiological Data for Groundwater Wells Near AGS, BLIP, and LINAC Areas

Well		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Na-22 (pCi/L)
44-02	#	4	4	4	4
	Max.	3.0±0.7	< 4.0	< 317	ND
	Avg.	0.9±1.2	0.5±1.2	-17±198	
53-01	#	4	4	4	4
	Max.	1.9±0.7	3.2±1.5	< 373	ND
	Avg.	0.6±0.8	0.0±2.4	-163±72	
54-01	#	4	4	4	4
	Max.	7.1±1.0	4.7±2.6	463 211	ND
	Avg.	2.3±2.8	2.1±1.8	49±274	
54-02	#	3	3	3	4
	Max.	< 1.3	< 3.9	606±248	ND
	Avg.	0.1±0.8	0.5±0.8	357±203	
54-03	#	4	4	4	4
	Max.	4.7±1.3	6.8±2.6	< 367	ND
	Avg.	2.0±1.9	4.2±2.3	-52±51	
54-05	#	3	3	3	3
	Max.	< 1.1	< 3.7	< 317	ND
	Avg.	0.2±0.7	0.0±1.1	-6±154	
54-06	#	3	3	3	3
	Max.	< 0.9	< 4.0	< 317	ND
	Avg.	0.1±0.1	1.1±1.6	-51±181	
54-07	#	4	4	4	4
	Max.	< 0.7	8.4±2.7	585±242	1.8±1.1
	Avg.	-0.2±0.2	6.5±1.4	321±204	0.4±0.7
54-08	#	3	3	5	5
	Max.	2.4±1.1	6.6±1.5	< 372	ND
	Avg.	1.4±0.6	2.5±3.0	73±72	
54-10	#	5	5	5	5
	Max.	6.8±0.9	< 8.3	419±214	ND
	Avg.	2.5±2.6	4.0±2.2	-12±196	
64-01	#	4	4	4	4
	Max.	2.2±0.6	3.8±1.4	< 373	ND
	Avg.	0.5±1.1	1.0±2.3	-34±123	
64-02	#	6	6	10	9
	Max.	0.9±0.8	40.7±3.7	14,100±601	43.6±7.2
Avg.	0.5±0.4	19.1±12.1	3,609±3149	15.3±9.7	
64-03	#	5	5	5	5
	Max.	< 0.7	5.7±2.3	594±219	5.5±1.9
	Avg.	0.0±0.4	3.2±1.1	292±200	3.4±1.1
SDWA Limit		15	50	20,000	400

Notes:
# = Number of samples collected.
ND = Not Detected.
1. All values shown with 95% confidence interval.
2. Out of three analyses, Well 54-05 showed one detection of Be-7 at 17.1 ± 13.3 pCi/L.

samples were collected from three shallow Upper Glacial aquifer wells located downgradient of the BMRR (Table 8-8). Compared to 1997 results, tritium concentrations decreased in wells directly downgradient of the facility, with a maximum observed value in Well 84-12 of 6,200 pCi/L (229 Bq/L).

8.1.3.2 SUPPORT FACILITIES

8.1.3.2.1 SEWAGE TREATMENT PLANT / PECONIC RIVER AREA

As described in Chapter 2, STP processes sanitary sewage for BNL facilities. Approximately 15 percent of the water released to the

Table 8-8. Radiological Analysis Results for Wells Downgradient of the BMRR.

Well (# Samples)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)
84-12	1.9±0.7	7.2±1.6	6,200±428
(4)	0.6±1.1	3.2±2.3	4,720±1,440
84-13	1.3±0.7	6.0±1.6	3,120±337
(4)	0.3±0.7	2.8±2.6	2,400±669
94-01	1.6±0.7	< 3.9	< 357
(4)	0.1±0.9	-18.9±35.0	4±118
SDWA Limit	15	50	20,000

Notes:
1. All values shown with 95% confidence interval.
2. No anthropogenic gamma-emitting radionuclides were detected in these wells in 1998.

STP's filter beds is lost either to evaporation or to direct groundwater recharge; the remaining water is discharged to the Peconic River. Past radiological and chemical releases to the sanitary system contaminated soils, sediments and groundwater in the STP and Peconic River areas. The STP groundwater monitoring program used 13 shallow Upper Glacial aquifer wells to evaluate groundwater quality near the plant's filter beds and along the Peconic River from the STP discharge point to the site boundary. These wells are typically monitored on a quarterly basis.

Volatile Organic Compounds, Metals and Water Quality Parameters: As noted earlier, groundwater quality impacts resulting from historical STP discharges are currently being monitored as part of the OU V monitoring program using wells that are located at the site boundary and offsite areas (see Section 8.1.2.5.1). The STP facility monitoring program, on the other hand, is designed to evaluate whether current operations are impacting groundwater quality. The 13 wells used under this program are situated close to the STP's sand filter beds and along the Peconic River. Samples are routinely analyzed for water quality, VOCs, and metals. In all groundwater samples, water quality parameters were within the applicable NYS AWQS. Iron levels exceeded NYS AWQS of 0.3 mg/L in five wells, with maximum concentrations ranging from 0.3 mg/L to 1 mg/L. Two wells had sodium concentrations above the NYS AWQS of 20 mg/L, with maximum concentrations ranging from 21.6 mg/L to 31.5 mg/L. Whereas the elevated iron concentrations may be due to naturally occurring sediments surrounding the wells, the sodium levels are likely due to Laboratory operations. Although trace amounts of chloroform were detected (maximum concentration of 1.6 µg/L), no VOCs were detected above NYS AWQS in any of the STP area wells.

Radionuclides: For groundwater in the area surrounding the STP, gross alpha and gross beta activity values were below DWS, and were typical of ambient groundwater values. However, gross beta activities were slightly elevated in Well 38-02 (a background well) and Well 38-03 (located near the filter beds) with maximum recorded values of 16 pCi/L (0.6 Bq/L) and 25.5 pCi/L (0.9 Bq/L), respectively (see Table 8-9). Because these wells are screened near shallow clay deposits, the slightly elevated gross beta values are likely due to naturally occurring potassium-40 from clay minerals introduced into the samples during collection. Tritium was present at up to 1,020 pCi/L (38 Bq/L) in wells located near the filter bed. Tritium concentrations in these wells have decreased over the past five years (Figure 8-27). Although cesium-137 has been detected in groundwater in this area in the past, no significant concentrations were observed in samples collected in 1998. No other man-made radionuclides were detected in groundwater in this area.

8.1.3.2.2 BNL SHOTGUN RANGE

In the north central portion of the site (north of the new WMF), BNL maintains a recreational shotgun range. Although impacts to groundwater quality from the deposition of lead shot used at the range are not expected, verification sampling is conducted because the range lies within the zone of contribution for BNL potable supply Wells 11 and 12, which are located to the south of the range. Routine sampling of the potable wells has not revealed detectable levels of lead. Groundwater quality in the shotgun range area is currently evaluated using four shallow Upper Glacial aquifer wells that are located in the general vicinity of the range. During 1998, two rounds of groundwater samples from these four wells were collected and analyzed for metals and water quality. All water quality parameters and metals concentrations, including lead, were below applicable NYS AWQS. BNL plans to

Table 8-9. Radiological Analysis Results for Wells in the STP and On-Site Peconic River Area

Well (# Samples)		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)
38-01	Max.	< 1.2	< 3.6	< 322
(4)	Avg.	0.2 ±0.4	-0.9±3.5	-61±129
38-02	Max.	3.5±0.7	16±1.7	520±218
(4)	Avg.	1.5±1.4	6.7±5.5	375±190
38-03	Max.	1.4±0.7	25.5±3	< 197
(4)	Avg.	1±0.4	15.2±7.5	-57±126
38-05	Max.	1.4±0.8	< 3.6	670±243
(4)	Avg.	0.9±0.6	-0.8±3.1	298±288
38-06	Max.	< 1.1	3.9±1.5	< 335
(4)	Avg.	0.2±0.6	0.9±2.1	21±128
39-05	Max.	< 1.2	6±1.8	475±211
(4)	Avg.	0.2±0.4	2.8±2.1	336±133
39-06	Max.	2.6±1	4.7±2.3	< 322
(4)	Avg.	0.5±1.4	2.2±3.3	166±59
39-07	Max.	< 1.2	< 3.6	435±203
(4)	Avg.	0.2±0.6	1.8±1.1	158±198
39-08	Max.	1.4±0.7	6.7±2.4	1020±259
(4)	Avg.	0.6±0.5	4.2±1.5	398±361
39-09	Max.	< 1.2	< 3.6	< 335
(4)	Avg.	-0.1±0.7	-0.3±3.4	-27±68
39-01	Max.	< 1.2	< 3.6	< 362
(2)	Avg.	-0.3±1	0±3	-88±40
60-01	Max.	8.4±1.5	13.5±2.6	405±233
(3)	Avg.	2.8±4.5	3±9	82±258
61-03	Max.	< 1.0	< 3.6	< 322
(5)	Avg.	-0.1±0.2	-0.7±2.7	-67±33
SDWA Limit		15	50	20,000

Notes:
1. All values shown with 95% confidence interval.

install two additional wells during 1999 to allow for improved monitoring of this area.

8.1.3.2.3 WATER TREATMENT PLANT (WTP) AREA

At the direction of the NYSDEC, five shallow Upper Glacial aquifer surveillance wells were installed at the WTP in 1993 to assess potential leaching of iron from the plant's recharge basins into the groundwater. Naturally high levels of iron in groundwater are removed at the WTP, and the precipitated iron is discharged to the recharge basins.

During 1998, two rounds of groundwater samples were collected from these five wells, and analyzed for water quality and metals. As in previous years, all water quality parameters and metals concentrations, including iron, were below the applicable NYS AWQS.

8.1.3.2.4 BUILDING 423 (MOTOR POOL) AREA

Building 423 serves as the site motor pool, where BNL's fleet vehicles are repaired and refueled. Gasoline is stored in two 30,280 liter (8,000 gallon) capacity underground storage tanks (USTs), and waste oil is stored in one 1,892 liter (500 gallon) capacity UST. Although the USTs and associated distribution lines meet Suffolk County Article 12 requirements for secondary containment, leak detection, and high level alarms, BNL initiated a groundwater monitoring program in 1996 to ensure that potential leakage would be detected if a tank alarm system were to fail.

During 1998, four rounds of groundwater samples were collected from the two shallow Upper Glacial aquifer surveillance wells and analyzed for VOCs and checked for floating petroleum product. TCA was detected at concentrations slightly exceeding NYS AWQS (of 5 µg/L) in Well 102-06, with a maximum observed concentration of 8.3 µg/L. The fuel additive methyl tertiary butyl ether (MTBE) was also detected in Well 102-06 at a maximum concentration of 8.4 µg/L, which is well below the NYS DWS of 50 µg/L. It is believed that the MTBE is related to gasoline spillage that occurred prior to the 1985 upgrade of the USTs. No floating product was observed.

8.1.3.2.5 ONSITE SERVICE STATION

Building 630 is a commercial automobile repair and gasoline station for the BNL site. Gasoline is stored in two 30,280 liter (8,000 gallon) capacity and one 22,710 liter (6,000 gallon) capacity underground storage tanks (USTs), and waste oil is stored in one 1,892 liter (500 gallon) capacity UST. Although the USTs and associated distribution lines meet Suffolk County Article 12 requirements for secondary containment, leak detection, and high level alarms, BNL initiated a groundwater monitoring program in 1996 to ensure that potential leakage would be detected if a tank alarm system were to fail.

During 1998, four rounds of groundwater samples were collected from the two shallow Upper Glacial aquifer surveillance wells and analyzed for VOCs and checked for floating petroleum product. PCE and carbon tetrachloride were detected at concentrations exceeding

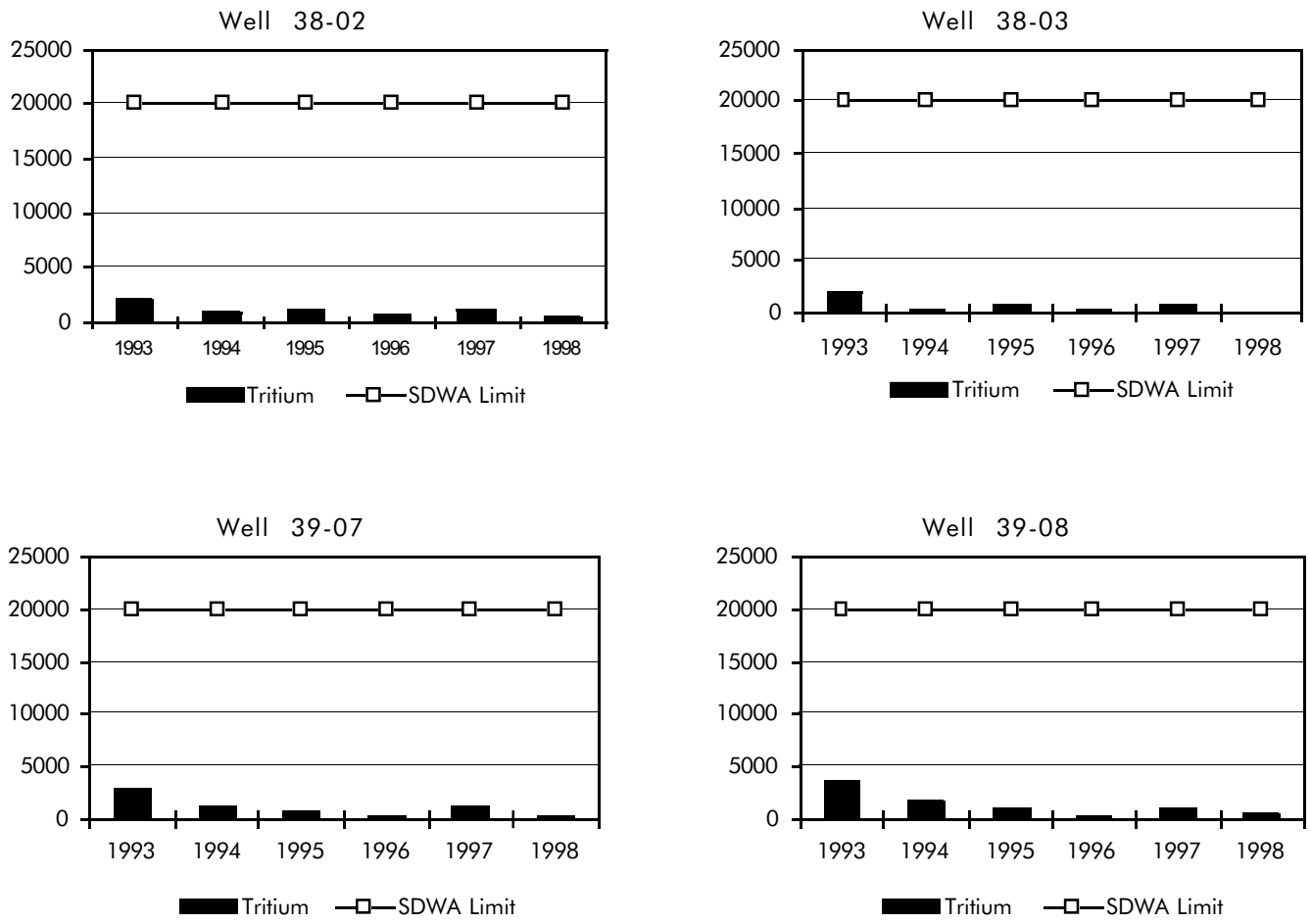


Figure 8-27.
Time-vs.-Tritium concentration trend plots for key wells in the Sewage Treatment Plantís filter bed area

NYS AWQS in Well 85-17. Carbon tetrachloride was observed at a maximum concentration of 13.3 µg/L, whereas PCE was detected at a maximum concentration 12.1µg/L. The fuel additive MTBE was not detected in either of the wells. No floating product was observed. The PCE and carbon tetrachloride are likely due to historical use of cleaning solutions at the station.

8.1.3.2.6 MAJOR PETROLEUM FACILITY (MPF) AREA

The CSF supplies steam for heating to all major facilities of the Laboratory through an underground distribution system. The MPF is the holding area for most fuels used at the CSF. Five shallow Upper Glacial aquifer wells monitoring the MPF were installed as part of the licensing requirements for this facility, and are screened across the water table so that free product (i.e., oil floating on top of the groundwater) could be detected. The surveillance wells at the CSF were installed primarily to monitor groundwater contamination resulting from a 1977 leak of approximately 23,000 gallons of Alternative Liquid Fuel (a fuel oil/spent solvent mixture). The CSF/MPF area has been the subject of an RI/FS (OU IV), and has been undergoing active soil and groundwater remediation since the winter of 1997.

The surveillance well network at the MPF area consists of five shallow Upper Glacial aquifer wells. During 1998, five wells were monitored for water quality, metals, and VOCs. The five MPF wells were also sampled monthly for floating petroleum products, and twice per year for polynuclear aromatics and base-neutral extractable compounds (EPA Method 625), in accordance with the NYSDEC license (see Chapter 2). All water quality parameters and metals concentrations were

Table 8-10. Radiological Analysis Resuts for Wells near the New Waste Management Facility

Well (# Samples)		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Co-60 (pCi/L)
55-03	Max.	2.7±1	< 4.1	< 320	ND
(3)	Avg.	1.1±1.3	0.2±2.2	92±115	
55-10	Max.	12.6±1.9	16.3±3	414±213	ND
(5)	Avg.	4.7±3.9	7.2±4.9	-1±199	
56-21[(a)]	Max.	3±0.8	4±1.4	< 320	8.1±1.2
(4)	Avg.	1.2±1.2	2.5±1	-51±112	2.9±3.8
56-22	Max.	1.9±0.9	< 3.6	444±211	ND
(4)	Avg.	0.2±1	0.7±1.5	57±224	
56-23	Max.	1.3±0.5	< 3.6	< 320	ND
(3)	Avg.	0.7±0.6	0.9±	1.988±184	
66-07	Max.	1.7±0.8	< 4.1	470±213	ND
(4)	Avg.	0.1±0.9	0.7±1.4	69±231	
66-83	Max.	2±0.6	< 4.1	< 320	ND
(4)	Avg.	0.7±1.1	0.7±0.7	33±52	
SDWA Limit		15	50	20,000	200

Notes:
ND= Not detected.
1. All values shown with 95% confidence interval.
(a) = Co-60 was detected in two of the four samples collected from this well in 1998.

below the applicable NYS AWQS. VOC concentrations were above NYS AWQS in upgradient Well 76-25 with TCA at a maximum concentration of 5.1 µg/L, and PCE was detected in downgradient Well 76-19 at a maximum concentration of 24.7 µg/L. The TCA detected in Well 76-25 is likely to have originated from releases in the Building 650 area, whereas the PCE in Well 76-19 is likely to have originated from historical spills at the MPF. No benzene/ethylbenzene/toluene/xylene (BETX) or other hydrocarbon-related compounds were detected in the MPF wells. As in previous years, no floating petroleum products were observed during 1998.

8.1.3.2.7 NEW WASTE MANAGEMENT FACILITY (WMF)

In 1997, BNL began operating a new WMF. The new WMF is designed and operated in a manner that meets all applicable federal, state and local environmental protection requirements; nevertheless, BNL established a groundwater monitoring program as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls. The new WMF is monitored by eight shallow Upper Glacial aquifer wells. During 1998, four rounds of groundwater samples were collected and analyzed for VOCs, radioactivity, metals and water quality.

Volatile Organic Compounds, Metals and Water Quality Parameters: All water quality and metals concentrations were below the applicable NYS AWQS. Although low levels of chloroform (up to 2.1 µg/L) were detected in a number of the wells, all VOC concentrations were below applicable NYS AWQS.

Radionuclides: With one exception, gross activity levels in these samples were typical of ambient (background) levels (Table 8-10). Slightly elevated gross alpha and gross beta concentrations were observed in upgradient Well 55-10, at maximum concentrations of 12.6 pCi/L and 16.3 pCi/L, respectively. As in previous years, low levels of cobalt-60 were detected in samples collected from Well 56-21. The maximum concentration of cobalt-60 observed was 8.1 pCi/L (0.3 Bq/L). The DWS for this radionuclide is 200 pCi/L (7 Bq/L). This material is not related to operations of the WMF. The likely sources of the cobalt are (1) past leakage from nearby underground sanitary lines (which at one time transported liquid wastes containing this nuclide from Building 811 to the STP) or (2) an underground storage tank leak which occurred at Building 830 in 1988. While the monitoring results indicated maximum tritium concentrations above the MDL at wells 55-10, 56-20 and 66-07, these values were extremely close to the typical MDL of 320 pCi/L (12 Bq/L). When the 95 percent confidence intervals are considered, these two values are not statistically different from the MDL and do not, therefore, represent clear detections. The annual average value for each well, which includes all three of the sample results, was less than the typical MDL for this analysis.

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Radiological Dose Assessment

CHAPTER 9

This chapter discusses the potential radiological doses to offsite individuals and the surrounding population from Brookhaven National Laboratory radioactive airborne emissions. Special case exposures such as fish and deer meat consumption are also discussed. These potential doses are based on calculations using 1998 emission data, fauna sampling data and conservative intake and exposure assumptions. All doses resulting from the internal deposition of radionuclides are expressed as 50 year committed effective dose equivalents, i.e., the total dose which would be received by an individual in the 50 years following radionuclide uptake.

9.1 EXTERNAL PENETRATING RADIATION MEASUREMENTS

The Brookhaven National Laboratory (BNL) measures environmental background radiation through a network of onsite and offsite dosimeter units. These units, called thermoluminescent dosimeters, or TLDs, measure gamma radiation originating from cosmic and terrestrial sources (see Chapter 4 for discussion) as well as any contribution from Laboratory operations. Calcium fluoride (CaF_2:Dy) type TLDs are used. There are a total of 24 onsite locations which have TLDs in place (see Figure 9-1 for locations). In addition to the dosimeters located on BNL property, 21 offsite locations were also monitored in 1998 (see Figure 9-2 for locations). These offsite measurements provide background comparison values and are used to determine whether BNL operations have had an impact on the ambient radiation levels of the surrounding area.

Onsite 1998 TLD data are summarized in Table 9-1. The second quarter data for these TLDs were invalidated due to the loss of the control dosimeter used to subtract exposure occurring between collection and read-out. However, the remaining three quarters show values which are consistent with previous years and typical of exposure from natural cosmic and terrestrial sources. Average quarterly dose values were between 15 and 20 mrem (150 and 200 μSv.

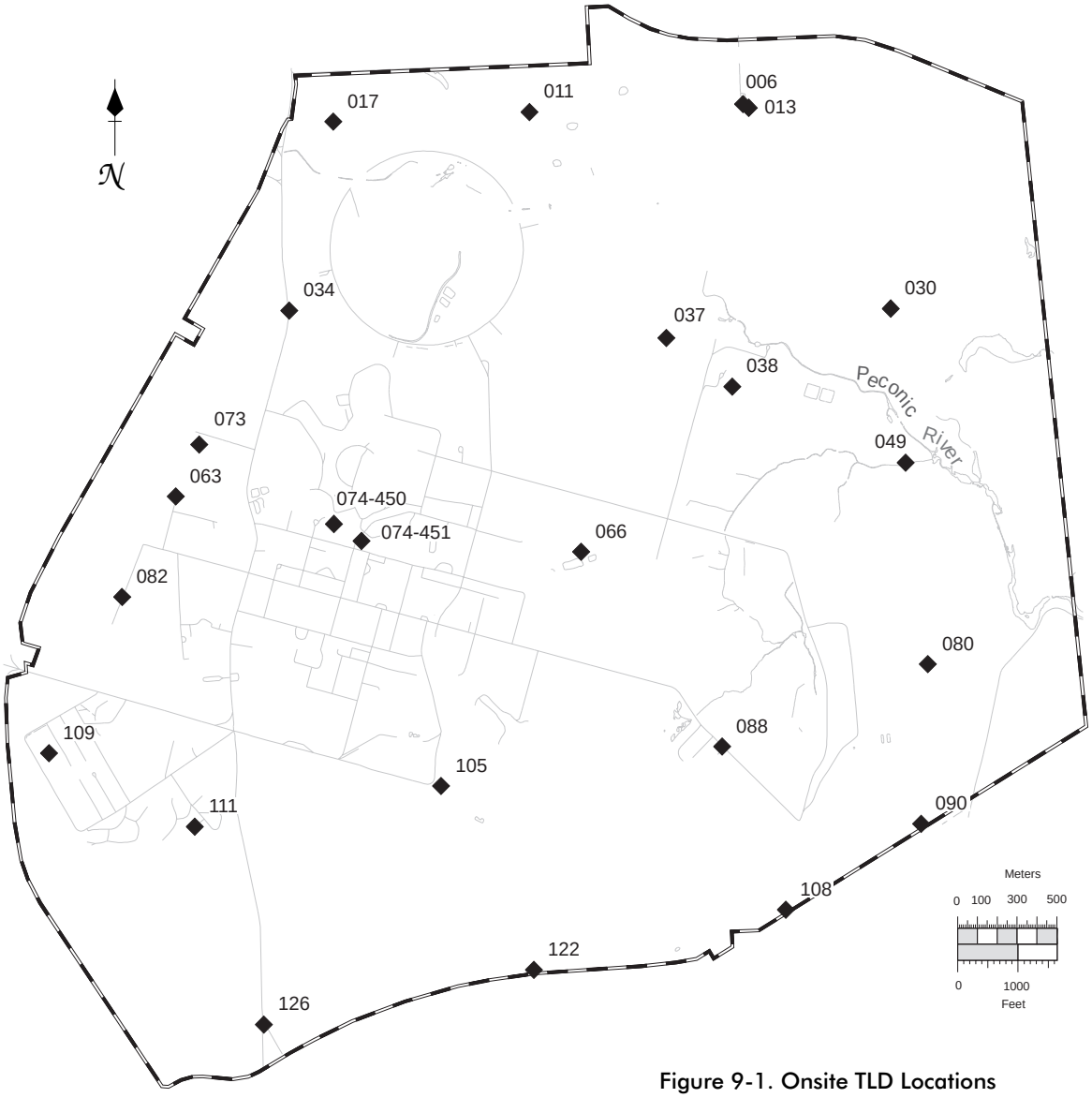

Figure 9-1. Onsite TLD Locations

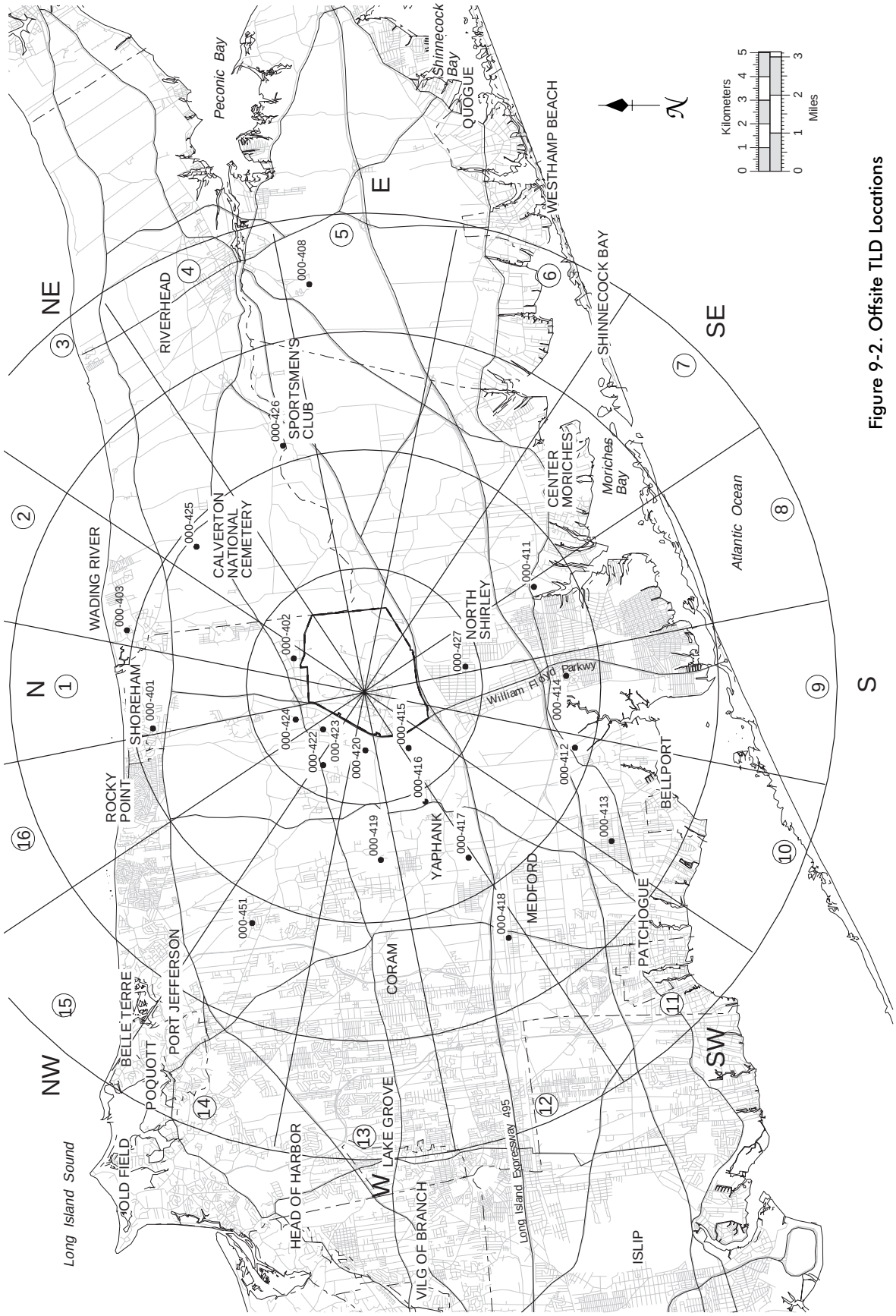

Figure 9-2. Offsite TLD Locations

Table 9-1. Quarterly Onsite Ambient Radiation Measurements

Station	Qtr. 1 (mrem)	Qtr. 2 (mrem)	Qtr. 3 (mrem)	Qtr. 4 (mrem)
011-400	13.0	(a)	14.6	18.5
013-400 (P9)	(b)	(a)	(b)	19.3
017-400 (P2)	13.1	(a)	13.6	18.0
030-400	13.9	(a)	13.5	19.9
034-400	15.6	(a)	16.5	20.6
034-401	15.0	(a)	20.0	22.1
037-400	16.4	(a)	16.4	19.6
038-450 (S5)	15.0	(a)	14.8	19.3
049-400	14.0	(a)	13.3	19.3
053-400	16.0	(a)	17.9	21.1
063-400	17.0	(a)	16.9	22.0
066-400	12.8	(a)	12.8	17.3
073-400	17.1	(a)	16.6	23.9
074-450 (Bldg. 197)	16.2	(a)	17.7	22.7
074-451 (Bldg. 907)	13.6	(a)	13.7	19.4
080-400	17.5	(a)	15.8	24.3
082-400	15.6	(a)	15.9	20.6
090-400 (P7)	14.8	(a)	15.5	19.8
105-400	16.2	(a)	15.6	20.6
108-450	14.6	(a)	16.0	21.5
109-400 (P4)	13.8	(a)	14.3	20.1
111-400	14.2	(a)	15.1	21.1
122-400	14.3	(a)	14.2	19.8
126-400	15.2	(a)	15.5	20.7
Average	15.0	N/A	15.5	20.5
Median	15.0	N/A	15.5	20.3
Population Std. Dev.	1.3	N/A	1.7	1.6

Notes:
a. All onsite qtr. 2 dosimeters invalidated due to loss of control dosimeter.
b. Dosimeter reported missing.

Table 9-2. Quarterly Offsite Ambient Radiation Measurements

Station	Qtr. 1 (mrem)	Qtr. 2 (mrem)	Qtr. 3 (mrem)	Qtr. 4 (mrem)	Annual Dose* (mrem/yr)
000-401	12.9	17.4	15.3	14.2	61.3
000-402	13.0	20.9	16.9	18.4	69.9
000-403	13.4	24.6	20.7	17.3	78.8
000-408	15.4	19.3	15.5	15.8	65.0
000-411	16.3	19.2	18.5	17.5	71.4
000-412	16.6	20.7	17.0	20.7	75.9
000-413	15.4	21.5	17.2	19.7	74.7
000-414	16.1	19.4	16.6	17.7	70.2
000-415	12.6	20.9	15.5	18.4	69.9
000-416	14.2	17.6	13.4	16.4	61.4
000-417	15.3	21.4	15.8	16.3	66.1
000-418	15.6	20.3	16.0	18.4	70.0
000-419	15.0	20.1	15.4	16.3	65.3
000-420	15.1	21.3	16.0	18.4	71.2
000-422	16.3	19.4	(a)	18.7	69.3
000-423	14.8	20.0	14.1	16.6	65.5
000-424	(a)	18.1	15.6	17.2	71.5
000-425	15.8	20.3	12.8	17.1	66.4
000-426	15.4	19.7	16.0	18.3	69.7
000-427	18.6	20.9	(b)	(b)	77.8
000-451	(c)	(c)	19.9	21.5	76.2
Average	15.1	20.2	16.2	17.8	69.9
Median	15.4	20.2	16.0	17.6	69.9
Population Std. Dev.	1.4	1.5	1.9	1.6	4.8

* Dose rate normalized to 365 day year.

Notes:
a. Dosimeter reported missing.
b. Station relocated after 2nd quarter, became station 000-451.
c. Station relocated from station 000-427 after 2nd quarter.

Offsite 1998 TLD data are summarized in Table 9-2. The average annual offsite external radiation dose value was 70 ± 5 mrem (0.7 ± 0.05 mSv) (the error term represents the standard deviation of the sample population). This is consistent with the value of 67 ± 5 mrem/yr (0.67± 0.05 mSv/yr) measured in 1997. These values are statistically indistinguishable from one another and are within the normal background exposure range typical of the northeastern part of the United States (NCRP, 1987), indicating that BNL operations had no measurable effect on local radiation exposure levels. (Note that measurements recorded by TLDs measure direct radiation only and cannot be used to assess exposure due to internally deposited radionuclides.)

9.1.1 BUILDING 650 SUMP OUTFALL

From approximately 1959 to 1969, decontamination of radiologically contaminated heavy equipment took place on a concrete pad adjacent to Building 650. The drainage from this pad was contained in underground storage tanks. In 1969 it was determined that under certain valve conditions, liquid from the underground tanks was inadvertently being routed to a depression in a wooded area approximately 800 feet northeast of Building 650. This depression is referred to as the Building 650 Sump Outfall. The Sump Outfall is a source of localized radiological soil and groundwater contamination which is being remediated under the Environmental Restoration program (Operable Unit [OU] IV, Area of

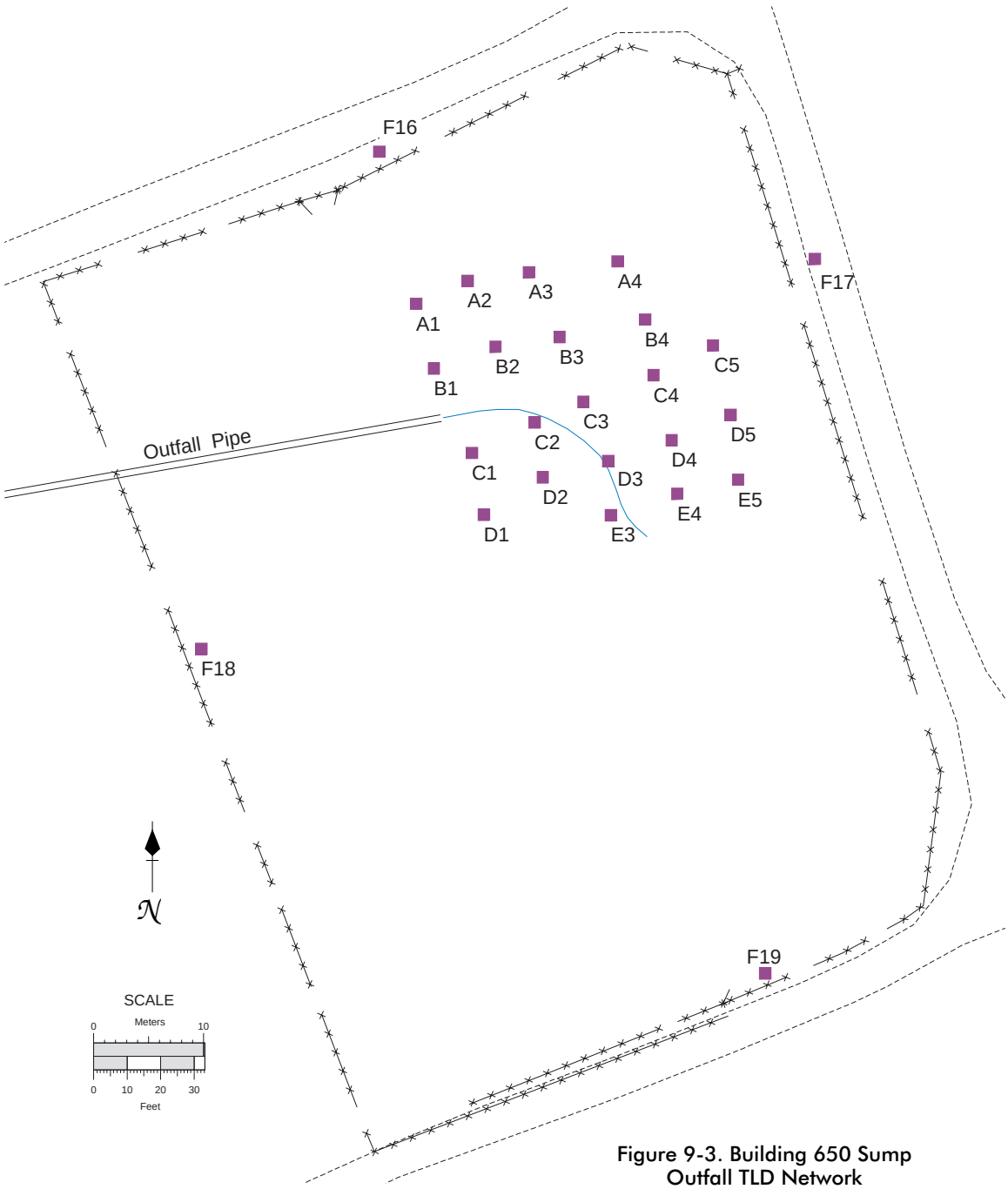

Figure 9-3. Building 650 Sump Outfall TLD Network

Concern [AOC] 6). Radionuclides identified in the soil in this area include strontium-90, cesium-137 and isotopes of europium and plutonium.

In 1997, as part of the OU IV Interim Remedy Plan, the outfall was fenced to exclude pedestrian traffic and a network of 16 TLDs (LiF:Mg,Ti type) was installed to monitor gamma radiation exposure levels in the area (see Figure 9-3). Four fence perimeter dosimeters were also installed, as well as two background dosimeters located onsite in an area not influenced by AOC 6 or other site radiation sources. In 1998, five locations were added to this TLD network: C5, D5, E3, E4, and E5. These TLDs were added when elevated readings from dosimeters D2 through D5 indicated that radionuclides related to the Building 650 Sump Outfall were probably also located to the southeast, just beyond the existing network.

Table 9-3. Building 650 Sump Outfall TLD Network Data

Location	Qtr. 1 (mrem)	Qtr. 2 (mrem)	Qtr. 3 (mrem)	Qtr. 4 (mrem)	Annual Dose* (mrem/yr)
A1	19	19	20	21	78
A2	69	74	72	77	292
A3	25	24	26	25	101
A4	19	19	20	20	78
B1	16	16	17	17	66
B2	36	37	38	38	148
B3	77	76	79	78	309
B4	37	35	39	38	149
C1	20	21	22	21	84
C2	44	45	47	47	182
C3	164	162	173	165	664
C4	338	328	348	337	1,352
C5	30	31	32	32	126
D1	20	20	20	20	80
D2	28	31	30	32	121
D3	123	123	126	126	497
D4	185	182	191	185	743
D5	58	56	59	59	232
E3	96	95	96	98	386
E4	136	133	139	139	547
E5	93	90	101	99	383
F16 (Fence N)	13	14	13	14	55
F19 (Fence S)	13	12	13	13	51
F17 (Fence E)	14	14	15	15	58
F18 (Fence W)	14	13	15	15	57
Bkg 1**	15	15	15	16	60
Bkg 2**	15	15	15	16	61

Notes:
* Dose rate normalized to a 360 day year.
** Distant background location.

The new stations were installed to monitor this area, though previous soil sampling and fence dosimeters show that radionuclides related to Building 650 are localized within the fenced area.

Consistent with the previous year, 1998 data from the Building 650 Sump Outfall TLD network indicated that the highest concentration of radionuclides are located in the area of position C4, where a dose rate of 1.4 rem/yr (14 mSv/yr) was recorded (Table 9-3). Other locations in the monitoring grid continued to show dose rates varying from background levels up to 743 mrem/yr (7.4 mSv/yr). Fence dosimeters showed no elevated dose rates and were consistent with the two distant background TLDs, demonstrating that the radiation field generated by the Sump Outfall contaminants is limited to the immediate area of the outfall itself. Due to the localization of contaminants, the Building 650 Sump Outfall is not an exposure hazard for either site workers or members of the public.

9.2 AIRBORNE PATHWAY

BNL is subject to the requirements of Title 40 CFR Part 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPs). This U.S. Environmental Protection (USEPA) Rule establishes national policy regarding the airborne emission of radionuclides. It specifies the monitoring and reporting requirements for various types of radionuclides and establishes the public dose limit for the airborne pathway as 10 mrem (0.1 mSv) per year.

9.2.2 AIR DISPERSION MODEL

Compliance with NESHAPs regulations is demonstrated through the use of the USEPA's CAP88-PC (Clean Air Act Assessment Package-1988) computer model. The CAP88-PC model uses a Gaussian plume equation to estimate the average dispersion of radionuclides released from elevated stacks or area sources (USEPA, 1992). The program computes radionuclide concentrations in air, rates of deposition on ground surfaces and concentrations in food (where applicable) to arrive at a final value for projected dose at the specified distance from the release point. The program supplies both the calculated effective dose equivalent (EDE) to the maximally exposed individual (MEI), and the collective population dose within an 80 km (50 mi) radius of the emission source. This model provides very conservative dose estimates in most cases. For purposes of modeling the dose to the MEI, all emission points are located at the center of the developed portion of the site.

Input parameters used in the model include radionuclide type, emission rate in curies per year, and stack parameters such as height, diameter and emission exhaust velocity. Site-specific weather and population data are also used. Weather data are supplied by measurements from BNL's meteorological tower. Data include wind speed, direction, frequency and temperature. For this emission assessment year, wind data recorded during 1998 were used. This is a change from previous years in which average wind data collected between 1980 and 1989 were used. Use of this updated wind data

Table 9-4. 1998 Airborne Radiological Dose by Facility as Calculated by CAP88-PC

Building	Facility or Process	Construction Permit No.	MEI Dose (mrem)*	Collective Dose (person-mrem)*	Notes
491	BMRR	None	2.1E-01	7.5E+03	
705	HFBR	None	2.7E-04	8.1E+01	
931	BLIP	None	1.1E-04	6.5E-02	
801	Target Processing Lab	None	6.9E-06	4.4E+01	
705	Evaporator Facility	BNL-288-01	2.1E-05	5.7E+00	
—	RHIC	BNL-389-01	0	0	
—	AGS Booster	BNL-188-01	0	0	a
—	AGS Cooling Tower #2	None	1.7E-05	5.3E-04	
930	Linac	None	3.3E-06	1.8E-05	
490	Radiation Therapy Facility	BNL-489-01	2.2E-04	9.3E+03	b
820	Accelerator Test Facility	BNL-589-01	0	0	c
938	REF/NBTF	BNL-789-01	0	0	d
510	Calorimeter Enclosure	BNL-689-01	0	0	d
463	Biology Dept.	None	9.7E-07	5.3E-02	e
555	Chemistry Dept.	None	3.2E-09	2.0E-04	e
318	Dept. of Applied Science	None	6.1E-08	3.3E-04	e
490A	Dept. of Applied Science	None	9.4E-09	4.4E-04	e
490	Medical Research Center	None	1.8E-07	5.1E-03	e
703W	Dept. of Advanced Tech.	None	6.0E-14	2.8E-09	e
		Total	2.1E-01	7.6E+03	

* "Dose" as used in this table means committed effective dose equivalent.

Notes:
a. Booster ventilation system prevents air release through continuous air recirculation.
b. Based on conservative engineering calulations.
c. This has become a zero-release facility since original permit application.
d. This facility is no longer in use, it produces no radioactive air emissions.
e. All doses based on emissions calculated using 40 CFR 61, Appendix D methodology.

had the effect of increasing the dose value somewhat, even though 1998 air emissions were consistent with those of previous years.

Population data for the surrounding area are based on customer records of the Long Island Power Authority (LILCO, 1996). Since visiting researchers and their families may reside at the onsite apartment area for extended periods of time, these residents are also considered in the population file used for dose assessment.

9.2.4 EFFECTIVE DOSE EQUIVALENT CALCULATIONS - AIRBORNE PATHWAY

In 1998, the EDE to the MEI from all radiological airborne emissions sources combined was 0.2 mrem (2 µSv). Argon-41 released from the Brookhaven Medical Research Reactor (BMRR) contributed 98 percent of this dose. By comparison, this is 50 times less than the USEPA airborne dose limit of 10 mrem (0.1 mSv) and about 1,500 times smaller than the EDE received annually from natural background radiation. Such a dose is too small to distinguish from background radiation sources using the most sensitive environmental TLDs. The MEI dose projected for emissions from each facility is shown in Table 9-4.

9.3 EFFECTIVE DOSE EQUIVALENT CALCULATIONS- FISH CONSUMPTION

Calculations were also made to determine the potential dose to an individual consuming fish taken exclusively from the Peconic River. As discussed in Section 7.2.2, fish from the Peconic River and Peconic-fed water bodies continue to be analyzed for radiological content because of known historical radionuclide discharges from the BNL Sewage Treatment Plant. These releases occurred primarily in the 1950s and 60s. In 1998, samples were analyzed for gamma-emitting radionuclides only; no analyses for strontium were performed (see Section 7.8.1 of the 1996 BNL Site Environmental Report for strontium test data). As in previous years, the only anthropogenic gamma-emitting radionuclide detected in fish

Table 9-5. Summary of Dose From All Environmental Pathways, 1998

Pathway	Primary Contributing Radionuclide	Maximum Individual EDE (mrem)	Regulatory Pathway Limit (mrem)	Collective EDE (person-mrem)
Air	Ar-41	0.21	10	7510
Fish	Cs-137	0.26	NS	163
Deer Meat	Cs-137	7.1	NS	NA

Notes:
1. 1 mrem = 0.01 mSv.
2. EDE = Effective Dose Equivalent.
3. NS = None Currently Specified
4. NA = Not Applicable
5. Because all doses in this Table are calculated rather measured, they are potential rather than actual doses.
6. Fish dose calculation is based on measured Cs-137 concentrations only. Sr-90 analyses were not performed in 1998.
7. Deer dose is based on average onsite deer concentrations. Onsite sport hunting is not permitted.
8. Fish and deer dose clculations assume a consumption rate of 7 and 29 kg/yr, respectively.
9. No water consumption dose projected following connection of public water supply to homes adjacent to BNL.

samples was cesium-137. The maximum concentration of detected cesium-137 occurred in a fish collected near the BNL boundary at North Street. The fish was of the chain pickerel *(Esox niger)* species and contained 0.73 pCi/g (27 mBq/g) of cesium-137. This result was obtained from analysis of the flesh and skin portions of the segregated sample. The measured concentration in a pickerel from the same location analyzed as a whole was 0.41 pCi/g (15 mBq/g).

For dose evaluation, an individual is assumed to eat 7 kg (15 lbs) of fish during the course of the year. Exclusive consumption of chain pickerel at the rate and the concentration given above would result in an EDE of 0.26 mrem (3 μSv) due to cesium-137. By comparison, the average individual EDE caused by the ingestion of naturally-occurring radionuclides in the U.S. is about 40 mrem (400 μSv) per year (NCRP, 1987).

9.4 EFFECTIVE DOSE EQUIVALENT CALCULATIONS - MEAT CONSUMPTION

As discussed in Chapter 7, measurements were made of flesh samples collected from deer taken on BNL property as well as from offsite locations. Cesium-137 is detectable in meat samples from onsite deer at concentrations higher than those found in comparable offsite deer. While onsite sport hunting is not permitted, there are no physical barriers preventing deer from migrating beyond the site boundary. It is, therefore, conceivable that deer which reside predominantly on the BNL site may occasionally be taken by sportsmen during the hunting season. An estimate of the dose resulting from consumption of deer meat based on samples collected in 1998 is presented here.

In March of 1999, the New York State Department of Health (NYSDOH) Bureau of Environmental Radiation Protection issued a report examining the possible dose impacts to members of the public who consume deer which have grazed extensively on the BNL site. In the NYSDOH report, the annual consumption rate of venison was estimated using the USEPA's Exposure Factors Handbook, which gives the average intake of game meat (for those who consume it) as approximately 1.1 g per day per kg of body weight (USEPA, 1996). For a 70 kg (154 lb) individual, this corresponds to about 29 kg (63 lb) of venison consumed per year. The same assumptions have been adopted for this report.

The potential dose from deer meat consumption has been calculated using the arithmetic average of the cesium concentrations measured in onsite hind meat samples. The dose calculation uses a wet weight average concentration, i.e., the concentration in the flesh sample prior to drying for analysis, which is equal to 4.9 pCi/g (0.18 Bq/g). Under the stated assumptions, the committed EDE due to exclusive consumption of local deer meat would be equal to 7.1 mrem (71 μSv). By comparison, the average EDE from eating foods which contain naturally-occurring radionuclides is 40 mrem (0.4 mSv) per year (NCRP, 1987).

9.5 COLLECTIVE EFFECTIVE DOSE EQUIVALENT (EDE)

Collective EDE, a value used to estimate potential health risks to a population, is the summation of the calculated EDE for each individual multiplied by the number of

individuals in the population being considered.

Assuming that total number of individuals who routinely consume fish taken from portions of the Peconic River, close to the BNL site, is equal to 625, the collective EDE from this pathway is 163 person-mrem (1.6 person-mSv). This value is based on the maximum fish concentrations discussed above. The collective EDE to the same population from consumption of naturally-occurring radionuclides in food is 25,000 person-mrem (250 person-mSv) annually.

Since onsite deer hunting is prohibited, and the individual dose estimate resulting from meat consumption is a theoretical maximum based on site-resident deer only, collective EDE is not calculated for this pathway.

For the air exposure pathway, the CAP88-PC computer model provides collective EDE estimates using population data for the area within an 80 km (50 mi) radius of the BNL site. The population data are broken into the number of people living within each of the 16 compass sectors at 16 km radial intervals. Again, argon-41 emitted from the BMRR was the largest contributor to the total collective dose at 7,510 person-mrem (75 person-mSv). This constitutes 99 percent of the total collective dose projected for the population within an 80 km (50 mi) radius of BNL.

By comparison, the collective dose due to external radiation from natural background to the population within an 80 km radius of the Laboratory amounts to approximately 291,000 person-rem (2,910 person-Sv), and about 196,800 person-rem (1,968 person-Sv) from internal radioactivity deposited in the body from natural sources (excluding potential radon contributions).

9.6 SUMMARY AND CONCLUSION

Calculations of EDE from all BNL facilities which have the potential to release radionuclides to the atmosphere indicated that radiological doses attributable to Laboratory operations were far below the limits established by Federal regulations (see Table 9-5). Direct measurement of external radiation levels by TLD confirmed that exposure rates at the site boundary were consistent with background levels observed throughout New York State (NYSDOH, 1993).

The EDEs presented in this Chapter were based on the MEI for each scenario using the stated assumptions. Given this, it is not plausible that any single person could receive a radiological dose equal to the sum of these individual pathways. For this to occur, an individual would be required to breathe air and consume fish and deer at the highest radionuclides concentrations calculated or observed in all samples collected in 1998. However, even if these pathways were to be summed, the total dose from all pathways would equal only 8 percent of the 100 mrem/yr (1 mSv/yr) DOE limit established for the protection of the public. This total is equivalent to approximately 3 percent of the average individual dose received annually from natural background sources, including radon (NCRP, 1987). These maximum credible doses demonstrate that in 1998, radioactive material associated with BNL operations had no impact on the health of the public or environment in the surrounding area.

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Quality Assurance

CHAPTER 10

Brookhaven National Laboratory uses the onsite Analytical Services Laboratory (ASL) and three offsite contractor laboratories to analyze environmental samples. The oversight of laboratory analyses involves proficiency testing, auditing and ensuring adherence to a Quality Assurance Program (QAP). All analytical laboratories used are certified by New York State.

ASL performs approximately 10,000 radiological and 2,000 nonradiological (chemical) analyses per year and provides supervision for the contracts with other laboratories. Quality Control is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy.

All laboratories performing radiological analyses scored between 90 and 95 percent satisfactory results on state and federal proficiency evaluation tests, including ASL. On nonradiological proficiency evaluation tests, ASL had an instrument failure that caused its rating of 76 percent to fall well behind the contractors' 97-100 percent. The instrument has been replaced. Overall, analytical data reported in the 1998 BNL Site Environmental Report are of high quality.

Review of the quality assurance measures at Brookhaven National Laboratory (BNL) presented here confirm that the analytical data reported in the 1998 Site Environmental Report are reliable. Quality is an integral part of every function at BNL. A program is in place to ensure that all environmental monitoring data meet appropriate Quality Assurance (QA) requirements. Environmental samples at BNL are analyzed by an onsite laboratory (the Analytical Services Lab [ASL]). BNL also procures and maintains contracts with offsite laboratories: General Engineering Lab (GEL), (for radiological analytes), H2M Lab, (for nonradiological analytes), and Chemtex Lab, (for select nonradiological analytes). All analytical laboratories are New York State certified and subject to audits. The process of selecting laboratories involves an evaluation of past Proficiency Evaluation (PE) testing results, pre-selection bidding, post selection auditing and adherence to its own Quality Assurance Program (QAP).

The ASL performs approximately 10,000 radiological and 2,000 nonradiological (chemical) analyses per year. Routine Quality Control (QC) procedures followed by the ASL include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. As in prior years, the ASL and the three contractor laboratories participated in several national and state PE testing programs. Results of those PE tests provide information on the quality of a laboratory's results and allow comparisons to be made between laboratories.

Figures 10-1 and 10-2 summarize the overall 1998 scores of the ASL and the three contractor laboratories that participated in either the Department of Energy (DOE) QAP for radiological analytes, the EPA's National Environmental Radiation Laboratory (NERL) and Environmental Monitoring Systems Laboratory (EMSL) programs (for radiological and nonradiological analytes, respectively) or the New York State Department of Health (NYS DOH) Environmental Laboratory Approval Program (ELAP). All PE testing results reported by each participating analytical laboratory during 1998 are summarized in Figures 10-1 and 10-2 and presented in detail in Tables 10-2 through 10-15. The bar graphs show both radiological and nonradiological results (as percentage scores) that were acceptable, within warning limits, and unacceptable for each analytical laboratory, and by PE testing program. A 'warning' is considered satisfactory, being within two and three standard deviations of the target value; an 'unacceptable' result is greater than three standard deviations of the target value.

Overall, BNL's radiological scores were comparable to those of the radiological contractor laboratory (GEL), with a 90 to 95 percent rate of satisfactory results. With the exception of the NYS DOH ELAP organic results, BNL's nonradiological scores were comparable to those of the nonradiological contractor laboratory (H2M), with a 97 to 100 percent rate of acceptable results. The 76 percent overall score in the ELAP for organics test was attributable to an instrument malfunction that occurred in one of four testing rounds during the year. Overall, proficiency testing results for BNL showed an improvement over 1997.

10.1 THE BNL QUALITY ASSURANCE PROGRAM

Responsibility for quality at BNL starts with the Laboratory Director and extends down through the entire organization. The BNL Quality Management (QM) Program coordinates and evaluates QA implementation at the Laboratory, and provides professional assistance to the Departments and Divisions. The objectives of BNL's Environmental Monitoring QA Program are to ensure proper planning, organization, direction, control, and support in order to achieve the objectives of the environmental program. Overall performance is reviewed and evaluated using a rigorous assessment process described in the following Sections of this Chapter. This QA program was developed to ensure compliance with requirements established by the DOE in Orders 5700.6C (QA), and 5400.1 (General Environmental Protection Program).

10.2 SCOPE OF THE PROGRAM

BNL has adopted or adapted program elements specified in DOE Order 5700.6C as well as the additional environmental QA requirements of DOE Order 5400.1 into sampling, analysis, and data handling activities. QA practices and procedures are documented in manuals and Standard Operating Procedures (SOP)(e.g., sample collection,

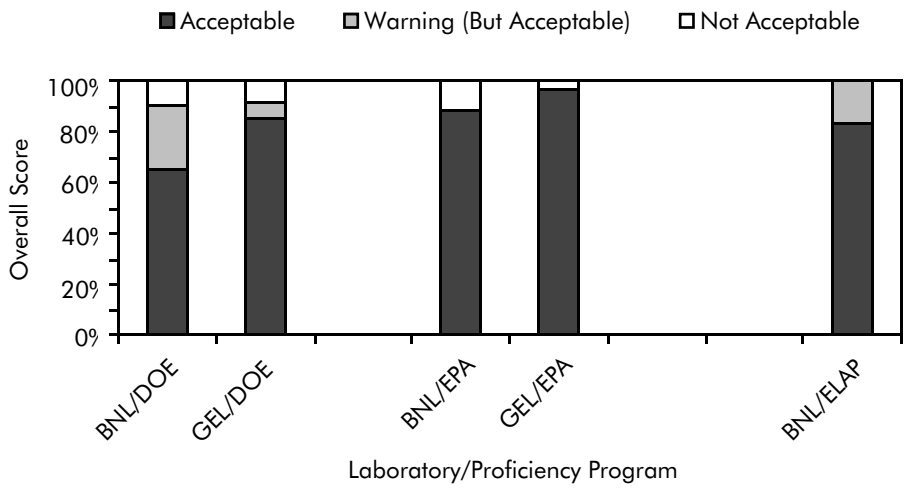


Figure 10-1. Summary of Proficiency Evaluation Scores in U.S. DOE, U.S. EPA and NYS DOH ELAP Radiological Programs

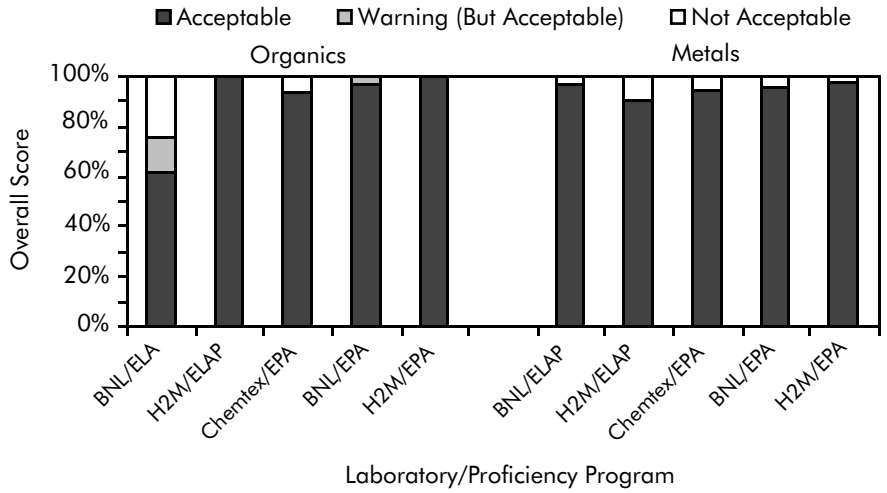


Figure 10-2. Summary of Proficiency Evaluation Scores in U.S. EPA and NYS DOH ELAP Non-Radiological Programs

radiation measurements, chain-of-custody and analytical chemistry).

BNL ensures that environmental media are sampled and analyzed in a way that provides representative, defensible data. The QA program supports this activity by incorporating QA elements, such as field sampling designs, documented procedures, chain of custody, a calibration/standardization program, acceptance criteria, statistical data analyses, software QA, and data processing systems, in the environmental surveillance and effluent monitoring programs. The offsite contractor laboratories that perform radiological and chemical analyses for BNL are also required to incorporate QA elements into their operation.

In addition, BNL has established a program of internal and external audits to verify the effectiveness of the environmental sampling, analysis, and database activities. Contractor laboratories are subject to audits by BNL personnel. The BNL QM Office, DOE Brookhaven Group, DOE Chicago Operations, regulatory agencies, and other independent groups periodically audit the environmental programs.

For in-house analyses, SOPs are established to calibrate instruments, analyze samples, and check quality control. Quality control checks

are performed and include: analysis of blanks or background concentrations, use of Amersham or National Institute for Standards and Technology (NIST) traceable standards, and analysis of reference standards, spiked samples, and duplicate samples. The Laboratory supervisor and/or QA Officer reviews all analytical and quality control results before the data are reported and incorporated into the database.

10.3 QUALITY ASSURANCE PROGRAM FOR CERCLA GROUNDWATER MONITORING ACTIVITIES

This section briefly describes the QA requirements for activities that were conducted as part of the 1998 Environmental Restoration groundwater monitoring program. By regulation, offsite contractor laboratories perform the radiological and chemical analyses for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The Environmental Restoration Calendar Year 1998 Site-wide Groundwater Monitoring Program Quality Assurance Project Plan describes the QA program and the QC requirements followed. The plan defines the project organization structure, documentation requirements, sample custody requirements, acceptance criteria, auditing functions, corrective action provisions, and guidance on the collection of QA/QC samples.

10.4 ANALYSES PERFORMED OFFSITE

Samples collected for regulatory compliance purposes are analyzed by offsite contractor laboratories. Contractors also augment the capabilities of the ASL. For example, strontium-90 and Toxicity Characteristic Leachate Procedure (TCLP) samples are sent offsite, when demand on the ASL exceeds its capacity.

10.4.1 THE CONTRACT PROCESS

During 1998, BNL had three contracts with offsite laboratories. The contracts specify the analytes, methods, required detection limits, and deliverables (which include standard batch QA/QC performance checks). Successful bidders must also provide BNL with a copy of their QA/QC Manual.

In December 1996, a contract was established with H2M Laboratories, Inc. (Melville, NY) with an option for second and third year renewal. A second nonradiological contract was established in 1997 with Chemtex Lab (Port Arthur, TX) in order to provide special analytical services required to meet BNL discharge permit requirements. These samples are wastewater samples collected from various recharge basins and one cooling tower.

In January 1997, a contract was established with General Engineering Environmental Physics Laboratory, Inc. (Charleston, SC) with an option for a second and third year renewal. Samples sent offsite for radiological analyses were those requiring either EPA methods or DOE Standard Methods that the ASL did not perform. Examples are Sr-90 and actinide analyses in soil, vegetation and water.

The commercial laboratories are audited periodically by the ASL manager (or his designee) and QA Officer to verify competence in analytical methodology and implementation of a comprehensive QA program. H2M Laboratory was audited by the ASL in the summer of 1996, and both GEL and Chemtex were audited in the Fall of 1997.

10.4.2 QA/QC VALIDATION PERFORMED AT BNL

External: Data packages for onsite samples sent to a contractor laboratory are reviewed at BNL by subject matter experts in either radiological analyses or analytical chemistry to ensure they comply with the contract specifications before the data are reported. In addition, data packages are examined to determine if samples exceeded holding times, if there are poor recoveries, if the proper method was used and if field blanks are less than the method Minimum Detection Limit (MDL). Nonradiological data analyzed offsite were verified and validated using EPA Contract Laboratory Protocol guidelines (EPA 1990, 1996). Radiological packages were verified and validated using both BNL and EPA guidance documents (BNL, 1997 and DOE EM-73, 1994).

Internal: In July of 1998, the ASL initiated plans to acquire a full-time, dedicated QA Officer whose function is to verify that all analytical batches fulfill internal QA/QC acceptance criteria. These criteria include: (a) precision, (b) accuracy (c) recovery, (d) instrument background checks, and (e) stable instrument efficiency performance. All QA/QC data were reviewed before the results were reported. The QA Officer and technical staff maintained the detailed QA/QC trend-charts included in this chapter.

10.4.3 PROFICIENCY TESTING RESULTS OF OFFSITE LABS

Nonradiological: In 1998, the contract laboratory responsible for analyzing the BNL State Pollution Discharge Elimination Systems (SPDES) samples was H2M Laboratory, which was required to participate in the SPDES performance evaluation study. These results are presented in Table 10-1. The results showed 100 percent acceptance for the thirty-three analytes listed. Acceptance is based on analytic-specific limits placed on the ratio of known to test values by the PE Program.

This same contractor participated in the EMSL-CI Water Pollution (WP) performance evaluation study (WP39 and WP040) in May

Table 10-1. H2M Performance Evaluation Study
BNL State Pollution Discharge Elimination System (SPDES) - DMR QA 18

Analyte	Units	Date	USEPA	H2M	Ratio (a)	Comments (b)
Cu	µg/L	Dec-98	700.00	714.00	1.02	
Fe	µg/L	Dec-98	834.00	804.00	0.96	
Pb	µg/L	Dec-98	70.60	71.40	1.01	
Ni	µg/L	Dec-98	2501.00	2590.00	1.04	
Zn	µg/L	Dec-98	631.00	671.00	1.06	
Cr	µg/L	Dec-98	650.00	663.00	1.02	
Mn	µg/L	Dec-98	240.00	237.00	0.99	
Cd	µg/L	Dec-98	170.00	169.00	0.99	
Al	µg/L	Dec-98	3105.00	2885.00	0.93	
As	µg/L	Dec-98	160.00	162.00	1.01	
Co	µg/L	Dec-98	503.00	505.00	1.00	
Hg	µg/L	Dec-98	1.15	1.08	0.94	
Se	µg/L	Dec-98	260.00	247.00	0.95	
V	µg/L	Dec-98	4202.00	4310.00	1.03	
pH		Dec-98	8.60	8.46	0.98	
Oil and Grease	mg/L	Dec-98	19.10	18.50	0.97	
Ammonia - N	mg/L	Dec-98	4.80	4.54	0.95	
NO3 - N	mg/L	Dec-98	12.00	11.90	0.99	
Orthophosphate	mg/L	Dec-98	0.58	0.58	1.00	
Kjeldahl - N	mg/L	Dec-98	5.40	5.01	0.93	
Non-filterable residue	mg/L	Dec-98	64.00	39.00	0.61	
COD	mg/L	Dec-98	60.70	63.30	1.04	
TOC	mg/L	Dec-98	24.00	26.30	1.10	
5 Day BOD	mg/L	Dec-98	37.60	40.00	1.06	
Total Cyanide	mg/L	Dec-98	0.14	0.13	0.96	
Total Phenolics	mg/L	Dec-98	0.07	0.05	0.69	
Total Phosphorus	mg/L	Dec-98	4.00	3.98	1.00	
Fathead Minnow Chronic Data -						
Survival, NOEC	%	Dec-98	25.00	12.50	0.50	
Growth, IC25	%	Dec-98	39.60	21.70	0.55	
Growth, NOEC	%	Dec-98	25.00	12.50	0.50	
Ceriodaphnia Chronic Data						
Survival, NOEC	%	Dec-98	25.00	12.50	0.50	
Growth, IC25	%	Dec-98	17.60	8.97	0.51	
Growth, NOEC	%	Dec-98	12.50	6.25	0.50	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides evaluation of analytical performance which is based on 95 and 99% prediction interval calculated from samples analyzed by EPA and State laboratories. No comment indicates performance within acceptable limits.

Table 10-2. H2M Water Pollution Performance Evaluation Studies WP39/40
USEPA Environmental Monitoring Systems Laboratory - Cincinnati

Analyte	Units	Date	EMSL-CI	H2M	Ratio (a)	Comments (b)
Cu	µg/l	May-98	74.30	76.40	1.03	
		Nov-98	700.00	714.00	1.02	
Fe	µg/l	May-98	191.00	177.00	0.93	
		Nov-98	834.00	804.00	0.96	
Pb	µg/l	May-98	1900.00	1860.00	0.98	
		Nov-98	70.60	71.40	1.01	
Ni	µg/l	May-98	702.00	729.00	1.04	
		Nov-98	2501.00	2590.00	1.04	
Zn	µg/l	May-98	131.00	136.00	1.04	
		Nov-98	631.00	671.00	1.06	
pH		May-98	5.03	5.05	1.00	
		Nov-98	8.60	8.77	1.02	
TDS at 180 C	mg/l	May-98	156.00	145.00	0.93	
		Nov-98	274.00	336.00	1.23	
Oil and Grease	mg/l	May-98	44.00	16.10	0.37	Not Acceptable
		Nov-98	19.10	18.50	0.97	
Ammonia - N	mg/l	May-98	0.84	0.83	0.99	
		Nov-98	4.80	4.54	0.95	
NO3 - N	mg/l	May-98	1.10	1.14	1.04	
		Nov-98	12.00	11.90	0.99	
Kjeldahl - N	mg/l	May-98	0.36	0.37	1.03	
		Nov-98	5.40	5.01	0.93	
5 Day BOD	mg/l	May-98	119.00	118.00	0.99	
	mg/l	Nov-98	37.60	40.00	1.06	
Total Phenolics	mg/l	May-98	0.80	0.73	0.91	
		Nov-98	0.07	0.05	0.69	
Total Residual Chlorine	mg/l	May-98	0.28	0.31	1.12	
	mg/l	Nov-98	0.93	1.06	1.14	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides evaluation of analytical performance which is based on 95 and 99% prediction interval calculated from samples analyzed by EPA and State laboratories. No comment indicates performance within acceptable limits.

and November of 1998. For the 28 routine analyses shown in Table 10-2, 27 results were acceptable corresponding to an overall score of 96 percent. Results for oil and grease were unacceptable. In actuality, H2M reported results for 75 chemical analytes (two results per analyte) during both WP39 and 40. The acceptable scores for H2M were 97 and 100 percent, respectively, for the 150 results they reported to the EPA (data not shown).

Table 10-3 shows H2M's performance in the EPA Water Supply (WS) Evaluation conducted in March and September 1998. For the 59 routine analyses shown in Table 10-3, 56 were acceptable and three unacceptable. The overall scores for the data shown in Table 10-3 were 95 percent acceptable and five percent unacceptable. H2M actually reported results for 98 chemical analytes (two results per analyte) in both WS testing rounds, scoring 90 percent acceptable and ten percent unacceptable (data not shown).

Table 10-4 shows H2M's performance in the NYS DOH ELAP WS Chemistry Program for July and October 1998. H2M scored 100 percent for the 16 organic results shown. H2M also participated in the NYS DOH ELAP WS Program for metals. The results in Table 10-5 show 100 percent acceptable results.

Table 10-6 shows the 1998 Chemtex results for select chemical analytes in the EPA WS and WP Programs. The overall acceptable

Table 10-3. H2M Water Supply Performance Evaluation Studies - WS040/041
USEPA Environmental Monitoring Systems Laboratory - Cincinnati

Analyte	Units	Date	EMSL-CI	H2M	Ratio (a)	Comments (b)
As	µg/l	Mar-98	102.00	104.00	1.02	
	µg/l	Sep-98	65.60	63.00	0.96	
Ba	µg/l	Mar-98	2700.00	2730.00	1.01	
B	µg/l	Mar-98	1150.00	1290.00	1.12	
	µg/l	Sep-98	790.00	848.00	1.07	
Be	µg/l	Mar-98	6.60	6.90	1.05	
	µg/l	Sep-98	2.58	2.70	1.05	
Cd	µg/l	Mar-98	6.31	6.80	1.08	
	µg/l	Sep-98	18.20	18.30	1.01	
Cr	µg/l	Mar-98	90.90	86.40	0.95	
	µg/l	Sep-98	55.50	54.00	0.97	
Cu	µg/l	Mar-98	1700.00	1700.00	1.00	
	µg/l	Sep-98	702.00	705.00	1.00	
Hg	µg/l	Mar-98	1.50	1.43	0.95	
	µg/l	Sep-98	5.82	5.53	0.95	
Mn	µg/l	Mar-98	32.00	31.60	0.99	
	µg/l	Sep-98	183.00	181.00	0.99	
Mo	µg/l	Mar-98	35.00	37.30	1.07	
	µg/l	Sep-98	76.70	79.30	1.03	
Na	mg/l	Mar-98	15.80	16.10	1.02	
	mg/l	Sep-98	23.30	22.90	0.98	
Ni	µg/l	Mar-98	25.00	21.10	0.84	Not Acceptable
	µg/l	Sep-98	352.00	355.00	1.01	
Pb	µg/l	Mar-98	71.00	68.00	0.96	
Sb	µg/l	Mar-98	13.00	12.60	0.97	
	µg/l	Sep-98	31.40	32.30	1.03	
Se	µg/l	Mar-98	74.00	78.00	1.05	
	µg/l	Sep-98	46.30	48.20	1.04	
Tl	µg/l	Mar-98	10.00	9.20	0.92	
Zn	µg/l	Mar-98	1700.00	1700.00	1.00	
	µg/l	Sep-98	402.00	420.00	1.04	
NO3 - N	mg/l	Mar-98	7.10	7.71	1.09	
	mg/l	Sep-98	15.00	14.70	0.98	
NO2 - N	mg/l	Mar-98	1.30	1.36	1.05	
	mg/l	Sep-98	1.70	1.72	1.01	
SO4	mg/l	Mar-98	225.00	205.00	0.91	
	mg/l	Sep-98	49.00	50.00	1.02	
Fluoride	mg/l	Mar-98	1.29	1.26	0.98	
	mg/l	Sep-98	6.20	5.60	0.90	
OrthoP	mg/l	Mar-98	0.82	1.00	1.21	Not Acceptable
	mg/l	Sep-98	1.30	1.38	1.06	
Turbidity	ntu	Mar-98	7.8	7.50	0.96	
	ntu	Sep-98	2.6	3.90	1.50	Not Acceptable
Chloroform	µg/l	Mar-98	27.40	28.50	1.04	
	µg/l	Sep-98	14.40	16.70	1.16	
1,2-trans-DCE	µg/l	Mar-98	26.80	26.70	1.00	
1,1-DCE	µg/l	Sep-98	5.25	4.90	0.93	
1,1,2-TCA	µg/l	Mar-98	17.20	16.20	0.94	
TCA	µg/l	Sep-98	12.60	12.20	0.97	
TCE	µg/l	Sep-98	6.87	6.65	0.97	
Benzene	µg/l	Mar-98	16.70	17.20	1.03	
	µg/l	Sep-98	18.70	17.60	0.94	
PCE	µg/l	Sep-98	11.50	11.40	0.99	
Toluene	µg/l	Mar-98	14.60	14.80	1.01	
	µg/l	Sep-98	18.70	19.20	1.03	
Ethylbenzene	µg/l	Mar-98	17.80	16.80	0.94	
	µg/l	Sep-98	14.70	14.40	0.98	
Total Xylenes	µg/l	Mar-98	30.30	34.20	1.13	
	µg/l	Sep-98	30.80	31.60	1.03	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides EMSL-CI evaluation of analytical performance which is based on 40CFR141 analyte-specific acceptance limits. No comment indicates performance within acceptable limits.

Table 10-4. H2M Non-Potable Water Chemistry Proficiency Test #193,198 Results
Environmental Laboratory Approval Program

Analyte	Date	ELAP (µg/L)	H2M (µg/L)	Ratio (a)	Comment (b)
1,1-Dichloroethane	Jul-98	15.70	15.20	0.97	
	Oct-98	blank	<0.5	1.00	
Tetrachloroethene	Jul-98	24.60	26.10	1.06	
	Oct-98	10.00	9.93	0.99	
1,1,2-Trichloroethane	Jul-98	19.20	18.40	0.96	
	Oct-98	blank	<0.5	1.00	
Trichloroethene	Jul-98	22.10	22.70	1.03	
	Oct-98	9.06	9.75	1.08	
Benzene	Jul-98	37.10	37.10	1.00	
	Oct-98	6.34	6.83	1.08	
Ethyl benzene	Jul-98	25.60	28.20	1.10	
	Oct-98	9.49	10.80	1.14	
Toluene	Jul-98	18.50	20.20	1.09	
	Oct-98	blank	<0.5	1.00	
Total Xylenes	Jul-98	27.20	31.10	1.14	
	Oct-98	blank	<0.5	1.00	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides ELAP evaluation of analytical performance which is based on 95 and 99% confidence interval about the target value.
No comment indicates performance within acceptable limits.

scores for Chemtex, in both the EPA WS41 (20 analyses reported) and WP40 (18 analyses reported) were 90 and 94 percent, respectively.

Radiological: On occasion, the ASL sent samples to GEL, an offsite contractor laboratory, for radiological analyses. GEL's performance in the DOE's EML Quality Assessment Program and EPA NERL Program are presented in Tables 10-7 and 10-8, respectively.

Overall, GEL performance in the DOE EML intercomparison study was acceptable or within warning limits in 94 percent of the analyses performed on the four matrices (air, vegetation, water and soil) shown in Table 10-7. Eighty of 93 analyses (86 percent) were within EML's acceptance limit; six of 93 (seven percent) were within upper and lower warning limits, demonstrating satisfactory agreement; seven analyses (eight percent) fell outside the acceptance limits. Most of the warning and non-acceptable results were for the air-filter matrix. It should be noted that the EML test filter is not the same geometry used by GEL (or BNL) to calibrate their gamma spectrometers, which would account for a positive bias.

Overall, GEL performance in the EPA NERL intercomparison study was acceptable or within warning limits in 97 percent of the radiological analyses performed in a water matrix shown Table 10-8. Thirty-six of 37 analyses were within EPA's acceptance limits, showing excellent agreement with the known value; one analysis (Ra-228) fell outside the acceptance limits.

10.5 ANALYSES PERFORMED IN-HOUSE

ASL performs radiological and nonradiological analyses in support of both environmental monitoring and facility operations. The ASL is certified by the NYS DOH for tritium, gross alpha/beta and gamma in potable and non-potable waters. It is also NYS

Table10-5. H2M Potable Water Chemistry Proficiency Tests #187, #197 Results
Environmental Laboratory Approval Program

Analyte	Date	ELAP (µg/L)	H2M (µg/L)	Ratio (a)	Comment (b)
Cadmium	Apr-98	5.00	4.70	0.94	
	Apr-98	12.50	12.90	1.03	
	Oct-98	16.70	17.50	1.05	
Chloride	Apr-98	22.70	23.60	1.04	
	Apr-98	142.00	138.00	0.97	
	Oct-98	129.00	135.00	1.05	
Chromium	Apr-98	37.50	37.60	1.00	
	Apr-98	62.50	61.30	0.98	
	Oct-98	100.00	103.00	1.03	
Copper	Apr-98	50.00	52.70	1.05	
	Apr-98	75.00	78.00	1.04	
	Oct-98	1330.00	1340.00	1.01	
Iron	Apr-98	88.10	87.50	0.99	
	Apr-98	112.00	111.00	0.99	
	Oct-98	299.00	299.00	1.00	
Lead	Apr-98	25.00	21.80	0.87	
	Apr-98	50.00	45.30	0.91	
	Oct-98	83.30	78.80	0.95	
Manganese	Apr-98	61.80	63.30	1.02	
	Apr-98	92.10	93.30	1.01	
	Oct-98	334.00	340.00	1.02	
Mercury	Apr-98	1.10	1.10	1.00	
	Apr-98	4.69	3.70	0.79	
	Oct-98	6.00	4.20	0.70	
Nitrate (as N)	Apr-98	1.11	1.09	0.98	
	Apr-98	7.10	6.93	0.98	
	Oct-98	12.00	11.30	0.94	
Silver	Apr-98	18.70	18.70	1.00	
	Apr-98	49.20	50.50	1.03	
	Oct-98	25.20	25.10	1.00	
Sodium	Apr-98	29.90	27.10	0.91	
	Apr-98	49.70	46.90	0.94	
	Oct-98	13.70	12.80	0.93	
Sulfate (as SO4)	Apr-98	52.00	57.00	1.10	marginal
	Apr-98	203.00	216.00	1.06	
	Oct-98	99.40	117.00	1.18	
Zinc	Apr-98	63.30	63.60	1.00	
	Apr-98	100.00	103.00	1.03	
	Oct-98	1670.00	1720.00	1.03	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides ELAP evaluation of analytical performance which is based on 95 and 99% confidence interval about the target value. No comment indicates performance within acceptable limits.

Table 10-6. ChemTex Water Supply and Water Pollution Performance Evaluation Studies-
WS041, WP040
USEPA Environmental Monitoring Systems Laboratory - Cincinnati

WS-041 Study Analyte	**Units**	**Date**	**EMSL-CI**	**ChemTex**	**Ratio (a)**	**Comments (b)**
Cd	µg/l	Sep-98	65.60	67.00	1.02	
Cr	µg/l	Sep-98	18.20	19.80	1.09	
Cu	µg/l	Sep-98	702.00	713.00	1.02	
Hg	µg/l	Sep-98	5.82	3.45	0.59	Not Acceptable
Be	µg/l	Sep-98	31.40	29.50	0.94	
Mn	µg/l	Sep-98	183.00	156.00	0.85	
Sb	µg/l	Sep-98	702.00	713.00	1.02	
Zn	µg/l	Sep-98	402.00	400.00	1.00	
Cl	mg/l	Sep-98	1.90	1.78	0.94	
SO4	mg/l	Sep-98	42.00	49.00	1.17	Not Acceptable
Turbidity		Sep-98	2.60	2.00	0.77	
Chloroform	µg/l	Sep-9	14.40	13.43	0.93	
DCE	µg/l	Sep-98	18.50	15.27	0.83	
TCA	µg/l	Sep-98	12.60	12.10	0.96	
TCE	µg/l	Sep-98	6.87	5.65	0.82	
Benzene	µg/l	Sep-98	18.70	15.45	0.83	
PCE	µg/l	Sep-98	11.50	9.80	0.85	
Toluene	µg/l	Sep-98	18.70	17.20	0.92	
Ethylbenzene	µg/l	Sep-98	14.70	12.50	0.85	
Total Xylenes	µg/l	Sep-98	30.80	24.68	0.80	
WP-040 Study						
Chloroform	µg/l	Nov-98	18.40	18.41	1.00	
1,1,1 Trichloroethane	µg/l	Nov-98	32.80	29.90	0.91	
Trichloroethene	µg/l	Nov-98	23.40	19.53	0.83	
Tetrachloroethene	µg/l	Nov-98	32.50	28.13	0.87	
Benzene	µg/l	Nov-98	25.70	30.43	1.18	
Ethylbenzene	µg/l	Nov-98	42.60	37.54	0.88	
Toluene	µg/l	Nov-98	32.30	34.05	1.05	
1,2-Dichlorobenzene	µg/l	Nov-98	36.30	32.15	0.89	
1,3-Dichlorobenzene	µg/l	Nov-98	33.70	38.50	1.14	
1,4-Dichlorobenzene	µg/l	Nov-98	41.60	30.23	0.73	Not Acceptable
1,2-Dichloroethane	µg/l	Nov-98	14.60	14.20	0.97	
Bromodichloromethane	µg/l	Nov-98	16.50	16.07	0.97	
Dibromochloromethane	µg/l	Nov-98	32.70	29.56	0.90	
Chlorobenzene	µg/l	Nov-98	24.70	24.50	0.99	
Bromoform	µg/l	Nov-98	14.70	14.73	1.00	
Carbon Tetrachloride	µg/l	Nov-98	26.30	23.51	0.89	
TDS	mg/l	Nov-98	274.00	299.50	1.09	
Total Residual Cl	mg/l	Nov-98	0.93	1.08	1.16	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides EMSL-CI evaluation of analytical performance which is based on 40CFR141 analyte-specific acceptance limits.
No comment indicates performance within acceptable limits.

Table 10-7. GEL Quality Assessment Program #48, #49 Results
Environmental Measurements Laboratory

Matrix	Units	Isotope	Date	EML	GEL	Ratio	Comments
Air Filter	Bq/Filter	Alpha	Mar-98	1.40	1.38	0.98	
			Sep-98	1.65	1.63	0.99	
		Beta	Mar-98	1.96	1.94	0.99	
			Sep-98	2.16	1.78	0.82	Warning
		Ce-144	Mar-98	8.21	7.51	0.91	
		Co-57	Mar-98	11.11	10.67	0.96	
		Co-60	Mar-98	9.09	9.01	0.99	
			Sep-98	9.16	9.18	1.00	
		Cs-134	Mar-98	19.74	18.27	0.93	
		Cs-137	Mar-98	11.86	11.58	0.98	
			Sep-98	22.47	22.58	1.00	
		Mn-54	Mar-98	5.44	5.40	0.99	
			Sep-98	4.92	5.30	1.08	
		Sr-90	Mar-98	1.76	1.03	0.58	Not Acceptable
			Sep-98	1.12	1.18	1.06	
		Sb-125	Mar-98	12.16	13.22	1.09	
			Sep-98	8.89	2.72	0.31	Not Acceptable
		U-234	Mar-98	0.03	0.03	1.10	
			Sep-98	0.26	0.24	0.93	
		U-238	Mar-98	0.03	0.04	1.17	
			Sep-98	0.26	0.25	0.95	
		µg U	Mar-98	2.47	2.93	1.19	
			Sep-98	20.96	16.94	0.81	Warning
		Pu-238	Mar-98	0.07	0.07	0.96	
			Sep-98	0.46	0.51	1.11	
		Pu-239	Mar-98	0.06	0.07	1.15	
			Sep-98	0.42	0.46	1.10	
		Am-241	Mar-98	0.07	0.13	1.94	Not Acceptable
			Sep-98	0.51	0.55	1.08	
Vegetation	Bq/kg	Co-60	Mar-98	10.58	11.14	1.05	
			Sep-98	20.00	19.35	0.97	
		Cs-137	Mar-98	181.50	189.40	1.04	
			Sep-98	390.00	377.96	0.97	
		K-40	Mar-98	707.50	812.52	1.15	
			Sep-98	460.00	468.42	1.02	
		Sr-90	Mar-98	359.01	339.96	0.95	
			Sep-98	606.00	588.24	0.97	
		Pu-239	Mar-98	1.77	2.28	1.29	Warning
			Sep-98	3.72	5.03	1.35	Warning
		Am-241	Mar-98	1.11	1.43	1.30	
			Sep-98	2.33	2.69	1.15	
		Cm-244	Mar-98	2.17	2.66	1.23	
			Sep-98	1.76	2.04	1.16	
Water	Bq/L	Alpha	Mar-98	1421.00	1650.86	1.16	Warning
			Sep-98	1080.00	1124.80	1.04	
		Beta	Mar-98	2200.00	2156.40	0.98	
			Sep-98	1420.00	1228.40	0.87	
		Co-60	Mar-98	13.60	14.73	1.08	
			Sep-98	49.40	53.50	1.08	
		Cs-137	Mar-98	46.00	51.60	1.12	
			Sep-98	50.00	52.56	1.05	
		H3	Mar-98	218.30	212.04	0.97	
			Sep-98	76.20	91.87	1.21	
		Mn-54	Mar-98	57.00	63.23	1.11	
			Sep-98	32.40	36.42	1.12	
		Sr-90	Mar-98	4.36	4.52	1.04	
			Sep-98	2.11	0.20	0.10	Not acceptable

Table 10-7. GEL Quality Assessment Program #48, #49 Results
Environmental Measurements Laboratory *(cont'd.)*

Matrix	Units	Isotope	Date	EML	GEL	Ratio	Comments
		Fe-55	Mar-98	202.80	260.37	1.28	
			Sep-98	139.00	116.97	0.84	
		U-234	Mar-98	0.40	0.39	0.97	
			Sep-98	0.51	0.54	1.06	
		U-238	Mar-98	0.40	0.39	0.99	
			Sep-98	0.52	0.52	1.00	
		µg U	Mar-98	0.03	0.04	1.09	
			Sep-98	0.04	0.04	1.03	
		Pu-238	Mar-98	2.53	2.32	0.92	
			Sep-98	1.10	1.14	1.03	
		Pu-239	Mar-98	1.65	1.60	0.97	
			Sep-98	1.41	1.46	1.04	
		Am-241	Mar-98	1.23	1.36	1.11	
			Sep-98	1.25	1.23	0.98	
		N-I63	Sep-98	95.70	55.45	0.58	Not acceptable
Soil	Bq/kg	Ac-228	Sep-98	52.60	53.60	1.02	
		Bi-212	Sep-98	58.30	31.76	0.54	Not acceptable
		Cs-137	Mar-98	329.50	353.18	1.07	
			Sep-98	954.00	980.69	1.03	
		K-40	Mar-98	313.50	354.09	1.13	
			Sep-98	314.00	350.32	1.12	
		Pb-212	Sep-98	52.80	56.53	1.07	
		Pb-214	Sep-98	29.10	32.56	1.12	
		Sr-90	Mar-98	13.09	11.29	0.86	
			Sep-98	39.63	32.93	0.83	Warning
		U-234	Mar-98	31.13	27.00	0.87	
			Sep-98	113.00	103.05	0.91	
		U-238	Mar-98	31.90	27.52	0.86	
			Sep-98	120.00	117.29	0.98	
		µg U	Mar-98	2.58	0.95	0.37	Not acceptable
		Pu-239	Mar-98	5.31	5.42	1.02	
			Sep-98	13.09	12.17	0.93	
		Am-241	Sep-98	7.47	6.96	0.93	
		Ra-226	Sep-98	29.00	29.98	1.03	
		Th-228	Sep-98	52.70	53.60	1.02	
		Th-234	Sep-98	114.00	109.28	0.96	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides EML evaluation of analytical performance
which is based on control limits established from percentiles of historic data distributions.
No comment indicates performance within acceptable limits.

Table 10-8. GEL Quality Assessment Program Results
National Exposure Research Laboratory (NERL-LV)

Matrix	Units	Isotope	Date	NERL	GEL	Ratio (a)	Comments (b)
Water	pCi/L	Alpha	Jan-98	30.50	19.30	0.63	
			Apr-98	54.40	58.07	1.07	
			Jul-98	7.20	6.17	0.86	
		Beta	Jan-98	3.90	6.70	1.72	
			Apr-98	94.70	83.80	0.88	
			Oct-98	94.00	87.97	0.94	
		H3	Mar-98	2155.00	2041.67	0.95	
			Aug-98	17996.00	16460.00	0.91	
		Sr-90	Jan-98	32.00	28.33	0.89	
			Apr-98	18.00	14.33	0.80	
			Jul-98	7.00	5.33	0.76	
			Oct-98	8.00	5.33	0.67	
		Co-60	Jun-98	12.00	14.00	1.17	
			Apr-98	50.00	49.67	0.99	
			Oct-98	21.00	23.67	1.13	
		Cs-134	Apr-98	22.00	20.33	0.92	
			Jun-98	31.00	26.67	0.86	
			Oct-98	6.00	6.33	1.06	
		Cs-137	Apr-98	10.00	13.00	1.30	
			Jun-98	35.00	35.67	1.02	
			Oct-98	50.00	50.00	1.00	
		Zn-65	Jun-98	104.00	115.00	1.11	
		Sr-89	Jan-98	8.00	6.33	0.79	
			Apr-98	6.00	9.00	1.50	
			Jul-98	21.00	17.67	0.84	
			Oct-98	19.00	12.67	0.67	
		I-131	Feb-98	104.90	108.7	1.04	
		Ba-133	Jun-98	40.00	40.33	1.01	
		Ra-226	Feb-98	16.00	18.20	1.14	
			Apr-98	15.00	18.93	1.26	
			Jun-98	4.90	5.40	1.10	
		Ra-228	Feb-98	33.30	31.63	0.95	
			Apr-98	9.30	9.87	1.06	
			Jun-98	2.10	4.30	2.05	Not Acceptable
		U	Feb-98	32.00	30.57	0.96	
			Apr-98	5.00	5.17	1.03	
			Jun-98	3.00	3.00	1.00	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides NERL evaluation of analytical performance which is based on 2 and 3 normalized standard deviations about the known value. Results outside these control limits are deemed not acceptable or a statistical outlier. No comment indicates performance within acceptable limits.

certified for metals and anions (silver, cadmium, chromium, copper, iron, mercury, manganese, sodium, lead, zinc, chloride, nitrate [as nitrogen], and sulfate) under the environmental analyses of potable water category, and specific purgeable organic compounds (benzene, toluene, xylene, ethylbenzene, chloroform, 1,1-dichloroethylene [DCE] , 1,1-dichloroethane [DCA], 1,1,1-trichloroethane [TCA], trichloroethylene [TCE], and tetrachloroethylene [PCE]) under the environmental analyses of non-potable water category.

The ASL performs gross alpha, gross beta, gamma, and tritium analyses in several matrices, all of which are approved EPA methods. In 1998, the ASL developed a method to measure actinides (Pu, Am, Cm, Th and U) in water using a state-of-the-art alpha liquid scintillation detection system. The ASL also evaluated a new Sr-90 analytical method that utilizes crown-ether separation technology. The results of this evaluation will be published in 1999 in the *Health Physics Journal*. All analytic methods performed by the ASL are described in detail in Appendix C.

10.5.1 RADIOLOGICAL LAB RELOCATION TO MEDICAL 490

In accordance with DOE recommendations, the ASL Radiological Laboratory was moved from its cramped quarters in Bldg. 535 to Bldg. 490, where the laboratory size and storage space eliminates the possibility of cross contamination of samples. There are five separate laboratories and a counting room for instruments.

10.6 ASL'S INTERNAL QUALITY ASSURANCE PROGRAM

During the last quarter of 1998, the ASL began upgrading its Quality Assurance Program Plan (QAPP) following EPA Region-5 guidelines (U.S. EPA QA/R-5, 1998). Some elements were in SOPs or revised SOPs maintained by the ASL (BNL RM-SOP, January 1994). The ASL has upgraded its internal QA/QC program as a result of corrective actions from two 1997 audits. All suggested corrective actions were implemented and successfully completed before the end of 1998. The QA for radiological analyses was improved by the addition of spikes and spiked duplicates to each analytical batch (see Section 10.4.2 for details). Additional efforts are underway to update quality assurance documents.

The QA procedures followed at ASL include daily instrument calibrations, efficiency and background checks, and routine tests for precision and accuracy. A brief summary of the methods and results of these procedures follows.

10.6.1 ASL INSTRUMENT CALIBRATIONS

Figures 10-3 through 10-6 summarize the internal quality control checks for the ASL's radiological instruments. Figure 10-3 shows the annual mean efficiencies, with 99 percent confidence interval, for the ASL's alpha, beta, tritium, and Sr-90 analyzers. Efficiency is the measure by which radiological decaying events are converted into observable counts (counts per minute). Instrument efficiencies were determined daily, using a calibration standard, and averaged for the calendar year. The data points show the annual mean and one standard deviation for each analyzer. All analyzers exhibited stable behavior. A power pack was replaced on one alpha/beta detector during the last quarter of 1998 which did not affect the data shown.

Figure 10-4 summarizes the variability in background counts experienced by each analyzer in 1998. Instrument background is used to determine the MDL of a radiological analyte. In 1998, there was no unusual drift or variability in instrument background for each type of analyzer, based on the mean background count-rates and their one standard deviation. The observed variability in the tritium background was normal.

Figure 10-5 shows the mean, with 99 percent confidence intervals, for eight high-purity germanium gamma detectors. Each detector was calibrated for energy and instrument efficiency daily using a NIST traceable cesium-137 standard. Geometry efficiency calibrations are performed quarterly. Cs-137 is illustrated on the graph, and the acceptance limit of 1 keV is shown as the upper and lower lines. The data showed that all eight gamma-detectors performed well within the EPA acceptance limit during 1998.

Figure 10-6 compares the mean, with 99 percent confidence interval, for each Sr-90 detector. The plot shows that the annual mean detector efficiencies, using calibration standards, were within 2 percent of each other and each of the daily efficiency checks performed

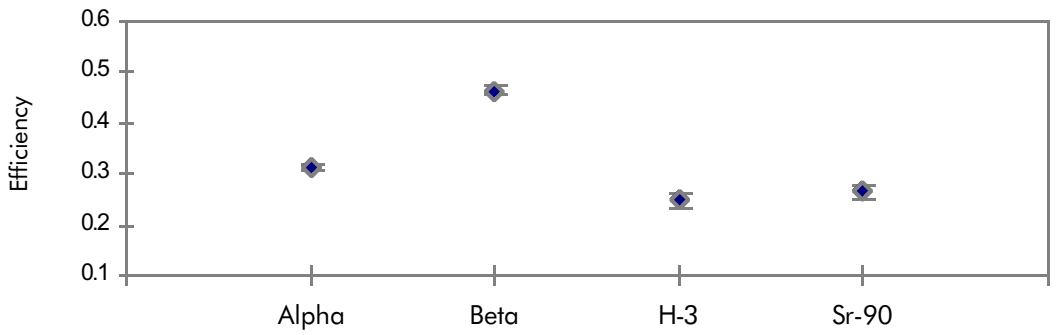


Figure 10-3.
Instrument Efficiency
Summary for 1998

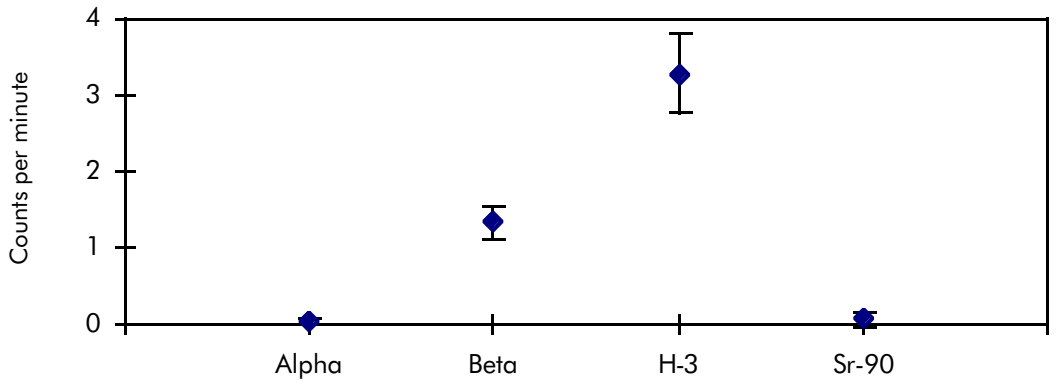


Figure 10-4
. Instrument Background
Summary for 1998

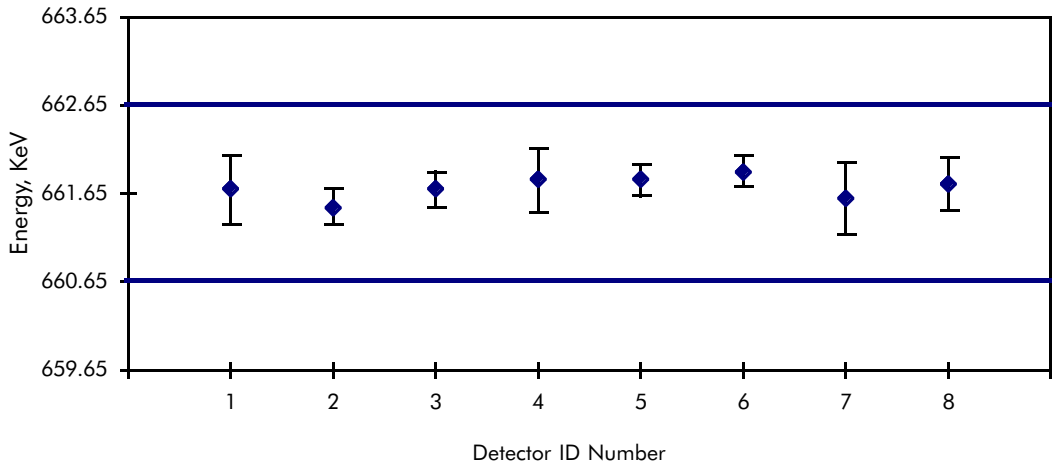


Figure 10-5
. Cesium 137
Energy Calibration
Summary for 1998

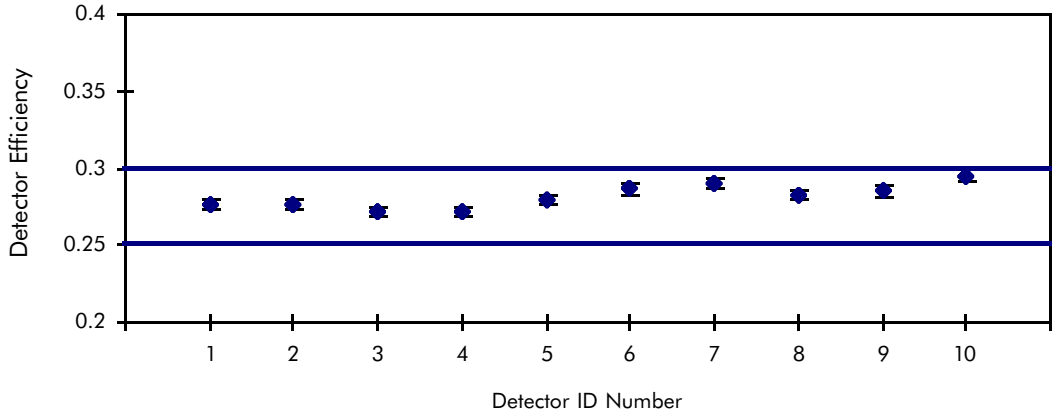


Figure 10-6.
Strontium-90
Instrument Efficiency
Summary for 1998

were within the five percent EPA acceptance limit.

10.6.2 PRECISION AND ACCURACY

Precision is the percent difference between two measured values whereas accuracy is the percent difference between a measured value and its known (expected) value. The Relative Percent Difference (RPD) statistic is the measure of batch precision and is defined as the difference between two results divided by the average of both results. Typically, a radioactive tracer solution (i.e., spike) is added to either a routine sample or tap water sample as a means of determining both precision and accuracy. In the case of nonradiological analyses, a known amount of a given analyte is added to a sample, and the percent recovery is the measure of accuracy.

Radiological: Gross Alpha/Beta and Tritium Analyses

Figure 10-7 shows the RPD statistics for the 310 batches of gross alpha and beta (GAB) analyses performed by the ASL in 1998. Tap water was spiked with known amounts of Am-241 (for alpha) and Sr/Y-90 (for beta) in order to determine batch precision. The acceptance criteria for batch precision is an RPD statistic

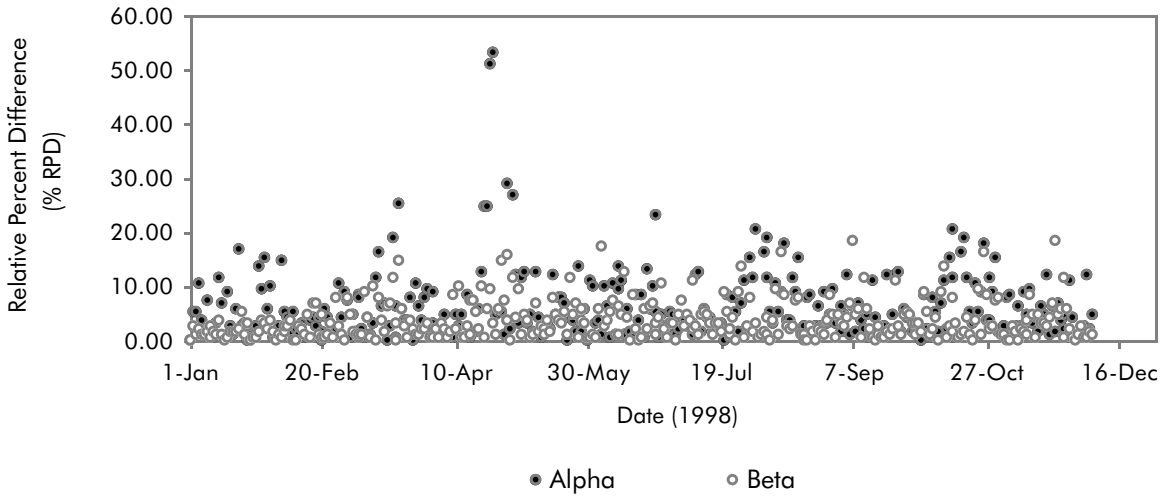


Figure 10-7. ASL Gross Alpha and Beta Precision

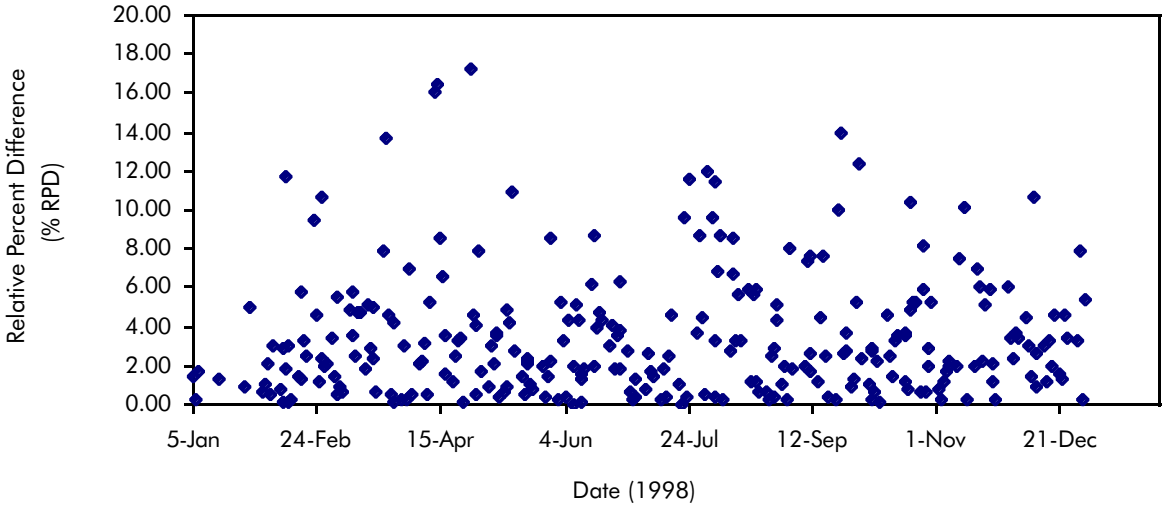


Figure 10-8. ASL Tritium Precision

less than 20 percent for activity concentrations that are five times greater than the method MDL. During 1998, GAB batch precision was consistently less than 20 percent, except for ten instances where precision exceeded the 20 percent acceptance criteria. In those instances, analytical results were rejected and the entire batch reanalyzed. In no cases were sample data lost. The rejection rate for GAB analyses performed in 1998 was 3.2 percent.

Figure 10-8 shows the RPD for each of the 190 analytical batches of tritium analyses performed by the ASL in 1998. The data in Figure 10-8 show tritium precision for all 190 analytical batches performed by the ASL during 1998. The RPD value was consistently less than 20 percent with no rejected batches.

Nonradiological: Organic and Inorganic Analyses

Figures 10-9 and 10-10 summarize the internal quality control program for the ion chromatography and atomic absorption methods used for inorganic analyses. Figure 10-9 presents the annual mean and 99 percent confidence interval for reference check and calibration check sample recoveries analyzed in

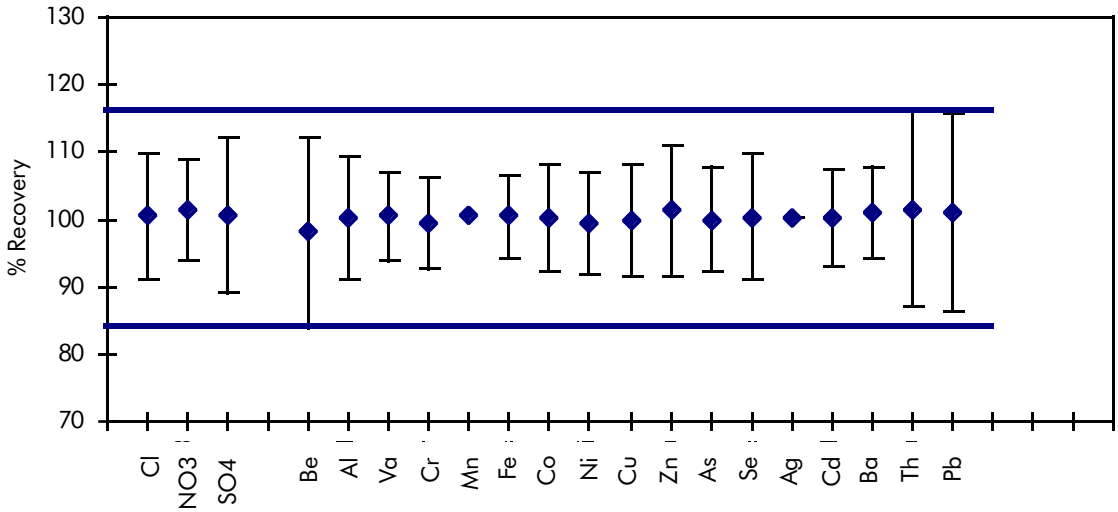


Figure 10-9. Reference Check Summary for 1998 Inorganic Analysis

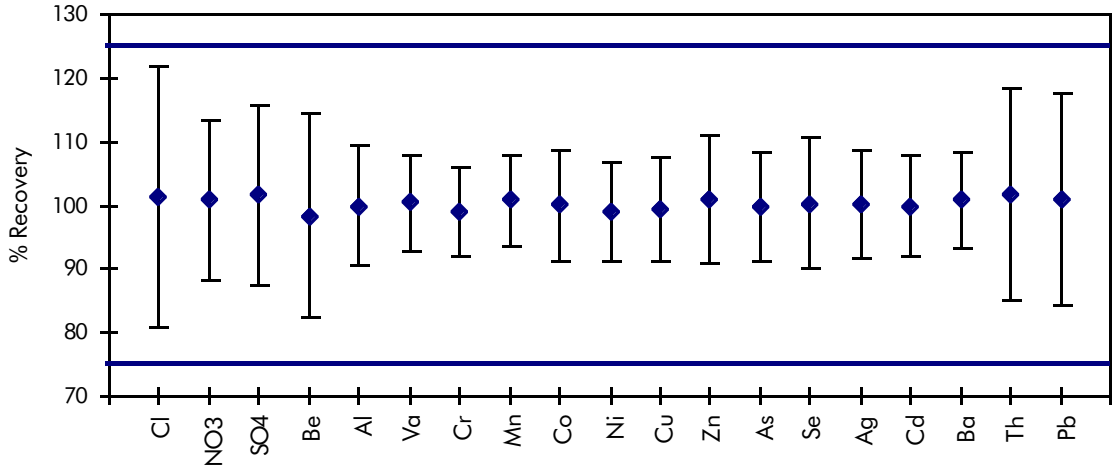


Figure 10-10. Spiked Recovery Summary for 1998 Inorganic Analysis

Figure 10-11. Reference Check Summary for Organic Analysis in 1998

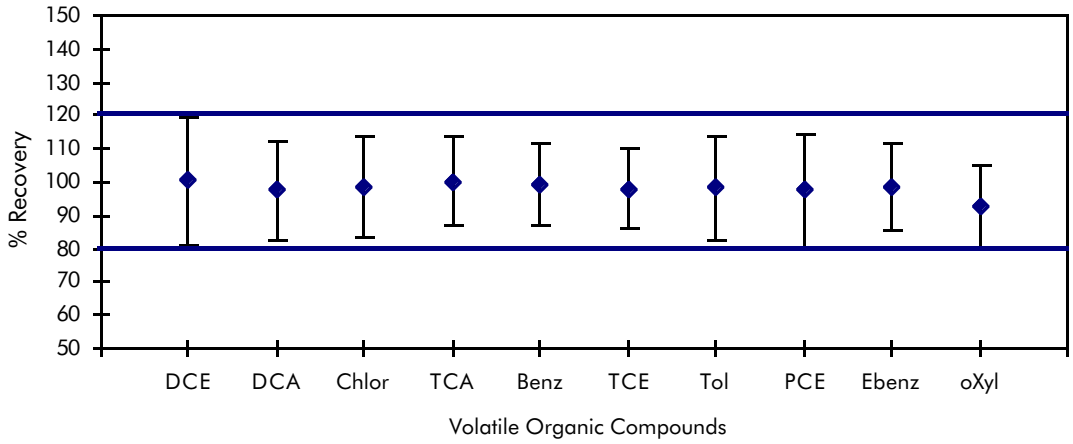


Figure 10-12. Surrogate and Spike Recovery Summaries for 1998 Organic Analysis

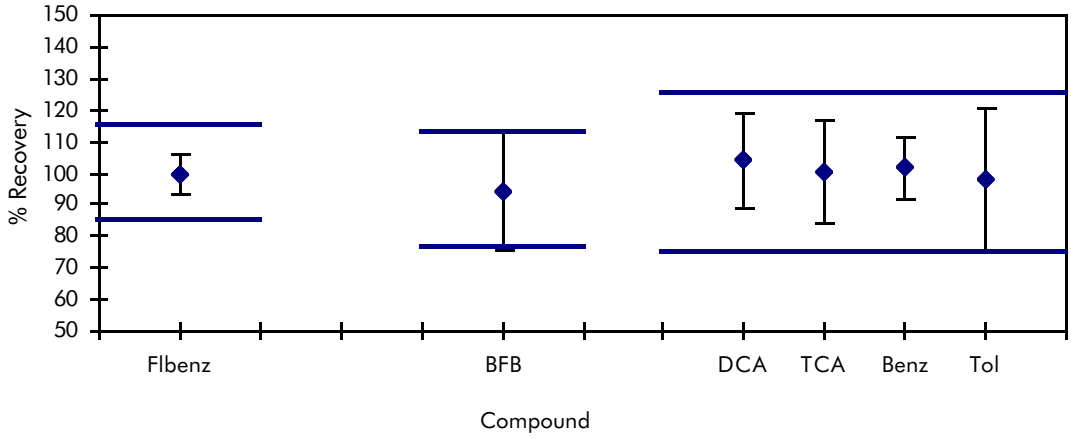
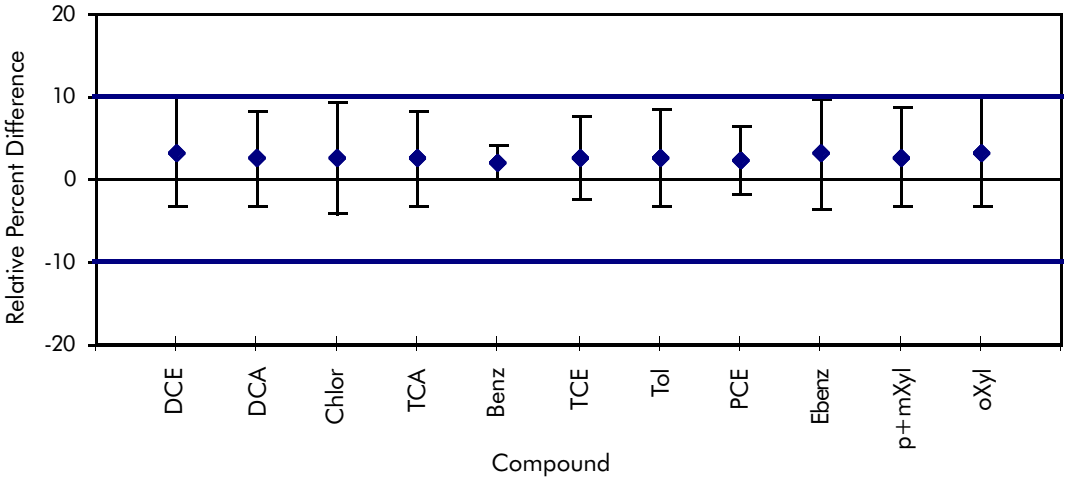


Figure 10-13. Matrix Spike Duplicate Summary for Organic Analysis in 1998



68 batches of metals and anions. All reference check results were within the + 15 percent EPA acceptance limit.

Figure 10-10 shows the mean and 99 percent confidence interval of spike recoveries performed for both metals and anions. The data represent the average of 68 batches. Each batch of spiked samples resulted in recoveries that were within the 25 percent EPA acceptance limit for 16 metals and three anions.

Figures 10-11 and 10-12 show the 1998 results of the ASL's internal quality control program for the gas chromatography/mass spectroscopy method used in the organic analyses. Figure 10-11 summarizes the recoveries of the ten organic reference check samples, presented as the means, with 99 percent confidence interval, for each of the primary volatile organic compounds (VOCs). Mean recoveries and 99 percent confidence intervals for all ten analytes were within their target ranges; that is + 20 percent.

Figure 10-12 presents the means, with 99 percent confidence intervals, of surrogate and spike recoveries for organic analyses. The method's performance for each of the two surrogate analyses (fluorobenzene [Flbenz] and 4-bromofluorobenzene [BFB]) was 16 percent and 21 percent, respectively. The matrix spike recoveries were less than 20 percent for DCA, TCA, benzene and toluene, all within the EPA acceptance limit of 25 percent.

Method precision was determined by analyzing samples in duplicate for ten compounds. Approximately 50 batches were processed in 1998. Figure 10-13 presents the results as the RPD. All duplicate analyses were within the ASL's internal acceptance limit of + 10 percent for organic compounds.

10.6.3 RADIOLOGICAL LABORATORY SWIPE TESTING

Beginning in November 1998, contamination surveys were performed in all radiological labs of the ASL in order to reduce the chance of sample contamination by analytical equipment. A BNL Radiological Control Technician (RCT) performed the contamination surveys. Monthly surveys consisted of swipe-tests of all radiological laboratories as well as the ASL Counting Room. Weekly surveys, swipe-tests and instrument surveillance, were also performed on (a) the ASL's 'Controlled Area' hood, and (b) all pipettes used to dispense samples and reagents. On a quarterly basis, the RCT performs a Dose-Report Review. No measurable contamination was found during either monthly or weekly ASL surveys.

10.7 RESULTS OF THE ASL'S INDEPENDENT PROFICIENCY EVALUATION TESTS

During 1998, the ASL participated in three proficiency evaluation testing programs; two national and one state.

10.7.1 RADIOLOGICAL ASSESSMENTS

The ASL participated in the DOE's EML QAP Program and the EPA's NERL performance evaluation study. The results of the DOE, EPA and NYSDOH PE testing programs are presented in Tables 10-9 through 10-15, respectively.

Overall, the ASL's performance in the DOE EML QA Program was satisfactory in 91 percent of the analyses performed on four matrices shown in Table 10-9. Twenty-eight of 43 analyses (65 percent) were within established EML limits showing acceptable agreement with the known value; 11of 43 results (26 percent) were within warning limits, demonstrating satisfactory agreement; four analyses (9 percent) fell outside the acceptance limits. Many of the March and September air filter gamma results were reported in the warning and unacceptable range. A review of the QC data for the unacceptable cobalt-57 and manganese-54 analyses on the air-filter matrix showed no problem associated with the sample preparation, analytical process, or data calculations, as can be seen by the acceptable soil and vegetation results. As previously noted (in the case of GEL), the EML test filter is not the same geometry used to calibrate the gamma spectrometer in the BNL air-monitoring program, which would account for a positive bias. These proficiency evaluation results imply that the environmental air sampling (i.e., filter) data presented elsewhere in this report may be overestimated by 15-30 percent. EML will be replacing its three-inch diameter filters with two-inch diameter filters that are compatible with most commercial high-purity germanium gamma detectors.

Similarly, several 'warnings' were observed for the gamma analyses in the water matrix. This is attributable to the fact that EML establishes their values using a 4-liter

Table 10-9. BNL Quality Assessment Program #48, #49 Results
Environmental Measurements Laboratory

Matrix	Units	Isotope	Date	EML	BNL	Ratio (a)	Comments (b)
Air Filter	Bq/Filter	Alpha	Mar-98	1.40	1.07	0.76	Warning
			Sep-98	1.65	1.49	0.90	
		Beta	Mar-98	1.96	1.79	0.91	
			Sep-98	2.16	1.77	0.82	Warning
		Ce-144	Mar-98	8.21	10.36	1.26	Warning
		Co-57	Mar-98	11.11	14.56	1.31	Warning
		Co-60	Mar-98	9.09	8.84	0.97	
		Cs-134	Mar-98	19.74	18.04	0.91	
		Cs-137	Mar-98	11.86	15.04	1.27	Warning
			Sep-98	22.47	33.67	1.50	Not Acceptable
		Mn-54	Mar-98	5.44	7.04	1.29	Warning
			Sep-98	4.92	7.29	1.48	Not Acceptable
		Sb-125	Mar-98	12.16	16.94	1.39	Warning
			Sep-98	8.89	13.99	1.57	Not Acceptable
Soil	Bq/kg	Ac-228	Sep-98	52.60	45.03	0.86	
		Bi-212	Sep-98	58.30	35.28	0.61	
			Mar-98	329.50	328.20	1.00	
			Sep-98	954.00	954.97	1.00	
		K-40	Mar-98	313.50	284.72	0.91	
			Sep-98	314.00	291.67	0.93	
		Pb-212	Sep-98	52.80	51.28	0.97	
		Pb-214	Sep-98	29.10	30.90	1.06	
		T-l208	Sep-98	18.30	18.71	1.02	
Vegetation	Bq/kg	Co-60	Mar-98	10.58	10.25	0.97	
			Sep-98	20.00	18.63	0.93	
		Cs-137	Mar-98	181.50	196.03	1.08	
			Sep-98	390.00	432.53	1.11	
		K-40	Mar-98	707.50	712.99	1.01	
			Sep-98	460.00	451.03	0.98	
Water	Bq/L	Alpha	Mar-98	1421.00	1490.43	0.95	
			Sep-98	1080.00	982.00	1.10	(c)
		Beta	Mar-98	2200.00	2236.48	0.98	
			Sep-98	1420.00	1277.00	1.11	(c)
		Co-60	Mar-98	13.60	14.43	0.94	
			Sep-98	49.40	51.50	0.96	
		Cs-137	Mar-98	46.00	56.87	0.81	Warning
			Sep-98	50.00	61.24	0.82	Warning
		H-3	Mar-98	218.30	180.36	1.21	
			Sep-98	76.20	57.31	1.33	Warning
		Mn-54	Mar-98	57.00	65.86	0.87	
			Sep-98	32.40	39.18	0.83	Warning
		Sr-90	Mar-98	4.36	4.78	0.91	
			Sep-98	2.11	7.07	0.30	Not Acceptable

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides EML evaluation of analytical performance which is based on control limits established from percentiles of historic data distributions. No comment indicates performance within acceptable limits.
c. Data transcription error in reported data; measured value is reported.

Maranelli counting geometry, whereas the ASL uses 300-mL geometry to perform its measurements. The ASL will be switching over to the 4-liter Maranelli configuration for PE testing in 1999.

The NERL-LV comparisons, shown in Table 10-10, resulted in excellent agreement for 22 of the 25 analyses (within one standard deviation of the known value); three results for gross alpha/beta (12 percent) were not acceptable. Overall, the ASL performance in the NERL intercomparison study was acceptable in 88 percent of the water analyses. A faulty instrument power pack was suspected to be the cause of the elevated gross alpha/beta results. The power pack in one of the two ASL alpha/beta detectors has since been replaced.

The radiological results from the ELAP

Table 10-10. BNL Quality Assessment Program Results
National Exposure Research Laboratory (NERL-LV)

Matrix	Units	Isotope	Date	NERL	BNL	Ratio (a)	Comments (b)
Water	Bq/L	Alpha	Nov-98	1746.40	1073.00	0.61	
			Jul-98	266.40	603.00	2.26	Not Acceptable
			Apr-98	2012.80	4192.00	2.08	Not Acceptable
			Jan-98	1128.50	681.00	0.60	
		Beta	Nov-98	129.50	296.00	2.29	Not Acceptable
			Jul-98	473.60	663.50	1.40	
			Apr-98	3503.90	2268.00	0.65	
			Jan-98	144.30	252.00	1.75	
		H-3	Mar-98	79735.00	74000.00	0.93	
			Aug-98	665852.00	584600.00	0.88	
		Sr-90	Jan-98	1184.00	984.20	0.83	
			Jul-98	259.00	203.50	0.79	
		Co-60	Jun-98	444.00	445.00	1.00	
			Apr-98	1850.00	1808.00	0.98	
			Nov-98	1406.00	1516.00	1.08	
		Cs-134	Jun-98	1147.00	1054.00	0.92	
			Apr-98	814.00	769.00	0.94	
			Nov-98	3885.00	4020.00	1.03	
		Cs-137	Jun-98	1295.00	1383.00	1.07	
			Apr-98	370.00	372.00	1.01	
			Nov-98	4107.00	5044.00	1.23	
		Ba-133	Jun-98	1480.00	1417.00	0.96	
			Nov-98	2072.00	2238.50	1.08	
		Zn-65	Jun-98	3848.00	4365.00	1.13	
			Nov-98	4847.00	5673.00	1.17	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides NERL evaluation of analytical performance which is based on 2 and 3 normalized standard deviations about the known value. Results outside these control limits are deemed not acceptable or a statistical outlier. No comment indicates performance within acceptable limits.

proficiency test for gross alpha and beta showed acceptable agreement for five of six analyses performed. The overall score in Table 10-11 corresponds to 83 percent. As a result of a transcription error on the data pair submitted in April 1998, the ASL temporarily lost gross beta certification only, for potable water analyses for a six-month period. During that time, compliance samples requiring gross alpha and beta analyses were sent to an offsite contractor laboratory. Certification for gross beta was re-instated in November 1998 after compliance was demonstrated to ELAP.

Table 10-11. BNL Potable Water Radiochemistry Proficiency Test #187, #197 Results
Environmental Laboratory Approval Program

Analyte	Date (Bq/L)	ELAP (Bq/L)	BNL	Ratio (a)	Comment (b)
Alpha	Apr-98	666.00	599.40	0.90	
	Apr-98	2701.00	2608.50	0.97	
	Oct-98	1998.00	1594.70	0.80	
Beta	Apr-98	592.00	577.20	0.98	(c)
	Apr-98	2442.00	2486.40	1.02	
	Oct-98	1776.00	1776.00	1.00	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides ELAP evaluation of analytical performance which is based on 95 and 99% confidence interval about the target value. No comment indicates performance within acceptable limits.
c. Transcription error on original data submission for beta only. Corrected data are presented.

10.7.2 NONRADIOLOGICAL ASSESSMENTS

The ASL also participated in the EPA Environmental Monitoring Systems Laboratory (EMSL-CI) WP and WS performance evaluation studies. Tables 10-12 and 10-13

Table 10-12. BNL Water Pollution Performance Evaluation Studies - WP040
USEPA Environmental Monitoring Systems Laboratory - Cincinnati

Analyte	Units	Date	EMSL-CI	BNL	Ratio (a)	Comments (b)
Chloroform	µg/l	Nov-98	18.40	18.05	0.98	
1,1,1 Trichloroethane	µg/l	Nov-98	32.80	35.08	1.07	
Trichloroethene	µg/l	Nov-98	23.40	23.19	0.99	
Tetrachloroethene	µg/l	Nov-98	32.50	31.17	0.96	
Benzene	µg/l	Nov-98	25.70	30.44	1.18	
Ethylbenzene	µg/l	Nov-98	42.60	39.20	0.92	
Toluene	µg/l	Nov-98	32.30	31.45	0.97	
Methyl Chloride	µg/l	Nov-98	44.10	45.79	1.04	
1,2-Dichlorobenzene	µg/l	Nov-98	36.30	32.81	0.90	
1,3-Dichlorobenzene	µg/l	Nov-98	33.70	29.18	0.87	
1,4-Dichlorobenzene	µg/l	Nov-98	41.60	38.63	0.93	
1,2-Dichloroethane	µg/l	Nov-98	14.60	14.20	0.97	
Bromodichloromethane	µg/l	Nov-98	16.50	14.90	0.90	
Dibromochloromethane	µg/l	Nov-98	32.70	29.15	0.89	
Chlorobenzene	µg/l	Nov-98	24.70	24.09	0.98	
Bromoform	µg/l	Nov-98	14.70	10.58	0.72	
Carbon Tetrachloride	µg/l	Nov-98	26.30	26.99	1.03	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides EMSL-CI evaluation of analytical performance which is based on 95 and 99% prediction interval calculated from samples analyzed by EPA and State Laboratories. No comment indicates performance within acceptable limits. Samples from WP040 were not reported in time to meet reporting deadline.

Table 10-13. BNL Water Supply Performance Evaluation Studies -
WS040/041 USEPA Environmental Monitoring Systems Laboratory - Cincinnati

Analyte	Units	Date	EMSL-CI	BNL	Ratio (a)	Comments (b)
Cd	µg/l	Mar-98	6.31	6.30	1.00	
	µg/l	Sep-98	18.20	17.30	0.95	
Cr	µg/l	Mar-98	90.90	93.30	1.03	
	µg/l	Sep-98	55.50	60.50	1.09	
Cu	µg/l	Mar-98	1700.00	1752.00	1.03	
	µg/l	Sep-98	702.00	695.00	0.99	
Hg	µg/l	Mar-98	1.50	1.47	0.98	
	µg/l	Sep-98	5.82	5.05	0.87	
Mn	µg/l	Sep-98	183.00	177.00	0.97	
Na	mg/l	Sep-98	23.30	23.20	1.00	
Zn	µg/l	Mar-98	1700.00	1760.00	1.04	
	µg/l	Sep-98	402.00	404.00	1.00	
Pb	µg/l	Mar-98	71.00	72.50	1.02	
NO3 - N	mg/l	Sep-98	15.00	1.51	0.10	Not Acceptable
SO4	mg/l	Sep-98	49.00	49.00	1.00	
Turbidity		Sep-98	2.60	2.40	0.92	
Chloroform	µg/l	Sep-98	14.40	15.70	1.09	
DCE	µg/l	Sep-98	5.25	6.80	1.30	
TCA	µg/l	Sep-98	12.60	12.20	0.97	
TCE	µg/l	Sep-98	6.87	6.99	1.02	
Benzene	µg/l	Sep-98	18.7	17.70	0.95	
PCE	µg/l	Sep-98	11.50	10.70	0.93	
Toluene	µg/l	Sep-98	18.70	17.60	0.94	
Ethylbenzene	µg/l	Sep-98	14.70	13.40	0.91	
Total Xylenes	µg/l	Sep-98	30.80	31.60	1.03	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides EMSL-CI evaluation of analytical performance which is based on 40CFR141 analyte-specific acceptance limits.
No comment indicates performance within acceptable limits.

respectively, give the results of these nonradiological studies. Overall, the ASL performance in the EPA WP intercomparison study (WP040), shown in Table 10-12 was acceptable in 100 percent of the 17 analyses performed.

Table 10-13 shows the results from using the EPA EMSL-CI WS samples. Twenty-four of 25 PE samples (96 percent) were acceptable. An investigation into the unacceptable September 1998 results for nitrate was attributable to technician error in preparing the samples.

Tables 10-14 and 10-15 present the results of organic and inorganic proficiency samples analyzed for the NYSDOH's ELAP. The results in Table 10-14 (for organics) show that 76 percent of proficiency samples analyzed in January and July 1998 were within acceptable or warning limits. The remaining five results (in January of 1998, only) were slightly greater than 30 percent of the known value and were not acceptable. The five results that were not acceptable in January 1998 were due to instrument failure of the purge and trap system during the second batch of samples analyzed in January 1998. The first set of the pair was not affected. The instrument has since been repaired. No environmental monitoring data were affected by this instrument failure.

The inorganic NYSDOH ELAP test results, shown in Table 10-15, were acceptable or within warning limits for 100 percent of the 39 analyses performed. This is an improvement from the 1996 and 1997 ELAP results. During the last quarter of 1996, the ASL nonradiological laboratory had relocated

Table 10-14. BNL Non-Potable Water Chemistry Proficiency Test #183 and #193 Results Environmental Laboratory Approval Program

Analyte	Date	ELAP (µg/L)	BNL (µg/L)	Ratio (a)	Comment (b)
1,1-Dichloroethane	Jan-98	24.60	28.80	1.17	
	Jan-98	48.50	61.30	1.26	Warning
	Jul-98	15.70	16.70	1.06	
Tetrachloroethene	Jan-98	24.30	23.80	0.98	
	Jan-08	37.10	43.70	1.18	
	Jul-98	24.60	23.60	0.96	
Trichloroethene	Jan-98	28.80	33.00	1.15	
	Jan-98	45.00	57.30	1.27	(c), Not Acceptable
	Jul-98	22.10	22.10	1.00	
Benzene	Jan-98	20.10	24.50	1.22	Warning
	Jan-98	45.10	59.40	1.32	(c), Not Acceptable
	Jul-98	37.10	34.80	0.94	
Ethyl benzene	Jan-98	31.90	35.70	1.12	
	Jan-98	44.20	55.40	1.25	(c), Not Acceptable
	Jul-98	25.60	24.90	0.97	
Toluene	Jan-98	27.60	32.60	1.18	
	Jan-98	40.30	54.30	1.35	(c), Not Acceptable
	Jul-98	18.50	18.10	0.98	
Total Xylenes	Jan-98	20.30	25.00	1.23	Warning
	Jan-98	36.50	51.00	1.40	(c), Not Acceptable
	Jul-98	27.20	27.00	0.99	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides ELAP evaluation of analytical performance which is based on 95 and 99% confidence interval about the target value. No comment indicates performance within acceptable limits.
c. Not acceptable because purge and trap system required repair/replacement after completion of first set of analyses in Jan.

Table 10-15. BNL Potable Water Chemistry Proficiency Test #187 and #197 Results
Environmental Laboratory Approval Program

Analyte	Date	ELAP (µg/L)	BNL (µg/L)	Ratio (a)	Comment (b)
Cadmium	Apr-98	5.00	4.80	0.96	
	Apr-98	12.50	11.20	0.90	
	Oct-98	16.70	16.90	1.01	
Chloride	Apr-98	22.70	23.80	1.05	
	Apr-98	142.00	146.00	1.03	
	Oct-98	129.00	133.50	1.03	
Chromium	Apr-98	37.50	39.10	1.04	
	Apr-98	62.50	62.20	1.00	
	Oct-98	100.00	103.50	1.04	
Copper	Apr-98	50.00	51.00	1.02	
	Apr-98	75.00	73.00	0.97	
	Oct-98	1330.00	1242.00	0.93	
Iron	Apr-98	88.10	88.00	1.00	
	Apr-98	112.00	117.00	1.04	
	Oct-98	299.00	304.00	1.02	
Lead	Apr-98	25.00	27.10	1.08	
	Apr-98	50.00	53.60	1.07	
	Oct-98	83.30	83.60	1.00	
Manganese	Apr-98	61.80	63.00	1.02	
	Apr-98	92.10	93.00	1.01	
	Oct-98	334.00	326.00	0.98	
Mercury	Apr-98	1.10	1.08	0.98	
	Apr-98	4.69	4.37	0.93	
	Oct-98	6.00	4.97	0.83	
Nitrate (as N)	Apr-98	1.11	1.18	1.06	
	Apr-98	7.10	6.94	0.98	
	Oct-98	12.00	12.19	1.02	
Silver	Apr-98	18.70	18.90	1.01	
	Apr-98	49.20	48.00	0.98	
	Oct-98	25.20	29.00	1.15	Warning
Sodium	Apr-98	29.90	30.10	1.01	
	Apr-98	49.70	49.00	0.99	
	Oct-98	13.70	14.10	1.03	
Sulfate (as SO4)	Apr-98	52.00	53.90	1.04	
	Apr-98	203.00	207.00	1.02	
	Oct-98	99.40	99.60	1.00	
Zinc	Apr-98	63.30	66.00	1.04	
	Apr-98	100.00	99.00	0.99	
	Oct-98	1670.00	1650.00	0.99	

Notes:
a. The ratio is the reported Lab result divided by the target value result.
b. Comment column provides ELAP evaluation of analytical performance which is based on 95 and 99% confidence interval about the target value. No comment indicates performance within acceptable limits.

which resulted in repeated instrument problems that adversely affected performance evaluation results in 1997.

10.8 AUDITS AND SELF-ASSESSMENTS OF THE ASL

During 1998, there was an onsite audit of the ASL conducted by NYSDOH ELAP. Four recommendations for improvement were made, all of which were successfully completed before the end of 1998.

In addition, an appraisal of the ASL was conducted by an independent organization as part of the BNL Integrated Assessment Program. Corrective action plans for the findings and recommendations were developed and implementation is ongoing. On November 30 1998, a Self-Assessment Plan was prepared. This program was developed to foster continuous improvement in ASL's programs and activities, and provide timely, valid performance measurements to complement the Laboratory's Assessment Program.

10.9 UNUSUAL OCCURRENCES

During 1998, the ASL did not receive many EPA PE samples in time to meet reporting deadlines (see Tables 10-12 and 10-13). However, the analyses were performed and reported in the tables. One of the ASL Quality Assurance Officer's new functions is to track shipping and receipt of all PE testing samples so that timelines for data reporting are met.

Effective December 21 1998, the EPA's NERL and EMSL Performance Evaluation Programs, for both radiological and nonradiological analytes, was terminated. A replacement for the EPA Programs is presently being sought.

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APPENDIX A

Acronyms

AGS	Alternating Gradient Synchrotron
AMSL	Above Mean Sea Level
AOC	Area of Concern
ASL	Analytical Services Laboratory
AS/SVE	Air Sparging/Soil Vapor Extraction
AUI	Associated Universities, Inc.
BETX	Benzene, Ethyl benzene, Toluene, and Xylene
BF	4-bromofluorobenzene
BGRR	Brookhaven Graphite Research Reactor
BHG	Brookhaven Group
BLIP	Brookhaven Linac Isotope Producer
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
BOD	Biological Oxygen Demand
CAA	Clean Air Act
CAP	CAA Assessment Package
CEM	Continuous Emissions Monitoring
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
CH	Chicago
CLP	Contract Laboratory Protocol
CO	Certificates to Operate
CSF	Central Steam Facility
CWA	Clean Water Act
D_2O	Heavy Water
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DDD	Dichlorodiphenyldichloroethane
DDT	Dichlorodiphenyltrichloroethane
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	Department of Energy
DOH	Department Of Health
DQO	Data Quality Objective
DWS	Drinking Water Standards
ECR	Environmental Compliance Representative
EDB	Ethylene Dibromide
EDE	Effective Dose Equivalent
EDTA	Ethylenediaminetetra Acid
ELAP	Environmental Laboratory Approval Program
EM	Environmental Monitoring
EML	Environment Measurements Laboratory
EMS	Environmental Management System
EMSL	Environmental Monitoring System Laboratory
ER	Environmental Restoration
EPA	Environmental Protection Agency
ES&H	Environment, Safety, and Health
FS	Feasibility Study
GEL	General Engineering Lab
HEPA	High Efficiency Particulate Air
HFBR	High Flux Beam Reactor
HTO	Tritiated Vapor Water
HWMA	Hazardous Waste Management Area
HWMF	Hazardous Waste Management Facility (Former)
IAG	Interagency Agreement
IAP	Integrated Assessment Program
ISO	International Standards Organization
LIE	Long Island Expressway
MACT	Maximum Available Control Technology
MDL	Minimum Detection Limit
MEI	Maximally Exposed Individual
MLD	Million Liters per Day
MGD	Million Gallons per Day
MOA	Memorandum of Agreement
MPF	Major Petroleum Facility
MRC	Medical Research Center
MTBE	Methyl tertiary butyl ether
MW	Mega Watt
NA	Not Analyzed
ND	Not Detected
NEPA	National Environmental Policy Act
NERL	National Environmental Radiation Laboratory
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute for Standards and Technology
NOx	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NR	Not Reported

NS	Not Sampled
NSLS	National Synchrotron Light Source
NYCRR	New York Code of Rules and Regulations
NYS	New York State
NYS AWQS	New York State Ambient Water Quality Standard
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYS DWS	New York State Drinking Water Standard
O&M	Operation and Maintenance
OU	Operable Unit
ORPS	Occurrence Reporting Processing System
P2	Pollution Prevention
PCB	Polychlorinated biphenyl's
PCE	Tetrachloroethylene (or perchloroethylene)
PC	Permit to Construct
PE	Plant Engineering
QA	Quality Assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QC	Quality Control
QM	Quality Management
R2A2's	Roles, Responsibilities, Accountability & Authorities
RA	Removal Action
RACT	Reasonable Available Control Technology
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RHIC	Relativistic Heavy Ion Collider
ROD	Record of Decision
RPD	Relative Percent Difference
SARA	Superfund Amendments and Reauthorization Act
SCDHS	Suffolk County Department of Health Services
SCWA	Suffolk County Water Authority
SDWA	Safe Drinking Water Act
SER	Site Environmental Report
SERC	State Emergency Response Committee
SOP	Standard Operating Procedures
SO_2	Sulfur Dioxide
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
STP	Sewage Treatment Plant
SU	Standard Unit
T½	Half life
TCA	1,1,1-trichloroethane
TCE	Trichloroethylene
TCLP	Toxic Characteristic Leachate Procedure
TLD	Thermoluminescent Dosimeter
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TVOC	Total Volatile Organic Compounds
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WCF	Waste Concentration Facility
WM	Waste Management
WMF	Waste Management Facility (New)
WP	Water Pollution
WQS	Water Quality Standard
WS	Water Supply
WSRRSA	Wild, Scenic, and Recreational River Systems Act
WTP	Water Treatment Plant

Glossary

This glossary reflects the typical manner in which terms are used for this specific document, and may not apply to all situations. For other radiological terms, see Chapter 4. For definitions and descriptions of the various environmental regulations, see Chapter 3.

A

Accuracy - The degree of agreement of a measurement with an accepted reference or true value. It is expressed as the difference between two values, as a percentage of the reference or true value, or as a ratio of the measured value and the reference or true value.

Activation - The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.

Activation products - Radionuclides produced through bombardment with neutrons, protons, or other nuclear particles.

Aerosol - A gaseous suspension of very small particles of liquid or solid.

Air Sparging - A method of extracting volatile organic compounds from the groundwater in situ (i.e., in place) using compressed air. The vapors are typically collected using a soil vapor extraction system.

Air Stripping - A process whereby volatile organic chemicals are removed from contaminated water by forcing a stream of air through the water in a vessel. The contaminants are evaporated into the air stream. The air may be further treated before it is released into the atmosphere.

ALARA - As Low As Reasonably Achievable, a phrase which describes the approach to environmental protection to control or manage exposures to individuals and releases of radioactive or other harmful material to the environment as low as social, technical, economic, practical, and public policy considerations will permit. ALARA is not a dose limit, but a process that has as its goal the attainment of dose levels as far below applicable limits as is practicable.

Alpha Radiation - An alpha particle is identical in make-up to the nucleus of a helium atom. Alpha particles have a positive charge, and have little or no penetrating power in matter. They are easily stopped by materials such as paper and have a range in air of only an inch or so. Naturally occurring radioactive elements such as radon emit alpha radiation.

Ambient air - The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.

Analyte - A constituent that is being analyzed.

Anthropogenic - man-made, as opposed to naturally occurring.

Anion - A negatively charged ion, for example Cl-.

Aquifer - A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

Area of Concern (AOC) - An area where releases of hazardous substances may have occurred or a location where there has been a release or threat of a release into the environment of a hazardous substance, pollutant, or contaminant (including radionuclides) under CERCLA. AOCs may include, but need not be limited to, former spill areas, landfills, surface impoundments, waste piles, land treatment units, transfer stations, wastewater treatment units, incinerators, container storage areas, scrapyards ("boneyards"), cesspools, and tanks and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

Atomic absorption (AA) - A method used to determine the elemental spectroscopy composition of a sample. In this method, the sample is vaporized and its light absorbance measured.

B

Beta Radiation - Beta radiation is composed of particles which are identical to electrons. Beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha, but may be stopped by materials such as aluminum foil. They have a range in area of a few inches. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

Blank - A control sample that is identical to the sample of interest, except that the analyte of interest is absent.

Blowdown - Water discharged from either a boiler or cooling tower in order to prevent the build-up of inorganic matter within the boiler or tower and to prevent scale formation (i.e., corrosion).

Biochemical (biological) Oxygen Demand (BOD) - A measure of the amount of oxygen in biological processes that breaks down organic matter in water;

a measure of the organic pollutant load. It is used as an indicator of water quality.

C

Cap - A layer of material, such as clay or a synthetic material, used to prevent rainwater from penetrating and spreading contaminated materials. The surface of the cap is generally mounded or sloped so water will drain off.

Carbon Adsorption/Carbon Treatment - A treatment system in which contaminants are removed from groundwater, surface water, and air by forcing water or air through tanks containing activated carbon (a specially treated material that attracts and holds or retains contaminants).

Chain-of-Custody (COC) - A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

Characterization - Facility or site sampling, monitoring and analysis activities to determine the extent and nature of contamination. Characterization provides the basis of necessary technical information to select an appropriate cleanup alternative.

Class GA groundwater - NYSDEC classification for high quality groundwater, where the best intended use is as a source of potable water.

Closure - Under the RCRA regulations, this term refers to a hazardous or solid waste management unit that is no longer operating, where potential hazards that it posed have been addressed (either through clean up, immobilization, capping, etc.) to the satisfaction of the regulatory agency.

Code of Federal Regulations (CFR) - A codification of all regulations developed and finalized by federal agencies in the Federal Register.

Collective Effective Dose Equivalent - A measure of health risk to a population exposed to radiation. It is the sum of the effective dose equivalents of all individuals within an exposed population, frequently considered to be within 80 km of an environmental release point. It is expressed in person-rem or person-sievert.

Committed Effective Dose Equivalent - The total effective dose equivalent received over a 50 year period following the internal deposition of a radionuclide, expressed in rem (or sieverts).

Composite Sample - A sample of an environmental media that contains a certain number of portions collected over a period of time. The samples may be collected from the same location or different locations. They may or may not be collected at equal time intervals over a pre-defined period of time (e.g., 24 hours).

Confidence Interval - A numerical range within which the true value of a measurement or calculated value lies. In this report, radiological values are shown with a 95% confidence interval, i.e., there is a 95% probability that the true value of a measurement or calculated value lies within the specified range.

Contamination - Unwanted radioactive and/or hazardous material that is disbursed on or in equipment, structures, objects, soil, or water.

Controlled Area - Any area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

Cooling Water - Water that is used to cool machinery and equipment. Contact cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal. Non-contact cooling water is water used for cooling purposes but has no direct contact with any process material or final product. Process wastewater cooling water is water used for cooling purposes that may have become contaminated through contact with process raw materials or final products.

D

Decontamination - The removal or reduction of radioactive or hazardous contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques to achieve a stated objective or end condition.

Derived Concentration Guide (DCG) - The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year would result in an effective dose equivalent of 100 mrem (1 mSv).

Disposal - Final placement or destruction of waste.

Dosimeter - A portable detection device for measuring the total accumulated exposure to ionizing radiation.

Downgradient - In the direction of groundwater flow from a designated area; analogous to downstream.

E

Effective Dose Equivalent (EDE) - A value used to express the health risk from radiation exposure to a tissue or tissues in terms of an equivalent whole-body exposure. It includes the sum of the effective dose equivalent due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of radionuclides. EDE is expressed in units of rem (or sieverts).

Effluent - Any liquid discharged to the environment, including stormwater runoff at a site or facility.

Emission - Any gaseous discharge to the atmosphere.

Environment - Surroundings in which an organization operates, including air, water, land, natural

a measure of the organic pollutant load. It is used as an indicator of water quality.

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Effluent - Any liquid discharged to the environment, including stormwater runoff at a site or facility.

Emission - Any gaseous discharge to the atmosphere.

Environment - Surroundings in which an organization operates, including air, water, land, natural

resources, flora, fauna, humans and their interrelation.

Environmental Assessment (EA) - A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA identifies a "significant" impact (as defined by NEPA), an Environmental Impact Statement is required.

Environmental Media - Includes air, groundwater, surface water, soil, flora and fauna.

Environmental Impact Statement (EIS) - A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.

Environmental Surveillance - Sampling for contaminants in air, water, sediments, soils, food stuffs, plants and animals, either by directly measuring or by collecting and analyzing samples.

Environmental Protection Agency (EPA) - The federal agency responsible for developing and enforcing environmental laws. Although state regulatory agencies may be authorized to administer environmental regulatory programs, EPA retains oversight authority.

Ethylene Dibromide (EDB) - A colorless, nonflammable, heavy liquid with a sweetish odor; slightly soluble in water, soluble in ethanol, ether, and most organic solvents. It was used as an additive in leaded gasoline, as a soil and grain fumigant, and in waterproofing preparations. It is still used to treat felled logs for bark beetles; to control wax moths in beehives; as a chemical intermediary for dyes, resins, waxes, and gums; to spot treat milling machinery, and to control Japanese beetles in ornamental plants. The federal Department of Health and Human Services has determined that ethylene dibromide may reasonably be anticipated to be a carcinogen.

Evapotranspiration - A process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other above ground tissue.

F

Feasibility Study (FS) - A process for developing and evaluating remedial actions, using data gathered during the remedial investigation to define the objectives of the remedial program for the site and broadly develop remedial action alternatives, perform an initial screening of these alternatives, and perform a detailed analysis of a limited number of alternatives that remain after the initial screening stage.

G

Gamma Radiation - Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete. X-rays are essentially a form of gamma radiation.

Gamma Spectroscopy - This analysis technique identifies specific radionuclides. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each nuclide, acting as a 'fingerprint' to identify a specific nuclide.

Grab Sample - A single sample, collected at one time and place.

Groundwater - Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.

H

Half-life - The time required for one half of the atoms of any given amount of a radioactive substance to disintegrate.

Hazardous Waste - Toxic, corrosive, reactive, or ignitable materials that can negatively affect human health or damage the environment. They can be liquid, solid, or sludge, and include heavy metals, organic solvents, reactive compounds, and corrosive materials. They are defined and regulated by the Resource Conservation and Recovery Act (RCRA). (See Resource Conservation and Recovery Act [RCRA]).

Hydrology - The science dealing with the properties, distribution, and circulation of natural water systems.

I

Inert - Lacking chemical or biological action.

Influent - Liquid (e.g., wastewater) flowing into a reservoir, basin, or treatment plant.

Isotope - Two or more forms of a chemical element, having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties.

Intermittent River - A stream that dries up on occasion. Seasonal factors frequently are the cause.

L

Leach/Leaching - The process by which soluble chemical components are dissolved and carried through soil by water or some other percolating liquid.

Liquid Scintillation Counter - An analytical instrument used to quantify tritium, carbon-14 and other beta-emitting radionuclides.

M

Maximally Exposed Individual (MEI) - The individual whose location and habits tend to maximize his/her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

Minimum Detection Limit (MDL) - The lowest level to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDL are sometimes measurable, they represent values which have a reduced statistical confidence associated with them (less than 95% confidence).

Mean Sea Level (MSL) - The average height of the sea for all stages of the tide. Used as a benchmark for establishing groundwater elevations.

Mixed waste - Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component.

Monitoring - The collection and analysis of samples or measurements of effluents and emissions for the purpose of characterizing and quantifying contaminants, and demonstrating compliance with applicable standards.

Monitoring Well - A well that collects groundwater for the purposes of evaluating water quality, establishing groundwater flow and elevation, determining the effectiveness of treatment systems and determining whether administrative or engineered controls designed to protect groundwater are working as intended.

O

Onsite - The area within the boundaries of a site that is controlled with respect to access by the general public.

Opacity - Under the Clean Air Act, a measurement of the degree to which emissions (e.g., smoke) reduce the transmission of light and obscure the view of an object in the background.

Operable Unit (OU) - Division of a contaminated site into separate areas based on the complexity of the problems associated with it. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action. They may also consist of any set of actions performed over time or any actions that are concurrent, but located in different parts of a site. An operable unit can receive specific investigation, and a particular remedy may be proposed. A Record of Decision (ROD) is prepared for each operable unit. (See Record of Decision.)

Outfall - The place where wastewater is discharged.

Ozone - A form of oxygen formed naturally in the upper atmosphere and providing a shield for the Earth from the sun's ultraviolet rays.

P

Permit - An authorization issued by a federal, state or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including RCRA, CAA, CWA, and TSCA, and they grant permission-e.g., permission to operate, to discharge, to construct, etc. Permit provisions may include emission/effluent limits and other requirements such as the use of pollution control devices, and monitoring, recordkeeping and reporting. Called a "license" or "registration" under some regulatory programs.

pH - A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 6; basic solutions have a pH greater than 7 and up to 14; and neutral solutions have a pH of 7.

Plume - A body of contaminated groundwater flowing from a specific source. The movement of the groundwater is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants.

Polychlorinated biphenyls (PCBs) - A family of organic compounds used from 1926 to 1979 (when they were banned by EPA) in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process.

Potable Water - Water of quality sufficient for use as drinking water without endangering the health of people, plants or animals.

Point source - Any confined and discrete conveyance (e.g., pipe, ditch, well, or stack) of a discharge.

Pollution - Levels of contamination that may be objectionable (perhaps due to a threat to health [see contamination]).

Pollution Prevention - The use of processes, practices, materials or products that avoid, reduce or control pollution. Processes may include recycling, process changes, control mechanisms, efficient use of resources and material substitution. The potential benefits of pollution prevention include the reduction of adverse environmental impacts, improved efficiency and reduced costs.

Precision - The dispersion around a central value, usually represented as a variance, standard deviation, standard error, or confidence interval.

Putrescible Waste - Garbage that contains food and other organic biodegradable materials. There are special management requirements for this waste in 6NYCRR Part 360.

Q

Quality Assurance (QA) - Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, such as, interlaboratory comparison studies, evaluations, and documentation.

Quality Control (QC) - The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

R

Radionuclide - A radioactive element characterized by the number of protons and neutrons in the nucleus. There are several hundred known radionuclides, both artificially produced and naturally occurring.

Recharge - The process by which water is added to a zone of saturation (aquifer) from surface infiltration. An area where rainwater soaks through the earth to reach an aquifer.

Recharge Basin - A basin (natural or artificial) that collects water. The water will infiltrate to the aquifer.

Record of Decision (ROD) - Documents the regulators' decision for the selected remedial action. The ROD also includes the responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the ROD is finalized, remedial design and implementation can begin.

Release - Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment. The National Contingency Plan also defines the term to include a threat of release.

Remedial (or Remediation) Alternatives - Options considered under the Comprehensive Environmental Compensation and Liability Act (CERCLA) for cleaning up contamination at a site, such as an Operable Unit (OU) or Area of Concern (AOC). Remedial actions are long-term activities that stop or substantially reduce releases or prevent possible releases of hazardous substances that are serious but not immediately life-threatening. See also Feasibility Study (FS) and Record of Decision (ROD).

Remedial Investigation (RI) - An investigation that includes extensive sampling and laboratory analyses to characterize the nature and extent of contamination, define the pathways of migration, and measure the degree of contamination in surface water, groundwater, soils, air, plants, and animals. Information gathered during the RI attempts to fully describe the contamination problem at the site so that the appropriate remedial action can be developed.

Removal Actions or Removals - Interim actions that are undertaken to prevent, minimize, or mitigate damage to the public health or environment that may otherwise result from a release or threatened release of hazardous substances, pollutants, or contaminants pursuant to CERCLA, and that are not inconsistent with the final remedial action. Under CERCLA or Superfund, the U.S. Environmental Protection Agency may respond to releases or threats of releases of hazardous substances by starting a removal action. The purpose of the removal action is to stabilize or clean up an incident or site that poses an immediate threat to public health or welfare. Removal actions differ from remedial actions. However, removal actions must contribute to the efficiency of future remedial actions.

Roughing Filter - A filter used to remove large particulate matter from a wastewater stream prior to treatment, via ion exchange, adsorption or another refined treatment technique.

Run-off - The movement of water over land. Run-off can carry pollutants from the land into surface waters or uncontaminated land.

S

Sampling - The extraction of a prescribed portion of an effluent stream or environmental media for purposes of inspection or analysis.

Sediment - The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers that may contain contaminants.

Sensitivity - The minimum amount of an analyte that can be repeatedly detected by an instrument.

Sludge - Semi-solid residue from industrial or water treatment processes.

Soil Vapor Extraction - An in-situ method of extracting volatile organic chemicals from soil. The chemicals are extracted by applying a vacuum to the soil and collecting the air, which can be further treated to remove the chemicals or discharged to the atmosphere.

Sole-Source Aquifer - An area defined by the U.S. Environmental Protection Agency where the only source of drinking water is groundwater.

Stakeholder - People or organizations with vested interests in BNL and its environment and operations.

State Pollution Discharge Elimination System (SPDES) - A permit issued by the state that regulates the discharge of wastewaters. This permit specifies the maximum discharge limits for the parameters present in the particular discharge.

Stripping - A process used to remove volatile contaminants from a substance (see also Air Stripping).

Sump - A pit or tank that catches liquid runoff for drainage or disposal.

T

Trichloroethylene or Trichloroethene (TCE) - A stable, colorless liquid with a low boiling point. TCE has many industrial applications, including use as a solvent and as a metal degreasing agent. TCE may be toxic to people when inhaled or ingested, or through skin contact, and can damage vital organs, especially the liver (see Volatile Organic Compounds).

TLD - Thermoluminescent dosimeter, a device used to measure integrated external penetrating radiation exposure.

U

Upgradient/Upslope - A location of higher groundwater elevation.

Underground Storage Tank (UST) - A stationary device, constructed primarily of non-earthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.

V

Vernal Pool - a small, isolated contained basin that holds water on a temporary basis, most commonly during winter and spring. It has no aboveground outlet for waster, and is extremely important to the life cycle of many amphibians (such as the spotted salamander), as it is too shallow to support fish, a major predator of amphibian larvae.

Volatile Organic Compounds (VOCs) - Secondary petrochemicals, including light alcohols, acetone, trichlorethylene, perchloroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride. These potentially toxic chemicals are used as solvents, degreasers, paints, thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential exposure to humans. Due to their low water solubility, environmental persistence, and widespread industrial use, they are commonly found in soil and groundwater

W

Waste Minimization - Associated with pollution prevention, but more likely to occur after the waste has already been generated (at the "end-of-the-pipe"). Includes techniques such as volume reduction (compaction, evaporation) and treatment to remove contaminants.

Water table - The water-level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.

Watershed - The region draining into a river, a river system, or a body of water.

Weighting factor - A factor which, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body.

Wind rose - A diagram that shows the frequency of wind from different directions at a specific location.

APPENDIX B

Radiological Data Methodologies

1. DOSE CALCULATION - ATMOSPHERIC RELEASE PATHWAY

Dispersion of airborne radioactive material was calculated for each of the 16 compass sectors using the CAP88-PC dose model. Site meteorology data from 1998 were used to calculate annual dispersions for the midpoint of a given sector and distance. Facility-specific radionuclide release rates (in Ci per year) were also used. All annual site boundary and collective dose values were generated using the CAP88-PC computer code, which calculates the total dose due to contributions from the immersion, inhalation and ingestion pathways.

2. DOSE CALCULATION - FISH INGESTION PATHWAY

To estimate the effective-dose equivalent from the fish consumption pathway, the following procedure was used:

a. Radionuclide data for fish samples were all converted to pCi/g wet weight; this is the form in which the fish is caught and consumed.
b. The average fish consumption for an individual engaged in recreational fishing in the Peconic River was based on a study done by the NYSDEC which suggests that the consumption rate is approximately 7 kg/yr.
c. DOE Order 5400.5 50-year Committed Dose Equivalent factors (in rem per µCi intake) based on the ICRP 26 model were applied. The factor for cesium-137 is 5.0E-02 rem/µCi
d. Calculation: Intake (7 kg/yr) x Activity in flesh (µCi/kg) x Dose Factor (rem/µCi)= rem

3. DOSE CALCULATION - DEER MEAT CONSUMPTION

This calculation is performed in exactly the same way as shown in the previous section. The same DOE Order 5400.5 dose conversion factors are used. The only change is the estimate of total kilograms ingested in the course of a year. For deer meat, the consumption rate of 29 kg/yr is based on the USEPA Exposure Factors Handbook (see References section of Chapter 9).

4. RADIOLOGICAL DATA PROCESSING

Radiation events occur in a random fashion such that if a radioactive sample is counted multiple times a distribution of results will be obtained. This spread, known as a *poisson* distribution, will be centered about a mean value. If counted multiple times, the background activity of the instrument (the number of radiation events observed when no sample is present) will also be seen to have a distribution of values centered about a mean. The goal of a radiological analysis is to determine whether the sample in question contains activity in excess of the instrument or method blank background. Since the activity of the sample and the background are both *poisson* distributed, subtraction of background activity from the measured sample activity results in a value which may vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) is established to determine the statistical likelihood that the sample contains activity that is truly greater than the instrument background.

Identifying a sample as containing activity greater than background when it actually is not is known as a Type I error. As with most laboratories, the BNL Analytical Laboratory sets its acceptance of a Type I error at 5% when calculating the minimum detection limit for a given analysis. That is, for any value which is greater than or equal to the MDL there is 95% confidence that it represents the detection of true activity. Values, which are less than the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all data is reported regardless of its value.

At very low sample activity levels, close to the instrument background, it is possible to obtain a sample result, which is less than the background. When the background activity is subtracted from the sample activity to obtain a net value, a negative value results. In such a situation, a single radiation event observed during a counting period could have a significant effect on the result. Subsequent analysis may produce a net result that is positive. Therefore, all negative values are retained for

reporting as well. This data handling practice is consistent with the guidance provided in NCRP Report No. 58, *Handbook of Radioactivity Measurements Procedures and DOE/EH-0173T, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. Typical MDLs for the various analyses performed on environmental and effluent samples are shown in Tables B-1, B-2 and B-3.

Average values were calculated using actual analysis results, regardless of whether they were above or below the minimum detection limit or even equal to zero. The uncertainty of the mean, or the 95% confidence interval, was determined by multiplying the population standard deviation of the mean by the $t_{(0.05)}$ statistic.

Table B-1. Typical Detection Limits for Gross Activity and Tritium Analyses

Analysis	Matrix	Aliquot (mL)	MDL (pCi/L)
Gross alpha	water	100	4
		500	1
Gross beta	water	100	7
		500	3
Tritium	water	1	3,900
		7	380

Table B-2. Typical Minimum Detection Limits for Gamma Spectroscopy Analysis

Nuclide	300 g, soil (µCi/g)	300 ml, water (µCi/ml)	12000 ml, water (µCi/ml)	3L, Maranelli (µCi/ml)
Be-7	7E-8	1E-7	2E-9	1E-8
Na-22	9E-9	1E-8	2E-10	1E-9
K-40	2E-7	2E-7	4E-9	2E-8
Sc-48	1E-8	1E-8	2E-10	3E-8
Cr-51	8E-8	1E-7	2E-9	1E-8
Mn-54	8E-9	1E-8	2E-10	1E-9
Mn-56	2E-7	3E-7	5E-9	2E-8
Co-57	7E-9	9E-9	1E-10	1E-9
Co-60	1E-8	1E-8	2E-10	1E-9
Zn-65	2E-8	2E-8	5E-10	2E-9
Cs-134	1E-8	1E-8	2E-10	1E-9
Cs-137	9E-9	1E-8	2E-10	1E-9
Ra-226	3E-8	3E-8	5E-10	4E-8
Th-228	2E-8	3E-8	4E-10	1E-7
Br-82	1E-8	2E-8	3E-10	8E-8
I-131	9E-9	1E-8	2E-10	3E-9
I-133	1E-8	2E-8	3E-10	3E-9

Note:
All MDLs shown above are approximate. For gamma spectroscopy, the MDL of the analysis is dependent upon several variables, such as the efficiency of the particular detector, the activity of the sample, etc. These factors will vary between analyses and instrumentation.

Table B-3. Typical Detection Limits for Chemical Analyses.

Constituent*	BNL	Offsite
Ag	0.025	0.010
Cd	0.0005	0.005
Cr	0.005	0.010
Cu	0.050	0.025
Fe	0.075	0.100
Hg	0.0002	0.0002
Mn	0.050	0.015
Na	1.0	5.0
Pb	0.005	0.003
Zn	0.02	0.020
Ammonia-N	NA	0.02
Nitrite-N	NA	0.01
Nitrate-N	1.0	NA
Specific Conductance	10 • µmhos/cm	NA
Chlorides	4.0	NA
Sulfates	4.0	NA
1,1,1-trichloroethane	0.002	0.005
trichloroethylene	0.002	0.005
tetrachloroethylene	0.002	0.005
chloroform	0.002	0.005
chlorodibromomethane	0.002	0.005
bromodichloromethane	0.002	0.005
bromoform	0.002	0.005
benzene	0.002	0.005
toluene	0.002	0.005
xylene	0.002	0.005

Note:
* All concentrations in mg/L except where noted.

APPENDIX C

Instrumentation and Analytical Methods

The Analytical Services Laboratory (ASL) is divided into 1) radiological, and 2) nonradiological sections to facilitate analysis of specific parameters in each category. The following analytes are analyzed in each section.

Radiological: Gross alpha, gross beta, gamma, tritium, and strontium-90.

Non-radiological: purgeable aromatics, purgeable halocarbons, PCBs, anions, and metals.

The methods and instrumentation for each category are briefly described below. Only validated and regulatory referenced methods were used during the analysis. All samples were collected and preserved by trained technicians according to appropriate referenced methods. Well-qualified, and trained analysts performed different analyses. The ASL is certified by NYSDOH for the radiological and nonradiological parameters (except for PCBs) performed. The radiological laboratory participates in the following:

Gross Alpha and Gross Beta Analysis - Water Matrix

Water samples are collected in one-liter polyethylene containers, and preserved at the time of collection by acidification to pH 2 using nitric acid. If the samples are effluent or surface stream samples from locations DA, EA, HM or HQ, or Building 535B daily process samples, then 100 ml are extracted for analysis. Groundwater samples are typically analyzed using a 100-ml aliquot. The aliquot is evaporated to near-dryness in a glass beaker, which is rinsed to remove the solids and the combined solids and rinsate are transferred to a 5-cm diameter stainless-steel planchet, which is then evaporated to dryness. The planchettes are placed in a drying oven at 105°C for a minimum of 2 hours; removed to a desiccator and allowed to cool; weighed and counted in a gas-flow proportional counter for 200 minutes. Samples are normally processed in batch mode. The first sample of each batch is a background, which is subtracted from the raw data before computing net activity concentration. System performance is checked daily with NIST-traceable standards: Americium-241 for alpha, and Strontium-90 for beta. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Gross Alpha and Gross Beta Analysis - Air Particulate Matrix

Air particulate samples are collected on 50-mm glass fiber filters at a nominal flow rate of 15 liters per minute. At the end of the collection, the filters are returned to the analytical laboratory for assay. Filters are counted twice in a gas flow proportional counter for 50 minutes. The first count occurs immediately upon receipt in the analytical laboratory, and is used to screen the samples for unusual levels of air particulate activity. The filters are then recounted approximately one week later. This delay permits the short-lived radon/thoron daughters to decay. The second analysis is used for environmental assessments. The first sample of each batch is a blank filter whose count rate is subtracted from the raw data before calculating net activity concentration. The system's performance is checked daily with National Institute for Standards and Technology (NIST) traceable standards: americium-241 for alpha, and strontium-90 for beta.

Tritium Analysis - Water Matrix

Water samples are collected in polyethylene containers. No preservatives are added before collecting the sample. Effluent and surface stream samples from locations DA, EA, HM, or HQ, or Building 535B daily- process samples as well as groundwater samples were analyzed using a 7-ml aliquot. Potable-water samples were distilled following the method outlined in EPA 1980, 906.0 and a 7-ml aliquot analyzed. Liquid scintillation cocktail then is added to the aliquot so that the final volume in the liquid-scintillation-counting vial is 7 ml of sample plus 10 ml of cocktail. Samples then are counted in a low-background liquid-scintillation counter for 50 minutes. Samples are normally processed in batch mode. The

first sample of each batch is a steam-distilled water background that is subtracted from the raw data before calculating the net activity concentration. The second sample in each batch is a NIST-traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, quenching, and efficiency of the sample matrix are factored into the final net concentrations for each sample. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Tritium Analysis - Air Matrix

Concentration of tritium in ambient and facility air is measured by drawing the air through a desiccant at a rate of approximately 200 cc/min. At the end of each collection period, typically one week, the desiccant is brought to the analytical laboratory for processing. It is heated in a glass manifold system. Effluent samples have dedicated glassware, as do environmental samples. The off-gas, containing moisture from the sampled air, is collected by a water-cooled glass condenser. A 7-ml aliquot of this water is then assayed for tritium content. Liquid scintillation cocktail is then added to the aliquot so that the final volume in the counting vial is 17-ml. Samples are then counted in a low-background liquid-scintillation counter for 50 minutes. Samples are normally processed in batch mode. The first sample of each batch is a steam- distilled water background that is subtracted from the raw data before computing net activity concentration. The second sample in each batch is a NIST-traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, water recovery, air sample volume, quenching and efficiency for the sample matrix are factored into the final net concentrations for each sample. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Strontium-90 Analysis

Strontium-90 analyses are currently performed on water, soil and aquatic biota samples. Ground water samples are processed in house using DOE Method RP500, which utilizes a crown ether to selectively separate strontium from the acidified sample matrix. The strontium is then eluted using dilute nitric acid. The resulting eluent is evaporated on a 2.5 cm stainless steel planchet and the sample counted in a gas-flow proportional counter. Samples are prepared in batches, including a standard and a method blank in each batch. Chemical recovery is determined for each sample by the recovery of strontium carbonate. NIST-traceable strontium-90 standards are used to calibrate and verify the performance of the counting instrument. Samples are counted twice to verify strontium-90 and yttrium-90 in growth.

Potable water samples as well as samples of solids are shipped to a contractor laboratory, which is certified to perform the EPA 1980, 905.0 method for strontium-90 in drinking water. This method employ's time-consuming and costly wet-chemistry techniques to isolate strontium from the sample. Samples are counted twice to verify strontium-90 and yttrium-90 in growth. Samples are typically processed in a batch. Backgrounds and system performance are verified with each batch. Chemical recoveries are determined by a combination of gravimetric and strontium-85 standard addition techniques.

Gamma Spectroscopy Analysis

Surface, potable, and groundwater surveillance samples are typically of 12 liters and are placed in polyethylene bottles without preservatives. Samples are then passed through a mixed-bed ion-exchange column at a rate of 20 cc/min. The column is then removed, the resin placed in a Teflon-lined aluminum can and counted on a calibrated gamma spectroscopy detector for 50,000 seconds. Where effluent is sampled in a flow-proportional manner, a 10-ml aliquot is passed through the mixed bed column on an as needed basis. Typically, the sizes for such samples approach 50 to 100 liters. Air-particulate filters and air-charcoal canisters are counted directly on the calibrated gamma spectroscopy detector for 10,000 seconds. Soil, vegetation, and aquatic biota are all processed following collection. Typically, a 50, 100, or 300-g aliquot is taken, placed in a Teflon-lined aluminum can and directly counted. For gamma spectroscopy analyses, overnight backgrounds are counted once per week, with

calibration check and background checked daily. Analytical results reflect net activity that has been corrected for background and efficiency for each counting geometry used.

Purgeable Aromatics and Purgeable Halocarbons

Water samples are collected in 40 ml glass vials with removable teflon-lined caps without any headspace, and preserved with 1:1 HCl to pH <2.0. Samples are stored at 4° C and analyzed within 14 days.

Ten purgeable compounds (benzene, toluene, ethyl benzene, total xylenes, chloroform, 1,1-dichloroethane, 1,1-dichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, and trichloroethylene) are analyzed under this category following EPA Method 624 protocols using GC/MS. These ten compounds were chosen as the target compounds since they are known or suspected to be present in the monitoring wells based on DOE's survey of the site in 1988 (USDOE, 1988) and a comprehensive analysis of 51 new monitoring wells installed in 1989 using EPA's Contract Laboratory Program (CLP) (EPA, 1987, 1988). There are currently two Hewlett-Packard GC/MS instruments. One instrument is exclusively used to analyze of purgeable compounds and the other for screening extractables and other extraneous compounds in non-routine samples. Since the groundwater under BNL is classified as a sole source aquifer under the Safe Drinking Water Act and Class GA groundwater by the NYSDEC, the detection limits reported for the compounds are close to NYS drinking water standards and the ambient water quality standard. Even though the QC generated for the purgeable analysis meets the EPA drinking water method 524.2 requirements, to facilitate certification from NYSDOH for limited number of analytes required by BNL, EPA method 624 is used under non-potable water category.

The method involves purging a 25-ml aliquot of the sample with ultra pure helium in a specially designed sparger using the Purge and Trap technique. Each sample is spiked with a known concentration of internal standards and surrogates before purging to facilitate identifying, quantifying and determining the extraction efficiency of analytes from the matrix. The purged analytes are trapped on to a specially designed trap and thermally desorbed on to the DB-624 megabore capillary-chromatographic column by back flushing the trap with helium. Individual compounds are separated with a temperature program of the GC and enter the mass spectrometer where they undergo fragmentation to give characteristic mass spectra. The unknown compounds are identified by comparing their mass spectra and retention times with reference compounds and quantitated by internal standard method. The quantitation data is supported by extensive QA/QC, such as tuning the mass spectrometer to meet bromofluorobenzene criteria, initial and continuing calibrations verifying daily response factors, method blanks, surrogate recoveries, duplicate analysis, matrix spike and matrix spike duplicate analysis, and reference standard analysis to verify the daily working standard.

PCB Analysis

Samples are collected in 50-100 ml glass containers with teflon-lined lid and stored at 4° C and analyzed within 30 days.

Transformer oil, mineral oil, hydraulic fluid, waste oil and spill wipe-samples are analyzed for PCBs using gas chromatography-electron capture detector (GC-ECD) method. This method is similar to EPA SW-846 method 8080 and is targeted to identify and quantify seven different mixtures of PCB congeners in the samples.

The method consists of diluting a known weight of the sample with isooctane and removing the interfering compounds with one or more aliquots of concentrated sulfuric acid till the acid layer is almost colorless. The entire oil matrix, along with other interfering polar compounds, are selectively removed from the sample, leaving the PCBs in isooctane solvent.

There are two GC-ECD instruments for analyzing PCBs. Each GC-ECD instrument is calibrated with different concentrations of each PCB mixture to establish linearity. The PCBs found in the samples are identified and quantitated by comparing the retention times and chromatographic patterns with the standards. Methods blanks, duplicates, spikes, and reference standards are run as part of QA/QC.

Anions

Chloride, nitrate-N, and sulfate are analyzed using Dionex Ion-chromatography (IC) with

ion suppression and conductivity detection technique.

Samples from monitoring wells are collected in 100-ml polyethylene bottles, cooled to 4° C, and analyzed within 28 days. For nitrate in drinking water analysis, samples are supposed to be analyzed within 48 hrs. However, even though holding times were exceeded for nitrate analysis of some non-potable monitoring well samples, the depletion of nitrate is expected to be negligible.

The anions are passed through an anion-exchange polymer column and eluted with carbonate/bicarbonate solution. Then the eluent passes through an ion-suppressing column where the background contribution from the eluent is suppressed, leaving the target anions to be detected by conductivity meter.

Initially, the IC system is calibrated with standards to define its working range. The target anions in the samples are identified and quantitated by comparing the retention times and areas with the standards. Method blanks, duplicates, replicates, spikes, and reference standards are routinely analyzed as part of QA/QC.

Metals

Samples are collected in 500-ml glass bottles and stabilized with ultra-pure nitric acid to a pH of < 2. The samples are analyzed within 6 months, except for mercury, which is analyzed within 26 days.

Cadmium, chromium, lead (furnace), copper, iron, manganese, silver, sodium, zinc (flame), and mercury (manual cold vapor) are analyzed with a Perkin-Elmer atomic absorption spectrometer. Using the flame technique, the sample containing the target element is nebulized and atomized in an oxy-acetylene flame. At the same time, a beam of light from a element-specific hollow cathode lamp corresponding to the absorption frequency of target element is passed through the flame. The atomized element absorbs the energy specific to that element from the cathode lamp and the intensity of absorption is proportional to the concentration of the element in the sample. Calibration curves establish the linearity of the system and samples are quantitated by comparing with standards.

Using the furnace technique, chemical interference is eliminated in two stages: first, by heating the sample at 105 - 110° C to remove moisture, and second, at 600 - 900° C to burn out any organic matrix. Final atomization is achieved by heating the furnace to 2400 - 2700° C. The rest of the technique is similar to the flame method, above. Using this furnace technique, sub-ppb detection limits are possible for water samples.

Using a cold-vapor technique for mercury, a 100-ml aliquot of the sample is digested with potassium permanganate/persulfate oxidizing solution at 95° C for 2 hours to oxidize any organically bound and/or monovalent mercury to mercury (II) ion state. Excess oxidizing agent is destroyed with hydroxylamine hydrochloride. The mercuric ion later is reduced to elemental mercury with excess stannous chloride, which is purged with helium into the absorption cell. The absorption is directly proportional to the concentration of mercury in the sample.

All these atomic absorption techniques involve initial calibrations to define the calibration range, continuing calibrations, method blanks, duplicates, replicates, matrix spikes, and reference standard analysis as a part of QA/QC.

APPENDIX D

Groundwater Monitoring Wells List

Operable Unit I Area

HWMF/Current Landfill (RA-V)

77-02* ERD	88-26 ERD	98-61 ERD	107-26 ERD	115-03 ERD	115-31 ERD	116-05 ERD
87-21* ERD	98-19 ERD	98-62 ERD	108-08 ERD	115-13 ERD	115-32 ERD	116-06 ERD
88-13* ERD	98-21 ERD	98-63 ERD	108-12 ERD	115-14 ERD	115-33 ERD	000-124 ERD
88-14* ERD	98-22 ERD	99-04 ERD	108-13 ERD	115-15 ERD	115-34 ERD	000-137 ERD
88-20* ERD	98-30 ERD	107-10 ERD	108-14 ERD	115-16 ERD	115-35 ERD	000-138 ERD
88-13 ERD	98-33 ERD	107-23 ERD	108-17 ERD	115-28 ERD	115-36 ERD	800-54 ERD
88-14 ERD	98-58 ERD	107-24 ERD	108-18 ERD	115-29 ERD	115-41 ERD	
88-20 ERD	98-59 ERD	107-25 ERD	108-30 ERD	115-30 ERD	115-42 ERD	

Total 54

Curent Landfill-Compliance

87-09* ERD	87-23 ERD	87-26 ERD	88-21 ERD	88-23 ERD	88-110 ERD
87-11 ERD	87-24 ERD	87-27 ERD	88-22 ERD	88-109 ERD	

Total 11

Former Landfill

86-42* ERD	87-22 ERD	97-64 ERD	97-277 ERD	106-02 ERD	106-30 ERD
86-72 ERD	97-17 ERD				

Total 8

Chem./Animal Holes

106-13 ERD	106-17 ERD	106-23 ERD	106-44 ERD	106-48 ERD	106-63 ERD
106-14 ERD	106-20 ERD	106-24 ERD	106-45 ERD	106-49 ERD	106-64 ERD
106-15 ERD	106-21 ERD	106-25 ERD	106-46 ERD	106-50 ERD	114-01 ERD
106-16 ERD	106-22 ERD	106-43 ERD	106-47 ERD	106-62 ERD	

Total 23

Operable Unit III Area

Waste Concentration Facility

65-06* ERD	65-03 ERD	65-05 ERD	65-18 ERD	65-19 ERD	65-20 ERD
65-02 ERD	65-04 ERD				

Total 8

AGS/Linac Areas

44-02* ESD	54-01 ESD	54-03 ESD	54-06 ESD	54-08 ESD	64-01 ESD	64-03 ESD
53-01* ESD	54-02 ESD	54-05 ESD	54-07 ESD	54-10 ESD	64-02 ESD	

Total 13

New Waste Management Facility

55-03 ESD	55-10 ESD	56-21 ESD	56-22 ESD	56-23 ESD	66-07 ESD	66-83 ESD

Total 7

BMRR

94-01 ESD	84-12 ESD	84-13 ESD

Total 3

* upgradient monitoring well

HFBR and Remed. System

HW-01 ESD	75-43 ERD	76-172 ERD	85-67 ERD	95-43 ERD	95-90 ERD	105-43 ERD
HW-02 ESD	75-44 ERD	76-173 ERD	85-68 ERD	95-44 ERD	95-91 ERD	105-44 ERD
65-01* ERD	75-45 ERD	76-174 ERD	85-69 ERD	95-45 ERD	95-92 ERD	113-08 ERD
65-3 7 ERD	75-46 ERD	76-175 ERD	85-70 ERD	95-46 ERD	95-93 ERD	113-09 ERD
65-38 ERD	73-47 ERD	76-177 ERD	85-71 ERD	95-47 ERD	96-55 ERD	113-11 ERD
65-39 ERD	75-48 ERD	77-10 ERD	85-72 ERD	95-48 ERD	104-10 ERD	
65-40 ERD	75-50 ERD	77-11 ERD	85-73 ERD	95-51 ERD	104-11 ERD	
65-41 ERD	75-85 ERD	85-01 ERD	85-74 ERD	95-52 ERD	104-25 ERD	
75-11 ERD	75-86 ERD	85-02 ERD	85-75 ERD	95-53 ERD	105-07 ERD	
75-12 ERD	75-87 ERD	85-39 ERD	85-76 ERD	95-54 ERD	105-22 ERD	
75-39 ERD	75-88 ERD	85-40 ERD	85-77 ERD	95-55 ERD	105-23 ERD	
75-40 ERD	75-89 ERD	85-41 ERD	85-78 ERD	95-87 ERD	105-24 ERD	
75-41 ERD	76-10 ERD	85-65 ERD	86-09 ERD	95-88 ERD	105-29 ERD	
75-4 2 ERD	76-171 ERD	85-66 ERD	95-42 ERD	95-89 ERD	105-42 ERD	

Total 89

Shotgun Range

46-01 ESD	56-04 ESD	56-05 ESD	56-06 ESD

Total 4

Water Treatment Plant Area

63-01 ESD	63-02 ESD	63-03 ESD	75-01 ESD	75-02 ESD

Total 5

BNL Gasoline Station

85-16 ESD	85-17 ESD

Total 2

BNL Motor Pool

102-01 ESD	102-05 ESD	102-06 ESD

Total 3

Central Sector

66-08 ERD	75-02 ERD	83-01 ERD	84-02 ERD	84-05 ERD	85-13 ERD
66-09 ERD	75-09 ERD	83-02 ERD	84-03 ERD	84-06 ERD	95-01 ERD
75-01 ERD	75-10 ERD	84-01 ERD	84-04 ERD	85-07 ERD	

Total 17

Southern Sector - OU III Plumes On- and Off-line Areas

95-84 ERD	113-07 ERD	122-12 ERD	122-05 ERD	124-02 ERD	000-105 ERD	800-43 ERD
95-85 ERD	113-08 ERD	121-13 ERD	122-09 ERD	126-01 ERD	000-107 ERD	800-44 ERD
96-07 ERD	113-10 ERD	121-14 ERD	122-10 ERD	130-02 ERD	000-112 ERD	800-50 ERD
105-05 ERD	114-06 ERD	121-18 ERD	122-15 ERD	130-03 ERD	000-114 ERD	800-51 ERD
105-06 ERD	114-07 ERD	121-19 ERD	122-16 ERD	130-04 ERD	000-130 ERD	800-52 ERD
105-21 ERD	121-06 ERD	121-20 ERD	122-17 ERD	000-97 ERD	000-131 ERD	800-53 ERD
105-44 ERD	121-07 ERD	121-21 ERD	122-18 ERD	000-98 ERD	800-21 ERD	
106-18 ERD	121-08 ERD	121-22 ERD	122-19 ERD	000-99 ERD	800-22 ERD	
109-03 ERD	121-09 ERD	121-23 ERD	122-20 ERD	000-101 ERD	800-23 ERD	
109-04 ERD	121-10 ERD	122-02 ERD	122-21 ERD	000 102 ERD	800-40 ERD	
113-06 ERD	121-11 ERD	122-04 ERD	122-22 ERD	000-104 ERD	800-41 ERD	

Total 72

SCWA Onsite Sentinel Wells - Wm. Floyd Well Field

109-03 ERD	109-04 ERD

Total 2

Operable Unit IV Area

Central Steam Facility - 1977 Spill Site

76-02* ESH/ERD	76-05 ERD	76-09 ERD	76-23 ERD	76-180 ERD	76-183 ERD	76-186 ERD
76-24* ESH/ERD	76-06 ERD	76-19 ERD	76-178 ERD	76-181 ERD	76-184 ERD	
76-04 ESH/ERD	76-07 ERD	76-21 ERD	76-179 ERD	76-182 ERD	76-185 ERD	
						Total 19

OU IV - Southern Plumes

86-04 ERD	000-108 ERD	000-211 ERD	000-215 ERD	106-55 ERD	106-59 ERD	800-63 ERD
86-43 ERD	000-153 ERD	000-212 ERD	106-53 ERD	106-56 ERD	800-59 ERD	
86-70 ERD	000-154 ERD	000-213 ERD	106-54 ERD	106-58 ERD	800-60 ERD	
						Total 19

Major Petroleum Facility

76-25* ESD	76-16 ESD	76-17 ESD	76-18 ESD	76-19 ESD
				Total 5

Building 650 Outfall

66-17 ERD	76-10 ERD	76-24 ERD	76-167 ERD	76-182 ERD	76-263 ERD
66-18 ERD	76-13 ERD	76-24 ERD	76-168 ERD	76-183 ERD	76-264 ERD
76-07 ERD	76-20 ERD	76-26 ERD	76-169 ERD	76-184 ERD	76-265 ERD
76-09 ERD	76-22 ERD	76-27 ERD	76-181 ERD	76-262 ERD	
					Total 23

Operable Unit V Area

Sewage Treatment Plant - Peconic River

37-02* ERD	38-05 ESD	39-10 ESD	50-02 ERD	000-141 ERD	600-15 ERD	600-23 ERD
37-03* ERD	38-06 ESD	41-01 ERD	60-01 ERD	000-142 ERD	600-16 ERD	600-24 ERD
37-04* ERD	39-05 ESD	41-02 ERD	61-03 ERD	000-143 ERD	600-18 ERD	600-25 ERD
38-01 ESD	39-06 ESD	41-03 ERD	61-04 ERD	000-144 ERD	600-19 ERD	600-26 ERD
38-02 ESD	39-07 ESD	49-05 ERD	61-05 ERD	000-145 ERD	600-20 ERD	600-27 ERD
38-03 ESD	39-08 ESD	49-06 ERD	000-122 ERD	000-146 ERD	600-21 ERD	
38-04 ESD	39-09 ESD	50-01 ERD	000-123 ERD	000-147 ERD	600-22 ERD	
						Total 47

Operable Unit VI Area

Biology Agricultural Fields - Meadow Marsh

58-02* ERD	99-05 ERD	100-04 ERD	100-14 ERD	000-175 ERD	000-179 ERD	000-209 ERD
58-03* ERD	99-06 ERD	100-11 ERD	000-110 ERD	000-176 ERD	000-180 ERD	800-24 ERD
89-13 ERD	99-10 ERD	100-12 ERD	000-173 ERD	000-177 ERD	000-181 ERD	800-25 ERD
89-14 ERD	99-11 ERD	100-13 ERD	000-174 ERD	000-178 ERD	000-201 ERD	
						Total 27

North Boundary - Background Wells

000-118 ERD	000-120 ERD	17-03 ERD	18-01 ERD	18-04 ERD	34-02 ERD	63-09 ERD
000-119 ERD	17-01 ERD	17-04 ERD	18-02 ERD	18-05 ERD	34-03 ERD	
						Total 13