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2008

Site Environmental Report

BROOKHAVEN NATIONAL LABORATORY

Volume I

BNL-82388-2009
Formal Report

2008
SITE ENVIRONMENTAL REPORT

BROOKHAVEN NATIONAL LABORATORY

Volume I

October 2009

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Brookhaven National Laboratory
Brookhaven Science Associates, LLC
P.O. Box 5000
Upton, NY 11973-5000

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A MESSAGE FROM THE LABORATORY DIRECTOR

Brookhaven's environmental performance remained at a high level in 2008 as we continued to work towards ever-cleaner and more efficient operations. In 2008, we received a DOE P2 STAR Honorable Mention Award, a Federal Environmental Executive Silver Award, and were the northeast winner of the Federal Environmental Executive's Annual Electronics Reuse & Recycling Campaign Award. These awards, the continued certification of our Environmental Management System, and our strong compliance assurance program are just a few examples of our commitment to environmentally responsible operations.

In 2008, two DOE Orders were issued which incorporated the goals of the 2007 Presidential Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management. These two new orders establish federal requirements for energy efficiency and conservation, renewable energy, fleet management, water conservation, sustainable buildings, reduction of toxic chemical use, purchasing of environmentally preferred products, electronic stewardship, and the implementation of an Environmental Management System. While most of these requirements are already incorporated into programs at BNL, these new orders will help direct the future of our Pollution Prevention Program.

Brookhaven also continues to advance its commitment to renewable energy research. This year, New York Governor David Paterson announced that a new solar power station would be sited at Brookhaven. The project, which will be the largest solar photovoltaic project in New York State, will provide a substantial source of lower-cost power, along with a significant research opportunity for Brookhaven. In addition to the main power array, there will be a smaller research array that will be used for a whole range of experiments. Our plan is to make the research array available to those at universities, in industry, and at other national laboratories.

This year's cover story discusses three Brookhaven buildings. Our Center for Functional Nanomaterials and the Research Support Building have each been awarded a LEED silver rating by the U.S. Green Building Council. Our newest facility, the National Synchrotron Light Source II (currently under construction), will also strive for LEED rating.

Finally, we continue to openly communicate with the community, regulators, employees, and other interested parties on our environmental issues and cleanup progress, incorporating their input into our decision processes. We know that the Laboratory's future as a world leader in science research depends in great part on the trust and support of our neighbors.

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Samuel H. Aronson,
Laboratory Director

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Executive Summary

Brookhaven National Laboratory (BNL) prepares an annual Site Environmental Report (SER) in accordance with DOE Order 231.1A, Environment, Safety and Health Reporting of the U.S. Department of Energy. The report is written to inform the public, regulators, employees, and other stakeholders of the Laboratory's environmental performance during the calendar year in review. Volume I of the SER summarizes environmental data; environmental management performance; compliance with applicable DOE, federal, state, and local regulations; and performance in restoration and surveillance monitoring programs. BNL has prepared annual SERs since 1971 and has documented nearly all of its environmental history since the Laboratory's inception in 1947.

Volume II of the SER, the Groundwater Status Report, also is prepared annually to report on the status of and evaluate the performance of groundwater treatment systems at the Laboratory. Volume II includes detailed technical summaries of groundwater data and its interpretation, and is intended for internal BNL users, regulators, and other technically oriented stakeholders. A brief summary of the information contained in Volume II is included in this volume in Chapter 7, Groundwater Protection.

Both reports are available in print and as downloadable files on the BNL web page at http://www.bnl.gov/ewms/ser/. *An electronic version on compact disc is distributed with each printed report. In addition, a summary of Volume I is prepared each year to provide a general overview of the report, and is distributed with a compact disc containing the full report.*

BNL is operated and managed for DOE's Office of Science by Brookhaven Science Associates (BSA), a partnership formed by Stony Brook University and Battelle Memorial Institute. For more than 60 years, the Laboratory has played a lead role in the DOE Science and Technology mission and continues to contribute to the DOE missions in energy resources, environmental quality, and national security. BNL manages its world-class scientific research with particular sensitivity to environmental issues and community concerns. The Laboratory's motto, "Exploring Life's Mysteries…Protecting its Future," and its Environmental, Safety, Security and Health Policy reflect the commitment of BNL's management to fully integrate environmental stewardship into all facets of its mission and operations.

INTEGRATED SAFETY MANAGEMENT SYSTEM, ISO 14001, AND OHSAS 18001

The Laboratory's Integrated Safety Management System (ISMS) integrates management of environment (i.e., environmental protection and pollution prevention), safety, and health issues into all work planning. BNL's ISMS ensures that the Laboratory integrates DOE's five Core Functions and seven Guiding Principles into all work processes. These integrated safety processes contributed to BNL's achievement of registration under both the International Organization for Standardization (ISO) 14001 Standard (for the Laboratory's Environmental Management System) and the Occupational Safety and Health Assessment Series (OHSAS) 18001 Standard (for the Laboratory's Safety and Health Program). Both standards require an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take correction actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness.

In 2001, an Environmental Management System (EMS) was established at BNL to ensure that environmental issues are systematically identified, controlled, and monitored. The EMS also provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual environmental improvement. The cornerstone of the Laboratory's EMS is BNL's Environment, Safety, Security, and Health (ESSH) Policy. This policy makes clear the Laboratory's commitments to environmental stewardship, the safety of its employees, and the security of the site. Specific environmental commitments in the policy include compliance, pollution prevention, conservation, community outreach, and continual improvement. The policy is posted throughout the Laboratory and on the BNL website at http://www.bnl.gov/ESHQ/ESSH.asp. It is also included in all training programs for new employees, guests, and contractors.

The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized ISO 14001 Environmental Management Standard. BNL was the first laboratory under the DOE Office of Science to become officially registered to this standard in 2001. Annual independent audits, which are required to maintain the registration, are conducted to validate that the Laboratory's EMS is being maintained and to identify evidence of continual improvement. In 2008, an EMS surveillance audit determined that BNL continues to conform to the standard. During the audit, six examples of BNL's continual improvement were highlighted, including an improved Management Review process and excellent spill prevention design practices.

The Laboratory's strong Pollution Prevention (P2) Program is an essential element for the successful implementation of BNL's EMS. The P2 Program reflects the 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 Laboratory's operating philosophy. Pollution prevention and waste reduction goals have been incorporated as performance measures into the DOE contract with BSA and into BNL's ESSH Policy. The overall goal of the P2 Program is to create a systems approach that integrates pollution prevention and waste minimization, resource conservation, recycling, and affirmative procurement into all planning and decision making. In 2008, two DOE Orders were issued which incorporated the goals of the Presidential Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management: DOE Order 430.2B, Departmental Energy, Utilities, and Transportation Management and DOE Order 450.1A, Environmental Protection Program. These orders establish federal requirements for: energy efficiency and conservation, renewable energy, fleet management, water conservation, sustainable buildings, pollution prevention, reduction of toxic chemical use, purchasing environmentally preferred products, electronic stewardship, and implementation of an Environmental Management System. Although most of these requirements have already been incorporated within the Laboratory's P2 Program, the new order will direct its future course.

Five of 15 P2 proposals, submitted by employees to BNL's P2 Council, were funded in 2008, for a combined investment of approximately $16,000. The anticipated annual savings from these projects is approximately $14,000, for an average payback period of approximately 1.3 years. Initiatives to reduce, recycle, and reuse 9.7 million pounds of industrial, sanitary, hazardous, and radiological waste through the P2 program resulted in more than $1.8 million in cost avoidance or savings in 2008.

BNL was accepted into the Environmental Protection Agency's (EPA) Performance Track (PTrack) Program in 2004. This program recognizes top environmental performance among participating U.S. facilities of all types and is considered the "gold standard" for facility-based environmental performance. The program requires that facilities commit to several improvement goals for a 3-year period and report on the progress of these goals annually. In 2007, the Laboratory renewed its membership to the PTrack Program and established four new goals: reducing non-transportation energy consumption, initiating a biobased fuel program for heavy equipment, achieving 95 percent E-PEAT registered products for all computer acquisitions, and reducing toxic releases through effective biosolids management.

Chapter 2 of this report describes the elements and implementation of BNL's EMS in further detail.

BNL'S ENVIRONMENTAL MANAGEMENT PROGRAM

BNL's Environmental Management Program consists of several Laboratory-wide and facility-specific environmental monitoring and surveillance programs. These programs identify potential pathways of public and environmental exposure and evaluate the impacts BNL activities may have on the environment. An overview of the Laboratory's environmental programs and a summary of performance for 2008 follows:

Compliance Monitoring Program

BNL has an extensive program in place to ensure compliance with all applicable environmental regulatory and permit requirements. The Laboratory must comply with more than 100 sets of federal, state, and local environmental regulations, numerous site-specific permits, 16 equivalency permits for the operation of 13 groundwater remediation systems, and several other binding agreements. In 2008, BNL complied with the majority of these requirements, and instances of noncompliance were reported to regulatory agencies and corrected expeditiously.

Eleven external environmental audits were conducted in 2008 by federal, state, and local agencies that oversee BNL activities:

- The New York State Department of Environmental Conservation (NYSDEC) performed its annual inspection of the BNL Hazardous Waste Program, and three instances of waste labeling were identified that did not fully comply with hazardous waste storage requirements. NYSDEC issued a Notice of Violation (NOV); however, no fine or penalties were issued because all items were corrected immediately.
- NYSDEC conducted an inspection of BNL's Chemical Bulk Storage (CBS) facilities and one issue was identified that required corrective action: modifying the generic BNL tank identification label to include both the design and working capacities of each tank registered under the CBS program. The issue was corrected in accordance with the NYSDEC directive.
- NYSDEC conducted its annual inspection of the Major Oil Storage Facility and found three conditions that required corrective action: repair of a malfunctioning alarm system associated with a fuel oil pipeline secondary containment leak detection system, inspection and repair of a product pipe stanchion that had settled and was not providing the necessary structural support, and evaluation of the Cathodic Protection System servicing three tanks to ensure that it is adequately protecting the tanks. Three other conditions were identified regarding underground storage tank management: reapplication of the proper color coding for an underground storage tank containing gasoline, addressing deficiencies associated with a satellite fuel tank, and modifying the generic BNL tank identification label to include both the design and working capacities of each tank. Most conditions were corrected in accordance with NYSDEC directives in 2008, and the remaining conditions will be addressed in 2009.
- NYSDEC inspected the Laboratory's Sewage Treatment Plant (STP) and other State Pollutant Discharge Elimination System (SPDES) regulated outfalls; no issues were identified.
- The Suffolk County Department of Health Services (SCDHS) conducted its annual inspection of the BNL potable water system; no issues were identified.
- SCDHS conducted quarterly inspections of the Laboratory's STP to evaluate operations and sample effluent; no performance or operational issues were identified.
- SCDHS also performed an inspection of

BNL recharge basins permitted under the SPDES program; no issues were identified.

- NYSDEC was present during an annual Relative Accuracy Test Audit. Monitoring equipment at the Central Steam Facility (CSF) was evaluated by a contracted testing firm to ensure that all equipment is operating as required and to document compliance with permit-related monitoring requirements. All conditions and equipment were found satisfactory.

In addition to routine regulatory inspections, EPA conducted an unannounced government-initiated oil spill response exercise and field inspection to test notification procedures, equipment deployment, and other actions associated with a response to an oil spill scenario identified within BNL's Facility Response Plan (FRP). BNL's FRP outlines emergency response procedures to be implemented in the event of a worst-case discharge of oil. All objectives were met.

BNL underwent several reviews by DOE in 2008. An assessment of the Laboratory's implementation of its Emergency Management Program was performed by DOE's Office of Emergency Management. Although significant improvement was noted compared to an audit in 2004, several areas for improvement were identified. A corrective action plan has been prepared to continue improvement in this program. The DOE Chicago Support Center and the DOE Brookhaven Site Office (BHSO) conducted a mercury assessment of the site, focusing on efforts to minimize mercury in effluents and emissions and to reduce the on-site inventory of mercury-bearing devices and chemicals. The assessment found mercury management to be satisfactory, with two recommendations for improvement; both recommendations were addressed immediately. BHSO conducted an assessment of the management of radiological inventory at the Waste Management Facility (WMF). Two findings and three noteworthy practices were identified. Corrective actions have been implemented to address accuracy in waste inventory and modification to personnel protective equipment. All corrective actions are complete. BHSO also coordinated with the Chicago Operations Support Center to perform a review of long-term monitoring and surveillance activities established for the Peconic River. Long-term stewardship was found to be effective and two improvements were recommended: interpret data presented in BNL's annual report and evaluate the need to maintain or remove the sediment trap installed at the site boundary. Both recommendations are being addressed through routine discussions with regulators and through modifications to routine reports.

BNL also performs self-assessments of its programs to ensure continued compliance. In 2008, EPA conducted a programmatic self-assessment on several aspects of BNL's Environmental Management System, including: requirements related to properly maintaining institutional and engineered controls for known or potentially contaminated areas of the site, accurately collecting and analyzing groundwater surveillance samples, and maintaining and retrieving environmental surveillance data. No conformance or noncompliance issues were identified and seven noteworthy practices, six observations, and 15 opportunities for improvement were identified. Corrective actions for the observations are being tracked to closure.

Compliance monitoring in 2008 showed that emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the CSF were all within permit limits. In addition, no opacity excursions were noted for the entire year.

Approximately 1,230 pounds of ozone-depleting refrigerants were recovered from refrigeration equipment for reuse by other DOE facilities or federal agencies. These reductions included the disposition of 10 cylinders of Halon 1301 from fixed fire suppression systems removed from operation. Additionally, approximately 4,500 pounds of ozone depleting substances were transferred to the Department of Defense Ozone Depleting Substances Reserve.

Monitoring of the potable water supply showed that all drinking water quality requirements were met. Most of the liquid effluents discharged to surface water and groundwater met applicable SPDES permit requirements; however, three minor excursions were reported for the year and reported to NYSDEC and SCDHS. Groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

The Laboratory continues to reduce the number and severity of spills on site. In 2008, there were nine reportable spills of petroleum products, antifreeze, or chemicals. All releases were cleaned up to the satisfaction of NYSDEC.

Chapter 3 of this report describes BNL's Compliance Program and status in further detail.

Air Quality Program

BNL monitors radioactive emissions at three facilities on site to ensure compliance with the requirements of the Clean Air Act (CAA). During 2008, Laboratory facilities released a total of 2,650 curies of short-lived radioactive gases. EPA regulations require continuous monitoring of all sources that have the potential to deliver an annual radiation dose greater than 0.1 mrem to a member of the public; all other facilities capable of delivering any radiation dose require periodic confirmatory sampling. Although the dose to the public is less than 0.1 mrem and monitoring is not required by EPA, the Brookhaven Linear Isotope Producer (BLIP) is continuously monitored. Oxygen-15 (half-life: 122 seconds) and carbon-11 (half-life: 20.48 minutes) emitted from the BLIP constituted more than 99.9 percent of radiological air emissions on site in 2008. The combined emissions were approximately 4 percent higher than 2007 levels, primarily due to increased hours of operation.

Monitoring was also conducted at one other active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Releases from the TPL in 2008 continued to be very small (0.025 µCi). The rise in tritium releases from the HFBR in 2008 were due to periodic venting of the reactor vessel when domestic water was added to the reactor vessel in preparation for the removal of the HFBR control rod blade.

The Laboratory conducts ambient radiological air monitoring to verify local air quality and assess possible environmental and health impacts from BNL operations. Air monitoring stations around the perimeter of the site measure tritium and gross alpha and beta airborne activity. Results for 2008 continued to demonstrate that on-site radiological air quality was consistent with off-site measurements and with results from locations in New York State that are not located near radiological facilities.

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emissions monitoring to demonstrate compliance with emission limits. The CSF is the only BNL facility that requires monitoring. Two of the four boilers at the CSF, specifically 6 and 7, are equipped with continuous emission monitors to measure opacity and nitrogen oxide (NOx) emissions. Opacity levels cannot exceed 20 percent, except for one 6-minute period per hour of not more than 27 percent opacity. In 2008, there were no exceedances of the NOx emission standards for either boiler. In addition, there were no violations of the 6-minute opacity limits.

Because natural gas prices were lower than residual fuel oil prices from January through October 2008, BNL used natural gas for most heating and cooling needs during these months. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably lower than in years when residual fuel oil was predominantly used.

Chapter 4 of this report describes BNL's Air Quality Program and monitoring data in further detail.

Water Quality Surveillance Program

BNL discharges treated wastewater into the headwaters of the Peconic River via the STP, and non-contact cooling water and storm water runoff to groundwater via recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and careful operation of treatment facilities ensure that these discharges comply with all applicable requirements and that the public, employees, and the environment are protected.

To assess the potential impact of discharges on the water quality of the Peconic River, surface water monitoring is conducted at several locations upstream and downstream of the STP discharge. The Carmans River, located to the west of BNL, is monitored as a geographical control location for comparative purposes, as it is not affected by Laboratory operations. In 2008, the average gross alpha and beta activity levels in the STP discharge were well below drinking water standards (DWS). Tritium detected at the STP originates from either HFBR sanitary system releases, or from small, infrequent batch releases that meet BNL discharge criteria from other facilities. Although the HFBR is no longer operating, tritium continues to be released from the facility at very low concentrations due to off-gassing. To minimize the quantity of tritium released to the STP, efforts have been made to capture most of the air compressor condensate collected in the equipment areas of the structure.

In 2008, with the exception of a single low-level reported value, tritium was not detected in the STP effluent. Due to the low level of detection and the high uncertainty, the concentration was indistinguishable from the minimum detection limit (MDL). Tritium was also detected in a single sample of STP influent at a similar low-concentration (280 ± 170 pCi/L). This concentration is also indistinguishable from the MDL due to the low level of detection and the uncertainty. Both positive detections were reported as estimates by the contract analytical laboratory. Total tritium released for 2008 was 40 percent less than that recorded for 2007, and the annual average concentration trend has been declining since 1995.There were no gamma-emitting nuclides or strontium-90 (Sr-90) detected in the STP wastewater throughout 2008. The STP effluent continued to show no detection of cesium-137 (Cs-137), Sr-90, or other gamma-emitting nuclides attributable to BNL operations. There were also no radionuclides detected along the Peconic River attributable to BNL operations.

The STP is also monitored for nonradiological contaminants. In 2008, Peconic River samples collected upstream, downstream, and at control locations demonstrated that elevated amounts of aluminum, iron, and vanadium detected in the river are associated with natural sources. Metals including copper, lead, silver, and zinc are present downstream of the STP at concentrations that are greater than the ambient water quality standard, but less than permitted levels for the STP discharge.

Discharges to recharge basins are sampled throughout the year for analyses of gross alpha and beta activity, gamma-emitting radionuclides, and tritium. Each recharge basin is a permitted point-source discharge under the Laboratory's SPDES permit. In 2008, there were no reported gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins. Tritium was also not detected. Low concentrations of disinfection byproducts were periodically detected in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, lead to the formation of volatile organic compounds (VOCs), including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. All concentrations were less than 10 µg/L. Acetone was also detected above the MDL for most recharge basins. In most instances, acetone was also found as a contaminant in the contract analytical laboratory, as evidenced by detections in blank samples.

Chapter 5 of this report describes BNL's Water Quality Surveillance Program and monitoring data in further detail.

Natural and Cultural Resource Management Program

The BNL Natural Resource Management Program was designed to promote stewardship of the natural resources found on site and to integrate natural resource management and protection with the Laboratory's scientific mission. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with the public, stakeholders, and staff members regarding environmental issues. Precautions are taken to protect and enhance habitats and natural resources at BNL. Activities to eliminate or minimize negative effects on sensitive or critical species (such as the eastern tiger salamander, eastern hognose snake, and banded sunfish) are incorporated into procedures or into specific programs or project plans. Restoration efforts continue to remove pollutant sources that could contaminate habitats. In some cases, habitats are enhanced to improve survival or increase populations. The Laboratory also monitors and manages other wildlife populations, such as white-tailed deer and Canada geese.

BNL conducts routine monitoring of flora and fauna to assess the impact, if any, of past and present activities on the Laboratory's natural resources. Generally, deer sampled on site contain higher concentrations of Cs-137 than deer sampled from more than 1 mile off site. This is most likely because on-site deer consume small amounts of contaminated soil and graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. The maximum on-site concentration in 2008 was seven times higher than the highest level reported in 2007, but continues to be much lower than the highest level ever reported (1996). The New York State Department of Health (NYSDOH) has formally reviewed the potential public health risk associated with elevated levels of Cs-137 in on-site deer and determined that neither hunting restrictions or formal health advisories are warranted. Testing of deer bones for Sr-90 indicated background levels. Sr-90 is present in the environment at background levels as a result of worldwide fallout from nuclear weapons testing. BNL will continue to test for Sr-90 in bone to develop baseline information.

In an effort to restore fish populations, the Laboratory suspended most on-site fish sampling in 2001. By 2007, fish populations had recovered and annual on site sampling resumed. In 2008, Cs-137 was detected at low levels in all samples from the Peconic River system and appears to be declining compared with historic values. The cleanup of both on-and off-site portions of the Peconic River in 2004 and 2005 removed approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Natural decay and the removal of this contamination are expected to result in further deceases.

Nonradiological analysis of fish continued in 2008. All concentrations for metals are considered safe and do not pose any health risks to humans or other animals that may consume fish. Due to its known health risk, mercury is the metal of most concern. In general, a trend of decreasing mercury content downstream from BNL's STP is evident. Pesticide analysis in fish was discontinued in 2008, since several years of sampling detected pesticides in only a few fish far off-site. Polychlorinaded biphenyl (PCB) analysis in fish was also discontinued off site, but continued to be completed for fish on site. A single sample taken from Area A tested positive for PCBs. The cleanup of the Peconic River, completed in 2005, has removed most PCBs within the sediments on site.

Annual sampling of sediment, vegetation, and freshwater in the Peconic River and a control location on the Carmans River was conducted in 2008. On- and off-site aquatic vegetation and sediments contained low levels of Cs-137 and metals in amounts that were consistent with levels detected in previous years. Pesticides and PCB analyses of aquatic sampling were also discontinued in 2008.

Under the Peconic River remediation project, sediment from the Peconic River was remediated to remove mercury and associated contaminants from the river. This project was completed in the summer of 2005. Sampling results for 2008 indicated that 97 percent of the samples were below the cleanup goal of 2.0 mg/kg.

Water column sampling for mercury and methylmercury was performed at 20 Peconic River sampling locations, the STP, and one reference location on the Connetquot River in 2008. The general trend of total mercury in water samples decreased with increasing distance downstream from the STP. Methylmercury concentrations increased slightly from the STP to the BNL site border; then decreased gradually with increasing distance downstream of the BNL site border until reaching the historic range of concentrations for the Connetquot River reference station.

BNL has completed two years of wetland monitoring and invasive species control. A formal approval from EPA will be requested in

2009 that all Peconic River federal wetland restoration requirements have been met.

On-site sampling of garden vegetables was completed in 2008 and the 5-year periodic confirmatory sampling of local farm vegetables was also conducted. Data shows that vegetables grown in the BNL garden plot and by local farmers continue to support historic analyses that there are no Laboratory-generated radionuclides in produce.

BNL sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem and to foster interest in science. Wildlife programs are conducted at BNL in collaboration with DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning. In 2008, the Environmental Protection Division hosted interns and one faculty member who worked on a variety of projects including: surveying dragonflies and damselflies, radio tracking and genetics of red and grey foxes, analyzing the water chemistry of the Carmans and Peconic Rivers, investigating the loss of the southern leopard frog on Long Island, assessing population health of the banded sunfish, analyzing soil microbial communities, performing statistical analysis of migratory bird data, and studying the distribution of aquatic invertebrates within the Carmans River. Teachers also participated in a workshop on environmental monitoring under the Open Space Stewardship Program (OSSP), managed by the BNL Office of Education Programs. In addition, the Foundation for Ecological Research in the Northeast (FERN) began work on video-based instruction for protocols used within OSSP.

The goal of BNL's Cultural Resource Management Program (CRMP) is to ensure the proper stewardship of BNL and DOE historic resources. Additional goals include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of resources to Laboratory personnel and the public for research and interpretation. Cultural resource management activities performed in 2008 included acquiring storage space for cultural resources and participating in the planning and execution of the 77th Division Casing of the Colors Ceremony. During this ceremony, U.S. Army officers of the division retired the 77th U.S. Army Regional Readiness Command.

Chapter 6 of this report describes BNL's natural and cultural resources in further detail.

Groundwater Protection Management Program

BNL's extensive groundwater monitoring well network is used to evaluate progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater that enters and exits the site. The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. In 2008, the Laboratory collected groundwater samples from 860 on- and off-site monitoring wells during 2,055 individual sampling events.

Under the environmental surveillance program, 10 active research and support facilities were monitored during 2008. Although no new impacts to groundwater quality have been discovered since 2001, groundwater quality continues to be impacted from past releases at two facilities: the former g-2 experiment within the Alternating Gradient Synchrotron (AGS) facility, and the Upton service station facility. Tritium continues to be detected at concentrations above the 20,000 pCi/L DWS in wells monitoring the g-2 source area. Monitoring data suggest that the continued release of tritium from the source area is due to residual tritium being flushed out of the unsaturated zone close to the water table by natural water table fluctuations. The amount of tritium entering the groundwater is expected to decrease over time, due to this flushing mechanism and by natural radioactive decay. At the Upton service station, VOCs associated with historical petroleum and solvent spills continue to be detected in the groundwater at concentrations above the applicable DWS. The levels of VOCs are expected to decrease over time by means of natural attenuation.

The primary mission of the Laboratory's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) groundwater program is to operate and maintain groundwater treatment systems and prevent additional groundwater contamination from migrating off site. During 2008, BNL continued to make significant progress in restoring groundwater quality with the removal of approximately 220 pounds of VOCs and approximately 3.4 mCi of Sr-90 with the treatment of more than 1.5 billion gallons of groundwater. To date, 6,117 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in the Operable Unit (OU) I South Boundary, OU III South Boundary, OU III Industrial Park, OU III Industrial Park East, OU III North Street, OU IV, Building 96, and Carbon Tetrachloride areas. Also to date, two of the treatment systems have removed approximately 20 mCi of Sr-90.

Chapter 7 of this report provides an overview of this program, and the SER Volume II, Groundwater Status Report, provides a detailed description, data, and maps relating to all groundwater monitoring performed in 2008.

Radiological Dose Assessment Program

BNL routinely assesses its operations to ensure that any potential radiological dose to members of the public, BNL workers, visitors, and the environment is "As Low As Reasonably Achievable" (ALARA). The potential radiological dose is calculated as the largest possible dose to a hypothetical Maximally Exposed Individual (MEI) at the BNL site boundary. For dose assessment purposes, the pathways include direct radiation exposure, inhalation, ingestion, immersion, and skin absorption. Radiological dose assessments at the Laboratory have consistently shown that the effective dose equivalent from operations is well below the EPA and DOE regulatory dose limits for the public and the environment. The dose impact from all BNL activities in 2008 was comparable to natural background radiation levels.

To measure direct radiation from Laboratory operations, 58 thermoluminescent dosimeters (TLDs) were placed on site and 15 TLDs are placed in surrounding communities. An additional 30 TLDs were placed in a lead-shielded container for use as reference and control TLDs for comparison purposes. In 2008, the average doses from all TLDs showed there was no additional contribution to on- and off-site locations from BNL operations.

The annual on-site external dose from all potential sources, including cosmic and terrestrial radiation, was 69 ± 13 mrem (690 ± 130 µSv), and the annual off-site external dose was 63 ± 11 mrem (630 ± 110 µSv). The effective dose to the MEI from air emissions was 6.12E-2 mrem (0.61 µSv). The ingestion pathway dose was estimated as 12.48 mrem (125 µSv) from consumption of deer meat and 0.09 mrem (0.9 µSv) from consumption of fish caught in the vicinity of the Laboratory. The total annual dose to the MEI from all pathways was estimated as 12.63 mrem (126 µSv). The dose from the air inhalation pathway attributable to BNL operations was less than 1 percent of EPA's annual regulatory dose limit of 10 mrem (100 µSv), and the total dose was less than 13 percent of DOE's annual dose limit of 100 mrem (1,000 µSv) from all pathways. Doses to aquatic and terrestrial biota were also evaluated and found to be well below the regulatory limits.

As a part of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) review process at BNL, any source that has the potential to emit radioactive materials is evaluated for regulatory compliance. In 2008, a preliminary NESHAP evaluation was performed for the removal of the graphite pile and bioshield at the Brookhaven Graphite Research Reactor (BGRR). The evaluation determined that this project could give a potential dose exceeding 0.1 mrem; therefore, the facility will be continuously monitored for radionuclides during the removal of these materials.

In 2008, the BLIP facility operated over a period of 23 weeks. Due to an anticipated increase in production of medical isotope production in 2009, BNL applied to EPA for NESHAPs authorization to increase dose from facility emissions to a maximum of 0.2 mrem. The request was approved noting that the Laboratory continue its efforts to maintain the dose "as low as reasonably achievable."

During 2008, tritium monitoring at the HRBR was increased from monthly to weekly when the reactor vessel, primary cooling water system, and fuel canal were filled with domestic water to prepare for removal of the control rod blades. Because the reactor vessel was periodically opened, tritium levels in the building were much higher than observed in recent years.

Chapter 8 of this report describes the BNL Radiological Dose Assessment Program and monitoring data in further detail.

Quality Assurance Program

The multilayered components of the BNL Quality Assurance (QA) Program ensure that all analytical data reported in this document are reliable and of high quality, and that all environmental monitoring data meet quality assurance and quality control objectives. Samples are collected and analyzed in accordance with EPA methods and standard operating procedures that are designed to ensure samples are representative and the resulting data are reliable and defensible. Quality control in the analytical laboratories is maintained through daily instrument calibrations, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated as required by project-specific quality objectives before being used to support decision making.

In 2008, the Laboratory used five off-site contract analytical laboratories to analyze environmental samples: General Engineering Lab (GEL), H2M Lab, Test American (TA), Chemtex Lab, and Brooks Rand. All analytical laboratories were certified by NYSDOH for the tests they performed for BNL, and were subject to oversight that included state and national performance evaluation (PE) testing, review of QA programs, and audits.

Four of the contract analytical laboratories (GEL, TA, H2M, and Brooks Rand) participated in several national and state PE testing programs in 2008. The fifth contractor, Chemtex Laboratory, did not participate in PE testing because there is no testing program for the specific analytes Chemtex analyzed. Each of the participating laboratories took part in at least one testing program, and several laboratories participated in multiple programs. Results of the tests provide information on the quality of a laboratory's analytical capabilities. The testing was conducted by Environmental Resource Associates (ERA), the National Voluntary Laboratory Accreditation Program (NVLAP), the voluntary Mixed Analyte Performance Evaluation Program (MAPEP), and NYSDOH Environmental Laboratory Accreditation Program (ELAP).

As part of DOE's Integrated Contract Procurement Team Program, TA and GEL were audited in 2008. During the audits, errors are categorized into Priority I and Priority II findings. Priority I status indicates a problem that can result in unusable data or a finding that the contract analytical laboratory cannot adequately perform services for DOE. Priority II status indicates problems that do not result in unusable data and do not indicate that the contract analytical laboratory cannot adequately perform services for DOE. There were no Priority I findings for GEL and two Priority II findings. The first Priority II finding stated that the GEL Standard Operating Procedure (SOP) for semivolatile analysis did not contain sufficient information on method blanks; the lab updated the SOP. The second Priority II finding indicated a failure to pass the PE sample for selenium in a soil matrix. Since this PE result, GEL has changed analysis techniques for selenium in soil and has obtained acceptable results on PE samples. Both these findings have been closed. TA had one Priority I finding and one Priority II finding. Both findings were from their inorganic division. The Priority I finding originated from a failure to obtain acceptable PE test results for antimony in a soil matrix. TA adjusted their soil preparation methods and received passing scores on the next two PE samples for antimony in a soil matrix. DOE accepted these results and closed this finding. The Priority II finding dealt with inorganic lab practices that did not exactly meet internal SOPs. TA updated their SOPs and this finding was also closed.

Based on the data reviews, data validations, and results of the independent PE assessments, the chemical and radiological results reported in this 2008 SER are of acceptable quality.

Chapter 9 of this report describes the BNL Quality Assurance/Quality Control Program in further detail.

2008 SITE ENVIRONMENTAL REPORT TEAM

The SER Team realizes that many other employees contributed to this report and thanks everyone for their assistance.

The SER Team
(Back row, left to right) John Burke, Robert Lee, Jason Remien, William Dorsch, Robert Howe, George Goode, Douglas Paquette, and Karen Ratel (Front row, left to right) Arland Carsten, Patricia Yalden, John Selva, Timothy Green, and Jeffrey Williams
(Balwan Hooda, Peter Pohlot, and Kathleen Robinson not pictured)

The Environmental Information Management Services Group
(Back row, left to right)
Andrew Rohkohl, and Frank Tramontano
(Front row, left to right)
John Burke, Susan Young, and Brian Foley

The Environmental and Waste Management Services Division Field Sampling Team
(From left to right) James Milligan, Lawrence Lettieri, and Robert Metz
(Richard Lagattolla not pictured)

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LEAD CHAPTER AUTHORS

ENVIRONMENTAL PROTECTION DIVISION

EXECUTIVE SUMMARY	Karen Ratel
CHAPTER 1	Karen Ratel
CHAPTER 2	Peter Pohlot
CHAPTER 3	Robert Lee
CHAPTER 4	Jeffrey Williams
CHAPTER 5	Robert Lee
CHAPTER 6	Timothy Green
CHAPTER 7	Douglas Paquette William Dorsch
CHAPTER 8	Balwan Hooda
CHAPTER 9	John Burke
SER SUMMARY	Karen Ratel

CO-AUTHORS AND/OR KEY CONTRIBUTORS

ENVIRONMENTAL PROTECTION DIVISION

Arland Carsten, Consultant
Mark Davis
George Goode
Jennifer Higbie
Robert Howe
Richard Lagattolla
Lawrence Lettieri
Robert Metz
Jason Remien
Glen Todzia

BIOLOGY DEPARTMENT

Richard Setlow

COMMUNITY, EDUCATION, GOVERNMENT AND PUBLIC AFFAIRS

Jeanne D'Ascoli
Peter Genzer

PLANT ENGINEERING DIVISION

Edward Phillips
Barbara Pierce
Mark Toscano

RADIOLOGICAL CONTROL DIVISION

Charles Schaefer

ENVIRONMENT, SAFETY & HEALTH DIRECTORATE

Mary Daum

SER PROJECT COORDINATOR

Karen Ratel, Environmental Protection Division

EDITOR

Kathleen Robinson, Information Services Division

DESIGNER

Patricia Yalden, Media & Communications and Production Services

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Community, Education, Government and Public Affairs Directorate
Environment, Safety & Health Directorate
Environmental Protection Division
Environmental Information Management System Group
Environmental Restoration Project Division
Information Services Division
Media & Communications and Production Services
Plant Engineering Division
Radiological Control Division

A Note from the Editor

Throughout the Site Environmental Report, there are many references to Brookhaven National Laboratory (BNL), the U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (EPA). These acronyms, and others that are explained in each chapter, are used interchangeably with their spelled-out forms as an aid to readers. Also, Appendix A opens with a list of acronyms and their meanings.

Contents

CHAPTER 3: COMPLIANCE STATUS

CHAPTER 4: AIR QUALITY

CHAPTER 5: WATER QUALITY

CHAPTER 6: NATURAL AND CULTURAL RESOURCES

CHAPTER 9: QUALITY ASSURANCE

List of Figures

List of Tables

Introduction

1

Established in 1947, Brookhaven National Laboratory is a multi-program national laboratory managed for the U.S. Department of Energy by Brookhaven Science Associates (BSA), a partnership formed by Stony Brook University and Battelle Memorial Institute. BSA has been managing and operating the Laboratory under a performance-based contract with DOE since 1998. From 1947 to 1998, BNL was operated by Associated Universities Incorporated. Prior to 1947, the site operated as Camp Upton, a U.S. Army training camp, which was active from 1917 to 1920 during World War I and from 1940 to 1946 during World War II.

BNL is one of 10 national Laboratories under DOE's Office of Science, which provides most of the Laboratory's research dollars and direction. BNL has a history of outstanding scientific achievements. For over 60 years, Laboratory researchers have successfully worked to envision, construct, and operate large and innovative scientific facilities in pursuit of research advances in many fields. Programs in place at BNL emphasize continual improvement in environmental, safety, security, and health performance.

1.1 LABORATORY MISSION

BNL's broad mission is to carry out basic and applied research in long-term programs in a safe and environmentally sound manner with the cooperation, support, and involvement of its scientific and local communities. The fundamental elements of the Laboratory's role in support of DOE's strategic missions in energy resources, environmental quality, and national security are:

- To conceive, construct, and operate complex, leading-edge, user-oriented research facilities.
- To develop advanced technologies that address national needs and initiate their transfer to other organizations and to the commercial sector.
- To disseminate technical knowledge to educate future generations of scientists and engineers.
- To maintain technical currency in the nation's workforce and encourage scientific awareness in the general public.

BNL's Environmental, Safety, Security, and Health (ESSH) Policy is the Laboratory's commitment to continual improvement in ESSH performance. Under this policy, the Laboratory's goals are to protect the environment, conserve resources, and prevent pollution; maintain a safe workplace by planning work and performing it safely; provide security for people, property, information, computing systems, and facilities; protect human health within our boundaries and in the surrounding community; achieve and maintain compliance with applicable ESSH requirements; maintain an open, proactive, and constructive relationship with employees, neighbors, regulators, DOE, and other stakeholders; and continually improve ESSH performance.

BNL was the first DOE Office of Science National Laboratory to be registered under the prestigious International ISO 14001 environmental management standard in 2001. In addition, in December 2006, BNL was the first DOE Laboratory to achieve full registration under the Occupational Health and Safety Assessment Series (OHSAS) 18001 Standard. These programs are described in detail in Chapter 2 of this report. Registration to these standards was maintained throughout 2008.

1.2 HISTORY

BNL was founded in 1947 by the Atomic Energy Commission (AEC), a predecessor to the present DOE. AEC provided the initial funding for BNL's research into peaceful uses of the atom. The objective was to promote basic research in the physical, chemical, biological, and engineering aspects of the atomic sciences. The result was the creation of a regional laboratory to design, construct, and operate large scientific machines that individual institutions could not afford to develop on their own.

Although BNL no longer operates any research reactors, the Laboratory's first major scientific facility was the Brookhaven Graphite Research Reactor (BGRR), which was the first reactor to be constructed in the United States following World War II. The reactor's primary mission was to produce neutrons for scientific experimentation in the fields of medicine, biology, chemistry, physics, and nuclear technology. The BGRR operated from 1950 to 1968 and is currently being decommissioned and will be dismantled. The BGRR will undergo long-term routine inspection and surveillance when decommissioning is complete.

The BGRR's research capacity was replaced and surpassed in 1965 by the High Flux Beam Reactor (HFBR). The HFBR was used solely for scientific research and provided neutrons for experiments in materials science, chemistry, biology, and physics. For more than 30 years, the HFBR was one of the premier neutron beam reactors in the world. In 1997, workers discovered that a leak in the HFBR spent fuel storage pool had been releasing tritium to the groundwater (see Chapter 7 for further details). In November 1999, the Secretary of Energy decided that the HFBR would be permanently shut down. In 2008, actions continued to prepare the HFBR for permanent decontamination and dismantling (D&D). With input from the community, a final Record of Decision was approved outlining the remedy for the D&D project. To date, completed actions include the removal and disposal of HFBR fuel and primary coolant, shipment of equipment for reuse at other facilities, cleanup and transfer of the Cold Neutron Facility for reuse, dismantling of many ancillary buildings in the HFBR complex, and removal and disposal of the reactor control rod blades and beam plugs. Near-term actions include the dismantling of the remaining ancillary buildings, removal of contaminated underground utilities and piping, and preparation of the confinement building for safe storage. An associated action conducted in 2008 was the cleanup of the Waste Loading Area, which was previously used for staging cleanup-derived wastes prior to shipping the materials for disposal via railway.

Medical research at BNL began in 1950 with the opening of one of the first hospitals devoted to nuclear medicine. It was followed by the Medical Research Center in 1958 and the Brookhaven Medical Research Reactor (BMRR) in 1959. The BMRR was the first nuclear reactor in the nation to be constructed specifically for medical research. Due to a reduction of research funding, the BMRR was shut down in December 2000. All spent fuel from the BMRR has been removed and transported off site, and the facility is currently in a "cold" shutdown mode as a radiological facility.

The Brookhaven Linac Isotope Producer (BLIP) was built in 1973. It creates radioactive forms of ordinary chemical elements that can be used alone or incorporated into radiotracers for use in nuclear medicine research or for clinical diagnosis and treatment. BNL's Center for Translational Neuroimaging (CTN) uses brain-imaging tools, including positron emission tomography (PET) and magnetic resonance imaging (MRI) equipment, to research causes of, and treatments for, brain diseases such as drug addiction, appetite disorders, attention deficit disorder, and neurodegenerative disease. The development of PET and MRI also has helped facilitate the development of new drugs for physicians worldwide to treat patients for cancer and heart disease.

High-energy particle physics research at BNL began in 1952 with the Cosmotron, the first particle accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Noble Prize in 1957. After 14 years of service, the Cosmotron ceased operation and was dismantled due to design limitations that restricted the energies it could achieve. The Alternating Gradient Synchrotron (AGS), a much larger particle accelerator, became operational in 1960. The AGS allowed scientists to accelerate protons to energies that yielded many discoveries of new particles and phenomena, for which BNL researchers were awarded three Nobel Prizes in physics. The AGS receives protons from BNL's linear accelerator (Linac), designed and built in the late 1960s as a major upgrade to the AGS complex. The Linac's purpose is to provide accelerated protons for use at AGS facilities and BLIP. The AGS booster, constructed in 1991, further enhanced the capabilities of the AGS, enabling it to accelerate protons and heavy ions to even higher energies. The Tandem Van de Graaff accelerator began operating in 1970 and is the starting point of the chain of accelerators that provide ions of gold, other heavy metals, and protons for experiments at the Relativistic Heavy Ion Collider (RHIC).

RHIC began operation in 2000. Inside this two-ringed particle accelerator, two beams of gold ions, heavy metals, or protons circulating at nearly the speed of light, collide head-on, releasing large amounts of energy. RHIC is used to study what the universe may have looked like in the first few moments after its creation, offering insights into the fundamental forces and properties of matter. Planned upgrades to RHIC will expand the facility's research capabilities. The first upgrade, RHIC II, will increase the collider's collision rate and improve the sensitivity of the large detectors it uses. Another planned upgrade, the eRHIC, will add a high-energy electron ring to create the world's only electron-heavy ion collider, which physicists expect will probe a new form of matter.

The NASA Space Radiation Laboratory (NSRL) became operational in 2003. It is jointly managed by DOE's Office of Science and NASA's Johnson Space Center. The NSRL uses heavy ions extracted from the AGS booster to produce beams of radiation similar to radiation that would be encountered by astronauts on long missions. Studies are conducted to assess risks and test protective measures. The NSRL is one of the few facilities in the world that can simulate the harsh cosmic and solar radiation environment found in space.

The National Synchrotron Light Source (NSLS) uses a linear accelerator and booster synchrotron to guide charged particles in orbit inside two electron storage rings for use in a wide range of physical and biological experiments. The NSLS produces beams of very intense light in the x-ray, ultraviolet, and infrared spectra, allowing scientists to study the structure of proteins, investigate the properties of new materials, and understand the fate of chemicals in the environment. Although the current NSLS has been continually updated since its commissioning in 1982, today the practical limits of its performance have been reached. To continue advances in these fields, the NSLS-II has been conceived as the next generation synchrotron light source. To help meet the critical scientific challenges of our energy future, this new state-of-the-art, medium-energy electron storage ring synchrotron will provide x-rays more than 10,000 times brighter than the current NSLS and will focus on research at the nanoscale. The NSLS-II will enable scientists to focus on some of the nation's most important scientific challenges at the nanoscale level, including clean, affordable energy, molecular electronics, and high-temperature superconductors. Construction of the new facility officially started in October 2008.

The Laboratory's Research Support Building (RSB) was completed in 2006, and provides administrative and support functions in a single location for employees and visiting scientists. The RSB has been awarded the Leadership in Energy and Environmental Design (LEED) Silver certification from the U.S. Green Building Council. The award is based on five categories: sustainability, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.

Construction of the Center for Functional Nanomaterials (CFN) began in 2005 and was completed in May 2007. The CFN provides state-of-the-art capabilities for the fabrication and study of nanoscale materials, with an emphasis on atomic-level tailoring to achieve desired properties and functions. Nanoscience has the potential to bring about and accelerate new technologies in energy distribution, drug delivery, sensors, and industrial processes. The CFN is a science-based user facility, used for developing strong scientific programs while offering broad access to its capabilities and collaboration through an active user program. It is one of five Nanoscale Science Research Centers funded by DOE's Office of Science and supports the Laboratory's goal of leadership in the development of advanced materials and processes for energy applications. Like the RSB, the CFN has also been awarded LEED Silver certification.

In addition, groundbreaking is expected in 2009 for the new Interdisciplinary Science Building (ISB), an energy-efficient and environmentally sustainable building that will provide labs, offices, and support functions to bring together a broad spectrum of researchers in a single location to foster energy research.

In 2008, the Laboratory was a proposed host-site for the construction of the largest solar energy project in New York State. Under this project, the Long Island Power Authority sought proposals for the construction of up to 50 megawatts of solar-generated power. This project, if awarded, will help the U.S. become less reliant on foreign energy sources and help meet renewable energy goals. In addition, a solar photovoltaic research and development facility may be developed for research, education, and community outreach to foster increased knowledge in the use of solar energy. The outcome of this proposal is expected to be finalized in 2009.

Past operations and research at the BNL site dating back to the early 1940s when it was Camp Upton have resulted in localized environmental contamination. As a result, the Laboratory was added to the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List of contaminated sites in 1989. One of 27 sites on Long Island identified for priority cleanup, BNL has made significant progress toward improving environmental operations and remediating past contamination. DOE will continue to fund cleanup projects until the Laboratory is restored and removed from the National Priorities List. Major accomplishments in cleanup activities at BNL are discussed further throughout this report.

1.3 RESEARCH AND DISCOVERIES

BNL conducts research in nuclear and high-energy physics; the physics and chemistry of materials; nanoscience; energy and environmental research; national security and nonproliferation; neurosciences and medical imaging; structural biology; and computational sciences. BNL's world-class research facilities are also available to university, industrial, and government personnel.

To date, six Nobel Prizes have been awarded for discoveries made wholly or partly at BNL. Some significant discoveries and developments made at the Laboratory include L-dopa, used to treat Parkinson's disease; the first synthesis of human insulin; the use of x-rays and neutrons to study biological specimens; the radionuclide thallium-201, used in millions of cardiac stress tests each year; the radionuclide technetium-99, also used to diagnose heart disease; x-ray angiography for noninvasive cardiac imaging; research on solar neutrinos and how they change form as they move through space; magnetically-levitated (maglev) trains; energy technologies studies; and researching pollution-eating bacteria.

Examples of current research at the Laboratory include the investigation of new nanostructures and nanoparticles; the development of high-temperature superconductors; novel states of matter being revealed at RHIC; medical imaging techniques to investigate the brain mechanisms underlying drug addiction, psychiatric disorders, and metabolism; new methods of understanding the earth's climate; and research into how infections begin.

1.4 FACILITIES AND OPERATIONS

Most of the Laboratory's principal facilities are located near the center of the site. The developed area is approximately 1,650 acres:

- 500 acres originally developed by the Army (as part of Camp Upton) and still used for offices and other operational buildings
- 200 acres occupied by large, specialized

research facilities
- 550 acres used for outlying facilities, such as the Sewage Treatment Plant, research agricultural fields, housing facilities, and fire breaks
- 400 acres of roads, parking lots, and connecting areas

The balance of the site, approximately 3,600 acres, is mostly wooded and represents the native pine barrens ecosystem.

The major scientific facilities at BNL are briefly described in Figure 1-1. Additional facilities, shown in Figure 1-2 and briefly described below, support BNL's science and technology mission by providing basic utility and environmental services.

- *Central Chilled Water Plant*. This plant provides chilled water sitewide for air conditioning and process refrigeration via underground piping. The plant has a large refrigeration capacity and reduces the need for local refrigeration plants and air conditioning.
- *Central Steam Facility (CSF)*. This facility provides high-pressure steam for facility and process heating sitewide. Either natural gas or fuel oil can be used to produce the steam, which is conveyed to other facilities through underground piping. Condensate is collected and returned to the CSF for reuse, to conserve water and energy.
- *Fire Station*. The Fire Station houses six response vehicles. The BNL Fire Rescue Group provides on-site fire suppression, emergency medical services, hazardous material response, salvage, and property protection.
- *Major Petroleum Facility (MPF)*. This facility provides reserve fuel for the CSF during times of peak operation. With a total capacity of 2.3 million gallons, the MPF primarily stores No. 6 fuel oil. The 1997 conversion of CSF boilers to burn natural gas as well as oil has significantly reduced the Laboratory's reliance on oil as a sole fuel source when other fuels are more economical.
- *Sewage Treatment Plant (STP)*. This plant treats sanitary and certain process wastewater from BNL facilities prior to discharge into the Peconic River, similar to the operations of a municipal sewage treatment plant. The plant has a design capacity of 3 million gallons per day. Effluent is monitored and controlled under a permit issued by the New York State Department of Environmental Conservation (NYSDEC).
- *Waste Concentration Facility (WCF)*. This facility was previously used for the receipt, processing, and volume reduction of aqueous radioactive waste. At present, the WCF houses equipment and auxiliary systems required for operation of the liquid low-level radioactive waste storage and pump systems.
- *Waste Management Facility (WMF)*. This facility is a state-of-the-art complex for managing the wastes generated from BNL's research and operations activities. The facility was built with advanced environmental protection systems and features, and began operation in December 1997.
- *Water Treatment Plant (WTP)*. The potable water treatment plant has a capacity of 5 million gallons per day. Potable water is obtained from six on-site wells. Three wells located along the western boundary of the site are treated at the WTP with a lime-softening process to remove naturally occurring iron and by the addition of sodium hypochlorite for bacterial control. The plant is also equipped with dual air-stripping towers to ensure that volatile organic compounds (VOCs) are at or below New York State drinking water standards. Three wells located along the eastern section of the developed site are treated by the addition of sodium hydroxide to increase the pH of the water to make it less corrosive and by the addition of sodium hypochlorite to control bacteria. BNL's potable water met all drinking water standards in 2008.

1.5 LOCATION, LOCAL POPULATION, AND LOCAL ECONOMY

BNL is located on Long Island, 60 miles east of New York City. The Laboratory's 5,265-acre site is near Long Island's geographic center and

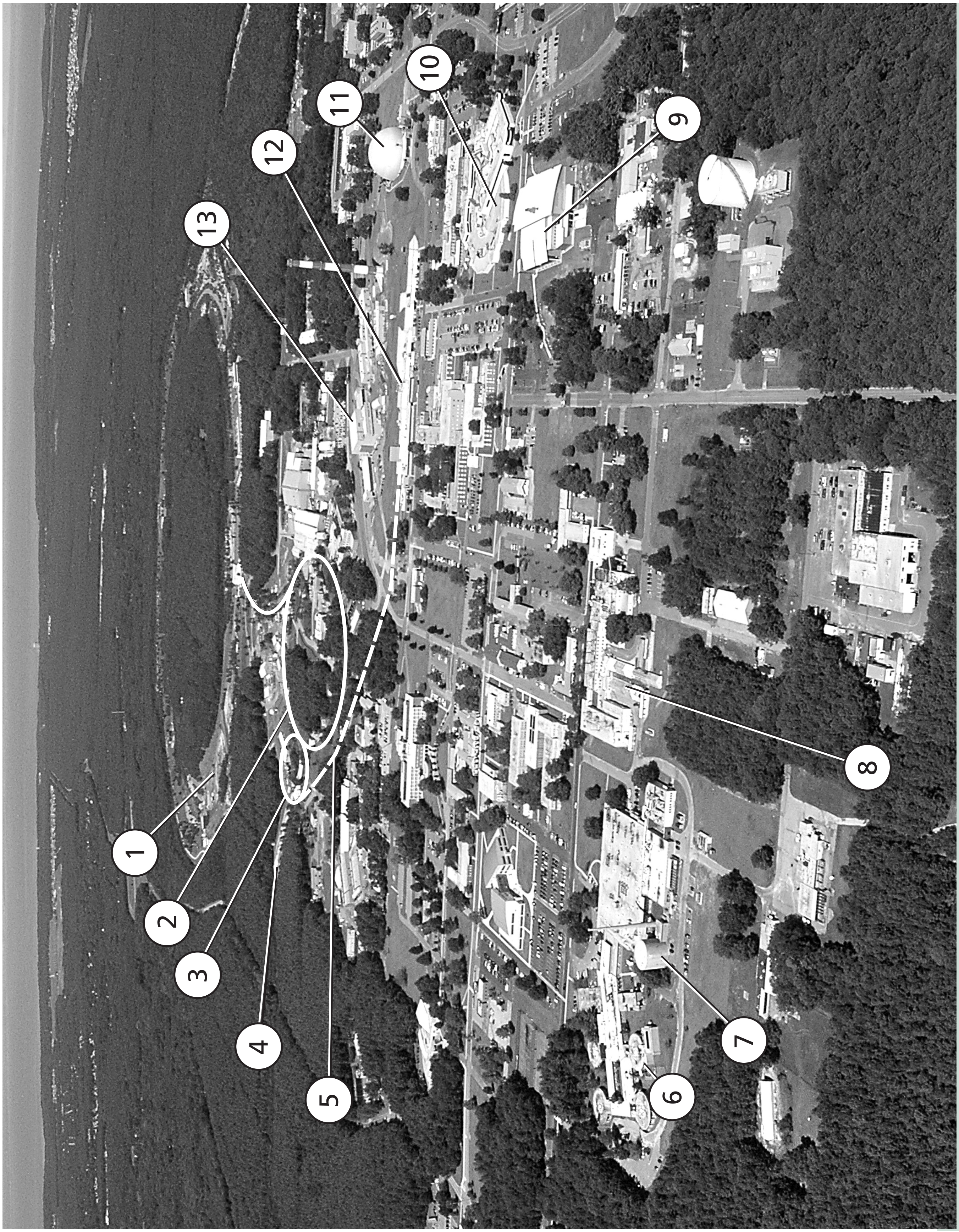


Figure 1-1. Major Scientific Facilities at BNL.

1. Relativistic Heavy Ion Collider (RHIC)

The RHIC is a world-class scientific research facility. The RHIC accelerator drives two intersecting beams of gold ions, other heavy metal ions, and protons head-on to form subatomic collisions. What physicists learn from these collisions may help us understand more about why the physical world works the way it does, from the smallest subatomic particles, to the largest stars. Current RHIC experiments include the Solenoidal Tracker at RHIC (STAR), a detector used to track particles produced by ion collisions; the PHENIX detector, used to record different particles emerging from collisions; the Broad Range Hadron Magnetic Spectrometer (BRAHMS), used to study particles as they pass through detectors; and PHOBOS, a detector designed to examine and analyze a very large number of unselected gold ion collisions.

2. Alternating Gradient Synchrotron (AGS)

The AGS is a particle accelerator used to propel protons and heavy ions, such as gold and iron, to high energies for physics research. The Linear Accelerator (Linac) serves as a proton injector for the AGS Booster.

3. AGS Booster

The AGS Booster is a circular accelerator used for physics research and radiobiology studies. It receives either a proton beam from the Linac or heavy ions from the Tandem Van de Graaff and accelerates these before injecting them into the AGS ring for further acceleration. The Booster also serves as the energetic heavy ion source for the NASA Space Radiation Laboratory, which is used to simulate the harsh cosmic and solar radiation environment found in space.

4. Linear Accelerator (Linac) and Brookhaven Linac Isotope Producer (BLIP)

The Linac provides beams of polarized protons for the AGS and RHIC. The excess beam capacity is used to produce radioisotopes for research and medical imaging at the BLIP. The BLIP is one of the nation's key production facilities for radioisotopes, which are crucial to clinical nuclear medicine. The BLIP also supports research on new diagnostic and therapeutic radiopharmaceuticals.

5. Heavy Ion Transfer Line (HITL)

The HITL connects the Tandem Van de Graaff and the AGS Booster. This interconnection enables the transport of ions of intermediate mass to the AGS Booster, where they are accelerated before injection into the AGS. The ions are then extracted and sent to the AGS experimental area for physics research.

6. Radiation Therapy Facility (RTF)

Part of the Medical Research Center, the RTF is a high-energy dual x-ray mode linear accelerator used for radiation therapy for 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 BMRR was the world's first nuclear reactor built exclusively for medical research and therapy. It produced neutrons in an optimal energy range for experimental treatment of a type of brain cancer known as glioblastoma multiforme. The BMRR was shut down in December 2000 due to a reduction in medical research funding.

8. Scanning Transmission Electron Microscope (STEM)

The STEM facility includes two microscopes, STEM 1 and STEM 3, used for biological research. Both devices allow scientists to see the intricate details of living things, from bacteria to human tissue. The images provide a picture and data that are used in Mass Analysis.

9. Center for Functional Nanomaterials (CFN)

The CFN provides state-of-the-art capabilities for the fabrication and study of nanoscale materials, with an emphasis on atomic-level tailoring to achieve desired properties and functions. The CFN is a science-based user facility, simultaneously developing strong scientific programs while offering broad access to its capabilities and collaboration through an active user program. The overarching scientific theme of the CFN is the development and understanding of nanoscale materials that address the Nations' challenges in energy security, consistent with the Department of Energy mission.

10. National Synchrotron Light Source (NSLS)

The NSLS uses a linear accelerator and booster synchrotron as an injection system for two electron storage rings that provide intense light spanning the electromagnetic spectrum from the infrared through x-rays. The properties of this light and the 80 specially designed experimental stations, called beamlines, allow scientists to perform a large variety of experiments.

11. High Flux Beam Reactor (HFBR)

The HFBR was one of the premier neutron physics research facilities in the world. Neutron beams produced at the HFBR were used to investigate the molecular structure of materials, which aided in pharmaceutical design and materials development and expanded the knowledge base of physics, chemistry, and biology. The HFBR was permanently shut down in November 1999 and is currently being decommissioned under the Environmental Restoration Program.

12. Tandem Van de Graaff and Cyclotron

These accelerators are used in medium energy physics investigations and for producing special nuclides. The Tandem Van de Graff accelerators are used to bombard materials with ions for manufacturing and testing purposes, and to supply RHIC with heavy ions. The cyclotrons, operated by the Chemistry Department, are used for the production of radiotracers for use in Positron Emission Tomography and Magnetic Resonance Imaging studies.

13. Brookhaven Graphite Research Reactor (BGRR)

The BGRR was the first reactor to be constructed in the United States following World War II. It was used for scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. The BGRR is currently being decommissioned under the Environmental Restoration Program.

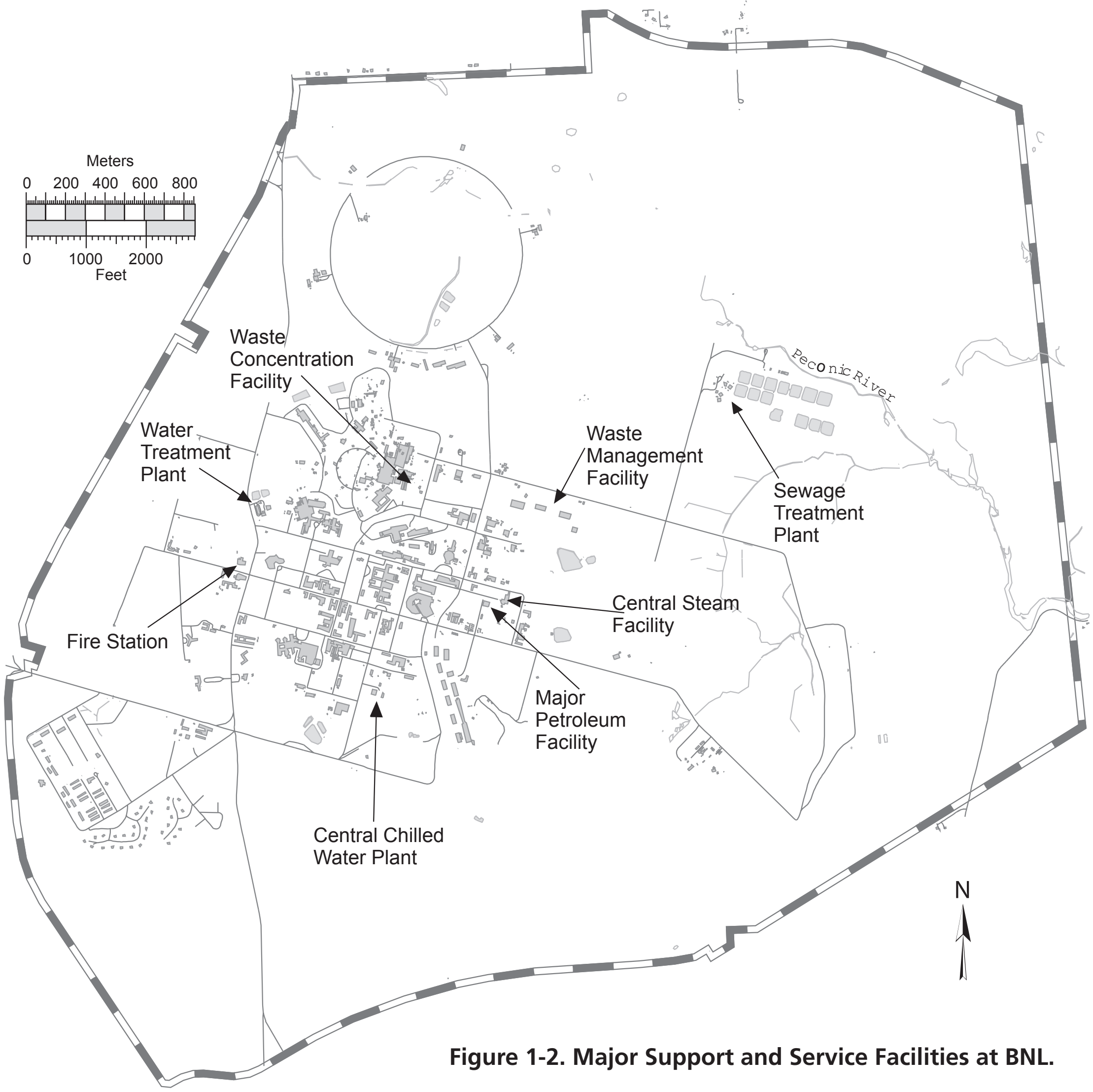


Figure 1-2. Major Support and Service Facilities at BNL.

is part of the Town of Brookhaven, the largest township (both in area and population) in Suffolk County. The Laboratory is one of the five largest, high-technology employers on Long Island, with approximately 2,800 employees that include scientists, engineers, technicians, and administrative personnel. More than 75 percent of BNL employees live and shop in Suffolk County. In addition, BNL annually hosts an estimated 4,000 visiting scientists, more than 30 percent of whom are from New York State universities and businesses. The visiting scientists and sometimes their families, as well as visiting students, reside in apartments and dormitories on site or in nearby communities.

An independent Suffolk County Planning Commission report concluded that BNL's spending for operations, procurement, payroll, construction, medical benefits, and technology transfer spreads throughout Long Island's economy, making BNL vital to the local economic health, as well as to New York State (Kamer 2006). In 2008, BNL purchased more than $32.5 million worth of supplies and services from Long Island businesses. Approximately $5.8 million was spent on 508 purchases in Nassau County, and $26.6 million was spent on 3,001 purchases in Suffolk County. BNL's total annual budget in 2008 was approximately $530.9 million, of which approximately 60.7 percent was spent on employee salaries, wages, and fringe benefits.

1.6 GEOLOGY AND HYDROLOGY

BNL is situated on the western rim of the shallow Peconic River watershed. The marshy areas in the northern and eastern sections of the site are part of the headwaters of the Peconic River. Depending on the height of the water table relative to the base of the riverbed, the Peconic River both recharges to, and receives water from, the underlying upper glacial aquifer. In times of sustained drought, the river water recharges to the groundwater; with normal to above-normal precipitation, the river receives water from the aquifer.

In general, the terrain of the BNL site is gently rolling, with elevations varying between 44 and 120 feet above mean sea level. Depth to groundwater from the land surface ranges from 5 feet near the Peconic River to about 80 feet in the higher elevations of the central and western portions of the site. Studies of Long Island hydrology and geology in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits, composed of highly permeable glacial sands and gravel, are between 120 and 250 feet thick (Warren et al. 1968, Scorca et al. 1999). Water penetrates these deposits readily, and there is little direct runoff into surface streams unless precipitation is intense. The sandy deposits store large quantities of water in the Upper Glacial aquifer. 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 the groundwater (Koppelman 1978).

The Long Island Regional Planning Board and Suffolk County have identified the Laboratory site as overlying a deep-flow recharge zone for Long Island groundwater (Koppelman 1978). Precipitation and surface water that recharge within this zone have the potential to replenish the Magothy and Lloyd aquifer systems lying below the Upper Glacial aquifer. It has been estimated that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. The extent to which groundwater on 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 & Miller 1996). This groundwater system is the primary source of drinking water for both on- and off-site private and public supply wells and has been designated a sole source aquifer system by the Environmental Protection Agency.

During 2008, the Laboratory used approximately 1.15 million gallons of groundwater per day to meet potable water needs and heating and cooling requirements. Approximately 75 percent of the water pumped from BNL supply wells is returned to the aquifer through on-site recharge basins and permitted discharges to the Peconic River. Under normal hydrologic conditions, most of the water discharged to the river recharges to the Upper Glacial aquifer before leaving the site. Human consumption, evaporation (cooling tower and wind losses), and sewer line losses account for the remaining 25 percent. An additional 3.4 million gallons of groundwater were pumped each day from remediation wells. This water is treated to remove contaminants and is then returned to the aquifer by way of recharge basins or injection wells.

Groundwater flow directions across the BNL site are influenced by natural drainage systems: eastward along the Peconic River, southeast toward the Forge River, and south toward the Carmans River (Figure 1-3). Pumping from on-site supply wells affects the direction and speed of groundwater flow, especially in the central, developed areas of the site. The main groundwater divide on Long Island is aligned generally east–west and lies approximately one-half mile north of the Laboratory. Groundwater north of the divide flows northward and ultimately discharges to the Long Island Sound. Groundwater south of the divide flows east and south, discharging to the Peconic River, Peconic Bay, south shore streams, Great South Bay, and Atlantic Ocean. The regional groundwater flow system is discussed in greater detail in Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity (Scorca et al. 1999). In most areas at BNL, the horizontal velocity of groundwater is approximately 0.75 to 1.2 feet per day (Geraghty & Miller 1996). In general, this means that groundwater travels for approximately 20 to 22

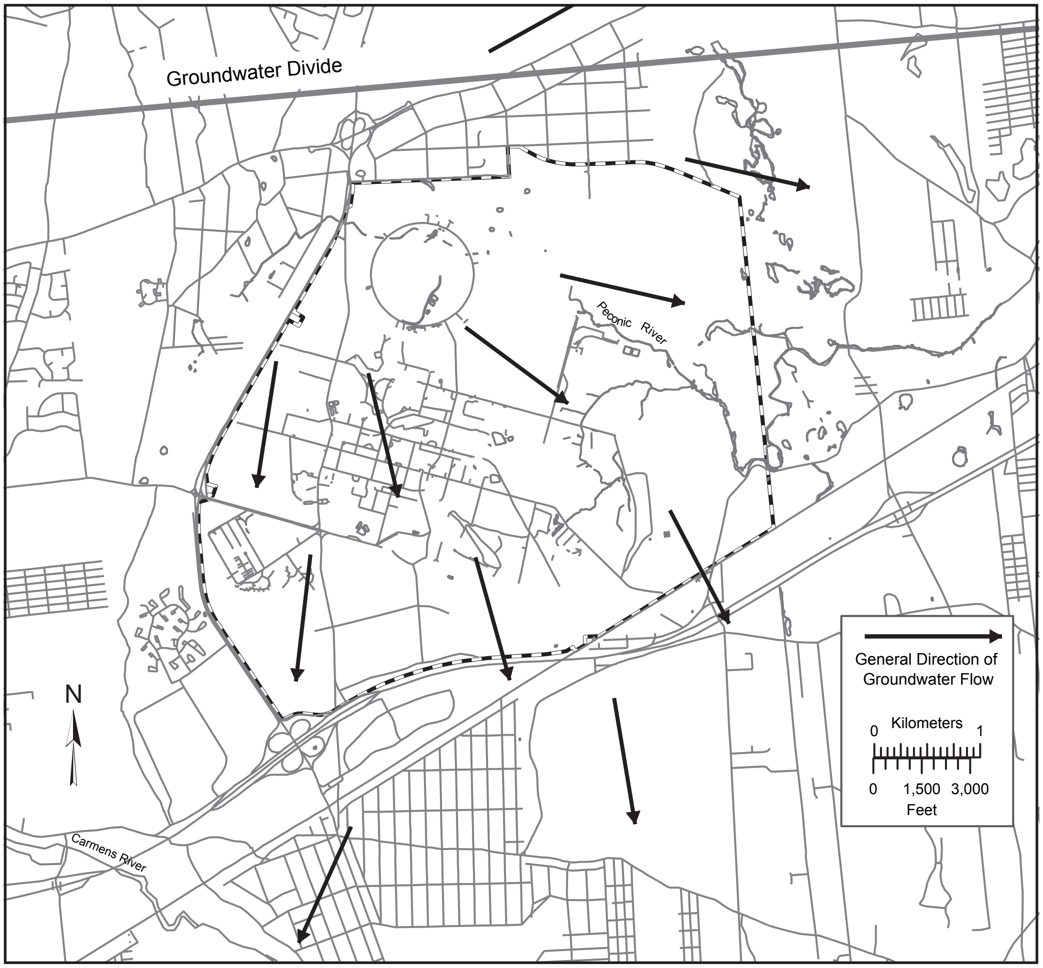


Figure 1-3. BNL Groundwater Flow Map.

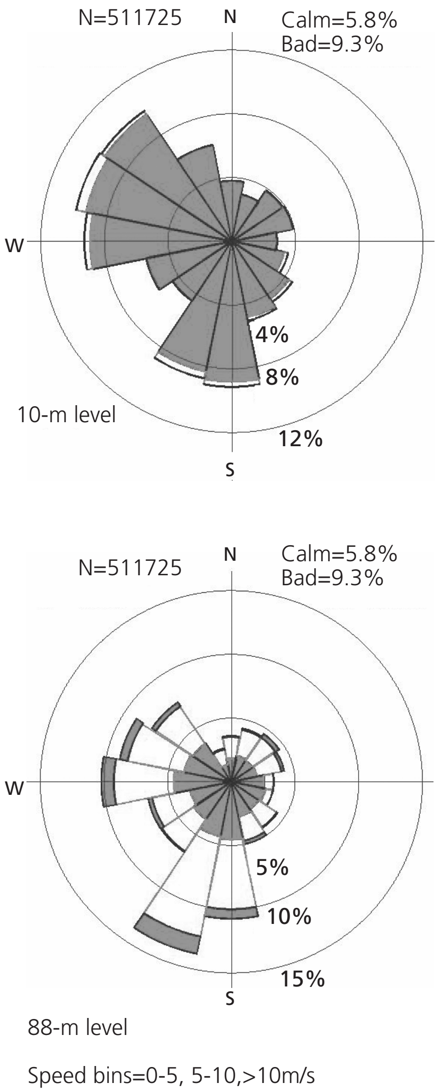
years as it moves from the central, developed area of the site to the Laboratory's southern boundary.

1.7 CLIMATE

The Meteorological Group at BNL has been recording weather data on site since 1949. The Laboratory is broadly influenced by continental and maritime weather systems. Locally, the Long Island Sound, Atlantic Ocean, and associated bays influence wind directions and humidity and provide a moderating influence on extreme summer and winter temperatures. The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from those two directions during the spring and fall (Nagle 1975, 1978). Figure 1-4 shows the 2008 annual wind rose for BNL, which depicts the annual frequency distribution of wind speed and direction, measured at an on-site meteorological tower at heights of 33 feet (10 meters) and 300 feet (88 meters) above land surface.

The average monthly temperature in the area for 2008 was 51.97 degrees Fahrenheit (°F). The average yearly temperature for the area was 50.23°F. Figures 1-5 and 1-6 show the 2008 monthly mean temperatures and the historical annual mean temperatures, respectively.

The total annual precipitation in 2008 was 51.64 inches. Figures 1-7 and 1-8 show the 2008 monthly and the 60-year annual precipitation data. Snowfall for the 2007–2008 winter season was 11.5 inches, well below the 31.2 inches of average yearly snowfall for Long Island, and about 10 times less than the record high snowfall of 90.8 inches, set in the 1995–1996 snow season.



Explanation: The arrows formed by the wedges indicate wind direction. Each concentric circle represents a 5 percent frequency; that is, how often the wind came from that direction. The wind direction was measured at heights of 10 and 88 meters. This diagram indicates that the predominant wind direction was from the south southwest at the 10-m level and west northwest at the 88-m level. Due to instrument failure, the 2008 Wind Rose data is limited to January through August 2008.

Figure 1-4. BNL Wind Rose (2008).

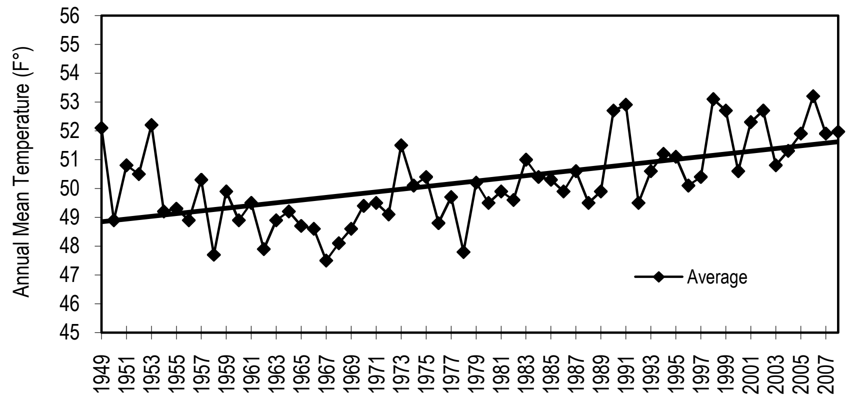


Figure 1-5. BNL 2008 Monthly Mean Temperature versus 60-Year Monthly Average.

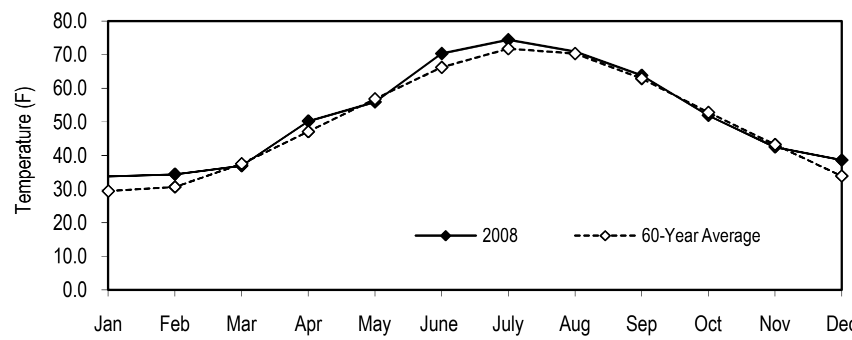


Figure 1-6. BNL Annual Mean Temperature Trend (60 Years).

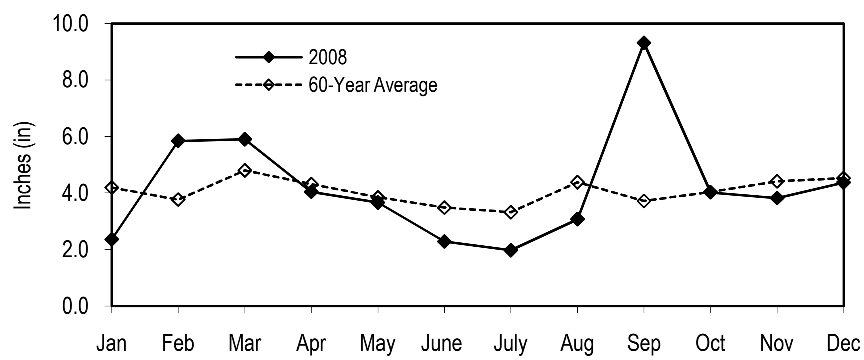


Figure 1-7. BNL 2008 Monthly Precipitation versus 60-Year Monthly Average.

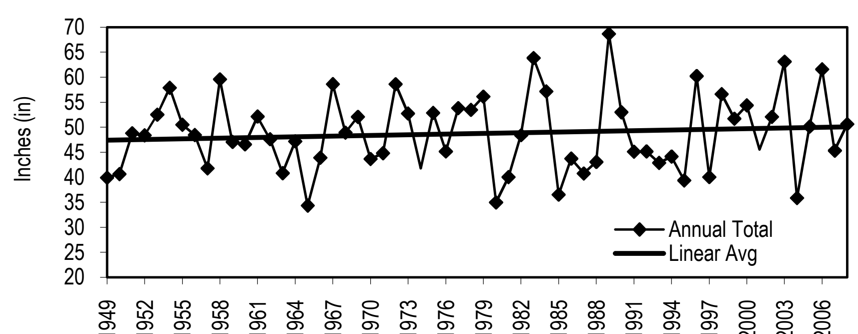


Figure 1-8. BNL 2008 Annual Precipitation Trend (60 Years).

1.8 NATURAL RESOURCES

The Laboratory is located in the oak/chestnut forest region of the Coastal Plain and constitutes about 5 percent of the 100,000-acre New York State–designated region on Long Island known as the Central Pine Barrens. The section of the Peconic River running through BNL is designated as "scenic" under the New York State Wild, Scenic, and Recreational River System Act of 1972. Due to the general topography and porous soil, the land is very well drained and there is little surface runoff or open standing water. However, depressions form numerous small, pocket wetlands with standing water on a seasonal basis (vernal pools), and there are six regulated wetlands on site. Thus, a mosaic of wet and dry areas correlates with variations in topography and depth to the water table.

Vegetation on site is in various stages of succession, which reflects a history of disturbances to the area. For example, when Camp Upton was constructed in 1917, the site was entirely cleared of its native pines and oaks. Although portions of the site were replanted in the 1930s, portions were cleared again in 1940 when Camp Upton was reactivated by the U.S. Army. Other past disturbances include fire, local flooding, and draining. Current operations minimize disturbances to the more natural areas of the site.

More than 230 plant species have been identified at the Laboratory, including two species that are threatened in New York State and two that are classified as rare. Fifteen animal species identified on site include a number that are protected in New York State, as well as species common to mixed hardwood forests and open grassland habitats. At least 85 species of birds have been observed nesting on site, and more than 200 transitory bird species have been documented visiting the site. (BNL is located within the Atlantic Flyway, with scrub/shrub habitats that offer food and rest to migratory songbirds.) Permanently flooded retention basins and other watercourses support amphibians and aquatic reptiles. Thirteen amphibian and 12 reptile species have been identified at BNL. Recent ecological studies have confirmed 26 breeding sites for the New York State endangered eastern tiger salamander in ponds and recharge basins. Ten species of fish have been identified as endemic to the site, including the banded sunfish and the swamp darter, both of which are threatened in New York State. Two types of butterflies that are protected in New York State are believed to breed on site due to the presence of their preferred habitat and host plants, and a New York State threatened damselfly was found on site in 2005. To eliminate or minimize any negative effects that Laboratory operations might cause to these species, precautions are in place to protect the on-site habitats and natural resources.

In November 2000, DOE established the Upton Ecological and Research Reserve at BNL. The 530-acre Upton Reserve (10 percent of the Laboratory's property) is on the eastern portion of the site, in the Core Preservation Area of the Central Pine Barrens. The Upton Reserve creates a unique ecosystem of forests and wetlands that provides habitats for plants, mammals, birds, reptiles, and amphibians. From 2000 to 2004, funding provided by DOE under an Inter-Agency Agreement between DOE and the U.S. Fish & Wildlife Services was used to conduct resource management programs for the conservation, enhancement, and restoration of wildlife and habitat in the reserve. In 2005, management was transitioned to the Foundation for Ecological Research in the Northeast (FERN). Management of the Upton Reserve falls within the scope of BNL's Natural Resource Management Plan, and the area will continue to be managed for its key ecological values and as an area for ecological research. Additional information regarding the Upton Reserve and the Laboratory's natural resources can be found in Chapter 6 of this report.

1.9 CULTURAL RESOURCES

The Laboratory is responsible for ensuring compliance with historic preservation requirements. BNL's Cultural Resource Management Plan was developed to identify, assess, and document the Laboratory's historic and cultural resources. These resources include World War I trenches; Civilian Conservation Corps features; World War II buildings; and historic structures, programs, and discoveries associated with high-energy physics, research reactors, and other science conducted at BNL. The Laboratory currently has three facilities classified as eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, and the World War I training trenches associated with Camp Upton. Further information can be found in Chapter 6.

REFERENCES AND BIBLIOGRAPHY

BNL. 2003. *Natural Resource Management Plan for Brookhaven National Laboratory.* Brookhaven National Laboratory, Upton, NY.

BNL. 2005. *Cultural Resource Management Plan for Brookhaven National Laboratory.* Brookhaven National Laboratory, Upton, NY.

DOE Order 231.1.A. 2003. *Environment, Safety and Health Reporting.* U.S. Department of Energy, Washington, DC.

Geraghty and Miller, Inc. 1996. *Regional Groundwater Model, Brookhaven National Laboratory, Upton, New York. A Report to Brookhaven National Laboratory.* November 1996.

Kamer, Pearl M. 2006. *The Economic Impact of Brookhaven National Laboratory on the New York State.* Suffolk County Planning Commission, Suffolk County Department of Planning. October 2005.

Koppelman, L.E. 1978. *The Long Island Comprehensive Waste Treatment Management Plan (Long Island 208 Study), Vol. I and II.* Long Island Regional Planning Board, Hauppauge, NY. July 1978.

Nagle, C.M. 1975. *Climatology of Brookhaven National Laboratory: 1949–1973.* BNL-50466. Brookhaven National Laboratory, Upton, NY. November 1975.

Nagle, C.M. 1978. *Climatology of Brookhaven National Laboratory: 1974–1977.* BNL-50857. Brookhaven National Laboratory, Upton, NY. May 1978.

NYCRR. Title 27. *Wild, Scenic, and Recreational River Systems Act.* Article 15 and subsequent updates. New York State Department of Environmental Conservation, Albany, NY.

Scorca, M.P., W.R. Dorsch, and D.E. Paquette. 1999. *Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, New York, 1994–97.* U.S. Geological Survey Water Resources Investigations Report 99-4086. 55 pp.

Warren, M.A., W. deLaguna, and N.J. Lusczynski.1968. *Hydrology of Brookhaven National Laboratory and Vicinity, Suffolk County, New York.* U.S. Geological Survey Bulletin, 1156-C.

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Environmental Management System 2

One of Brookhaven National Laboratory's highest priorities is ensuring that its environmental commitment is as strong as its passion for discovery. The contractor operating the Laboratory on behalf of DOE, Brookhaven Science Associates (BSA), takes environmental stewardship very seriously. As part of their commitment to environmentally responsible operations, they have established the BNL Environmental Management System (EMS). One measure of an effective EMS is recognition of good environmental performance. In 2008, the Laboratory was recognized with three national or regional environmental awards: DOE awarded BNL a P2 STAR Honorable Mention for pollution prevention practices in the Study of DNA Repair Using Fluorescently Labeled Oligonucleotides; the Laboratory received its second Silver Level Award for Electronics Recycling from the Office of the Federal Environmental Executive; and BNL was named the Northeast Region winner in the Office of the Federal Environmental Executive's annual Electronics Reuse & Recycling Campaign. The Laboratory reused or recycled 143,600 pounds of electronics during fiscal year 2008, a period from October 1, 2007 to September 30, 2008.

An EMS ensures that environmental issues are systematically identified, controlled, and monitored. Moreover, an EMS provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement. The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized International Organization for Standardization (ISO) 14001 Environmental Management Standard, with additional emphasis on compliance, pollution prevention, and community involvement.

Annual audits are required to maintain EMS registration. Recertification audits of the entire EMS occur every three years. In 2008, an EMS Surveillance Audit determined that BNL remains in conformance with the ISO 14001: 2004 Standard.

BNL continued its strong support of its Pollution Prevention Program, which seeks ways to eliminate waste and toxic materials. In 2008, pollution prevention projects resulted in more than $1.8 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 9.7 million pounds of waste. Also in 2008, the BNL Pollution Prevention Council funded five new proposals or special projects, investing approximately $16,000. Anticipated annual savings from these projects are estimated at approximately $14,000, for an average payback period of less than 1.3 years. The ISO 14001-registered EMS and the nationally recognized Pollution Prevention Program continue to contribute to the Laboratory's success in promoting pollution prevention.

BNL continues to address legacy issues under the Environmental Restoration Projects Division and openly communicates with neighbors, regulators, employees, and other interested parties on environmental issues and cleanup progress on site.

2.1 INTEGRATED SAFETY MANAGEMENT, ISO 14001, AND OHSAS 18001

The Laboratory's Integrated Safety Management System (ISMS) integrates environment, safety, and health management into all work planning. The integrated safety processes within ISMS contributed to BNL achieving ISO 14001 and Occupational Safety and Health Assessment Series (OHSAS) 18001 registrations.

The ISO 14001 Standard is globally recognized and defines the structure of an organization's EMS for purposes of improving environmental performance. OHSAS 18001 mirrors the ISO 14001 structure. The process-based structure of the ISO 14001 and OHSAS 18001 standards are based on the "Plan-Do-Check-Act" improvement cycle. Both standards require an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take corrective actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness. To gain registration to the ISO 14001 and OHSAS 18001 standards, an organization must comply with the set of requirements listed and described in Table 2-1. Table 2-1 also defines where these requirements fit into the ISMS structure.

BNL's EMS was officially registered to the ISO 14001 Standard in July 2001 and was the first DOE Office of Science Laboratory to obtain third-party registration to this environmental standard. BNL was officially registered to the OHSAS 18001 Standard in 2006, and was again the first DOE Office of Science Laboratory to achieve this registration. Each certification requires the Laboratory to undergo annual audits by an accredited registrar to assure that the system is maintained.

In 2008, an EMS and OHSAS Surveillance Audit determined that BNL remains in conformance with the ISO 14001 and OHSAS 18001 standards. In their recommendation for continued certification, auditors from NSF-Interna-

Table 2-1. Elements of the Environmental Management System (EMS) and their Relationship to OHSAS 18001 and Integrated Safety Management (ISM) – Review of EMS Implementation at BNL.

<table>
<tr><th>ISO 14001 EMS Clause</th><th>OHSAS 18001 Clause</th><th>ISM Guiding Principle and Core Function</th></tr>
<tr><td>4.2 Environmental policy</td><td>4.2 OH&S policy</td><td>Core function 1: Define the scope of work
Guiding principle 1: Line manager clearly responsible for ES&H</td></tr>
<tr><td colspan="3">The Environmental, Safety, Security, and Health Policy is a statement of BNL's intentions and principles regarding overall environmental, safety, security, and health performance. It provides a framework for planning and action. In the policy, BNL has reaffirmed its commitment to the environment, safety, security, health, and compliance; the community; and continual improvement.</td></tr>
<tr><td>4.3.1 Environmental aspects</td><td>4.3.1 Planning for hazard identification, risk assessment, and risk control</td><td>Core function 2: Identify and analyze hazards associated with the work
Guiding principle 5: Identify ES&H standards and requirements</td></tr>
<tr><td colspan="3">When operations have an environmental aspect, BNL implements the EMS to minimize or eliminate any potential impact. The Laboratory evaluates its operations, identifies the aspects of operations that can impact the environment, and determines which of those potential impacts are significant. BNL has determined that the following aspects of its operations are significant and have the potential to affect the environment:</td></tr>
<tr><td>▪ Waste generation
▪ Atmospheric emissions
▪ Liquid effluents
▪ Storage or use of chemicals and radioactive materials</td><td>▪ Natural resource usage — power and water consumption
▪ Work with engineered nanomaterials
▪ Historical and cultural resources
▪ Environmental noise</td><td>▪ Disturbances to endangered species/protected habitats
▪ Soil activation
▪ Historical contamination</td></tr>
<tr><td>4.3.2 Legal and other requirements</td><td>4.3.2 Legal and other requirements</td><td>Core function 2: Identify and analyze hazards associated with the work
Guiding principle 5: Identify ES&H standards and requirements</td></tr>
<tr><td colspan="3">The Laboratory has implemented and continues to improve the Standards Based Management System (SBMS), a BNL web-based system designed to deliver Laboratory-level requirements and guidance to all staff. New or revised requirements (e.g., new regulations) are analyzed to determine their applicability and to identify any actions required to achieve compliance. This may involve developing or revising BNL documents or operating procedures, implementing administrative controls, providing training, installing engineered controls, or increasing monitoring.</td></tr>
</table>

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Table 2-1. Elements of the Environmental Management System (EMS) and their Relationship to OHSAS 18001 and Integrated Safety Management (ISM) – Review of EMS Implementation at BNL *(continued).*

ISO 14001 EMS Clause	OHSAS 18001 Clause	ISM Guiding Principle and Core Function
4.3.3 Objectives Targets and Programs	4.3.3 Objectives 4.3.4 OH&S management program(s)	Core function 1: Define the scope of work Guiding principle 5: Identify ES&H standards and requirements
The Performance Based Management System is designed to develop, align, balance, and implement the Laboratory's strategic objectives, including environmental objectives. Objectives and targets are developed by fiscal year (FY). The following objectives and targets in FY08 included:		
▪ Continually improving the EMS ▪ Improving compliance in targeted areas ▪ Integrating pollution prevention into work planning	▪ Improving communications, trust, and relationships with stakeholders on environmental programs and issues ▪ Fully implementing the BNL Groundwater Protection Management Program	▪ Ensuring responsible stewardship of natural and historical resources on site ▪ Efficiently implementing environmental restoration projects
Organizations within BNL develop action plans detailing how they will achieve their objectives and targets and commit the necessary resources to successfully implement both Laboratory-wide programs and facility-specific programs. BNL has implemented a Pollution Prevention Program to conserve resources and minimize waste generation. The Laboratory also has a budgeting system designed to ensure that priorities are balanced and that resources essential to the implementation and control of the EMS are provided.		
4.4.1 Resources, roles, responsibilities, and authority	4.4.1 Structure and responsibility	Core function 1: Define the scope of work Guiding principle 1: Line manager is clearly responsible for ES&H Guiding principle 2: Clear ES&H roles and responsibilities Guiding principle 4: Balanced priorities
All employees at BNL have specific roles and responsibilities in key areas, including environmental protection. Environmental and Waste Management technical support personnel assist the line organizations with developing and meeting their environmental responsibilities. Every Laboratory employee is required to develop a Roles, Responsibilities, Accountabilities, and Authorities (R2A2) document signed by the employee, their supervisor, and the supervisor's manager. Specifics on environment, safety, and health performance expectations are included in these documents.		
4.4.2 Competence, training, and awareness	4.4.2 Training, awareness, and competence	Core function 4: Perform work within controls Guiding principle 3: Competence commensurate with responsibilities
Extensive training on EMS requirements has been provided to staff whose responsibilities include environmental protection. BNL's training program includes general environmental awareness for all employees; regulatory compliance training for selected staff; and specific courses for managers, internal assessors, EMS implementation teams, and operations personnel whose work can impact the environment.		
4.4.3 Communication	4.4.3 Consultation and communication	Core function 4: Perform work within controls Core function 5: Provide feedback on adequacy of controls and continue to improve safety management Guiding principle 2: Clear ES&H roles and responsibilities
BNL continues to improve processes for internal and external communications on environmental issues. The Laboratory solicits input from interested parties such as community members, activists, civic organizations, elected officials, and regulators. This is accomplished primarily through the Citizens Advisory Committee and the Brookhaven Executive Roundtable. At the core of the communication and community involvement programs are the Environmental Safety, Security, and Health Policy and the Community Involvement Plan.		
4.4.4 Documentation	4.4.4 Documentation	Core function 2: Identify and analyze hazards associated with the work Guiding principle 6: Hazard controls tailored to work Guiding Principle 7: Operations authorization
BNL has a comprehensive, up-to-date set of Laboratory-wide environmental documents describing the EMS. Using the SBMS, staff can access detailed information on regulatory requirements, Laboratory-wide procedures, and manuals on how to control processes and perform their work in a way that protects the environment. The SBMS has improved the quality, usability, and communication of Laboratory-level requirements.		
4.4.5 Control of documents	4.4.5 Document and data control	Core function 4: Perform work within controls Guiding principle 6: Hazard controls tailored to work
The SBMS includes a comprehensive document control system to ensure effective management of procedures and other requirements documents. When facilities require additional procedures to control their work, document control protocols are implemented to ensure that workers have access to the most current versions of procedures.		

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Table 2-1. Elements of the Environmental Management System (EMS) and their Relationship to OHSAS 18001 and Integrated Safety Management (ISM) – Review of EMS Implementation at BNL *(concluded)*.

ISO 14001 EMS Clause	OHSAS 18001 Clause	ISM Guiding Principle and Core Function
4.4.6 Operational control	4.4.6 Operational control	Core function 2: Identify and analyze hazards associated with the work Core function 3: Develop and implement hazard controls Core function 4: Perform work within controls Guiding principle 5: Identify ES&H standards and requirements Guiding principle 6: Hazard controls tailored to work Guiding principle 7: Operations authorization
Operations at BNL are evaluated for the adequacy of current controls to prevent impacts to the environment. As needed, additional administrative or engineered controls are identified, and plans for upgrades and improvements are developed and implemented.		
4.4.7 Emergency preparedness and response	4.4.7 Emergency preparedness and response	Core function 2: Identify and analyze hazards associated with the work Core function 3: Develop and implement hazard controls Guiding principle 6: Hazard controls tailored to work
BNL has an Emergency Preparedness and Response Program and specialized staff to provide timely response to hazardous materials or other environmental emergencies. This program includes procedures for preventing, and as responding to emergencies.		
4.5.1 Monitoring and measurement	4.5.1 Performance measurement and monitoring	Core function 5: Provide feedback on adequacy of controls and continue to improve safety
Effluent and emission monitoring helps ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL has a comprehensive, Laboratory-wide Environmental Monitoring Program in place. Monitoring results are reported to regulatory agencies and are summarized annually in the Site Environmental Report. In addition, BNL tracks and trends its progress and performance in achieving environmental objectives and performance measures.		
4.4.2 Evaluation of compliance	NA	Core function 5: Provide feedback on adequacy of controls and continue to improve safety
Specific environmental legislation and regulations are evaluated and assessed on a program- or facility-specific basis. BNL has established a documented procedure for periodically evaluating its compliance with relevant environmental regulations. This procedure is often integrated in an organization's environmental, safety, and health inspection process, which is performed in a prioritized fashion by a team of experts including one on environmental regulatory issues. Periodically, the environmental support organizations will perform a regulatory assessment in a particular topical area to verify the compliance status of multiple organizations throughout the Laboratory. Lastly, external regulatory agencies and/or technical experts may conduct independent audits of compliance.		
4.5.3 Nonconformance, corrective action, and preventative action	4.5.2 Accidents, incidents, non-conformances, and corrective and preventative action	Core function 5: Provide feedback on adequacy of controls and continue to improve safety
BNL continues to improve processes that identify and correct problems. A Lessons Learned Program to prevent recurrences, a Laboratory-wide Self-Assessment Program, and an electronic web-based assessment and action tracking system have been implemented.		
4.5.2 Control of records	4.5.3 Records and records management	Core function 2: Identify and analyze hazards associated with the work Guiding principle 6: Hazard controls tailored to work Guiding principle 7: Operations authorization
EMS-related records, including audit and training records, are maintained to ensure integrity, facilitate retrieval, and protect them from loss.		
4.5.5 Internal audit	4.5.4 Audit	Core function 5: Provide feedback on adequacy of controls and continue to improve safety
To periodically verify that the EMS is operating as intended, audits are conducted. These audits, which are part of the Laboratory-wide Self-Assessment Program, are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. An independent accredited registrar also conducts ISO 14001 registration audits. In addition, compliance with regulatory requirements is verified through routine inspections, operational evaluations, and periodic audits.		
4.6 Management review	4.6 Management review	Core function 5: Provide feedback on adequacy of controls and continue to improve safety Guiding principle 1: Line manager clearly responsible for ES&H
In addition to audits, a management review process has been established to involve top management in the overall assessment of environmental performance, the EMS, and progress toward achieving environmental goals. This review also identifies, as necessary, the need for changes to, and continual improvement of, the EMS.		

tional Strategic Registrations, Ltd. highlighted six examples of BNL's continual improvement, some of which include an improved Management Review process and excellent spill prevention design practices. The auditors also identified one EMS minor nonconformance in Operational Control and three EMS opportunities for improvement: one in Operational Control and two in Objectives and Targets. Corrective actions were prepared for findings and will be tracked to closure.

2.2 ENVIRONMENTAL, SAFETY, SECURITY, AND HEALTH POLICY

The cornerstone of an EMS is a commitment to environmental protection at the highest levels of an organization. BNL's environmental commitments are incorporated into a comprehensive Environmental, Safety, Security, and Health (ESSH) Policy. The policy, issued and signed by the Laboratory Director, makes clear the Laboratory's commitment to environmental stewardship, the safety of the public and BNL employees, and the security of the site. The policy continues as a statement of the Laboratory's intentions and principles regarding overall environmental performance. It provides a framework for planning and action and is included in employee, guest, and contractor training programs. The ESSH Policy is posted throughout the Laboratory and on the BNL website at http://www.bnl.gov. The goals and commitments focusing on compliance, pollution prevention, community outreach, and continual improvement include:

- **Environment:** We protect the environment, conserve resources, and prevent pollution.
- **Safety:** We maintain a safe workplace, and we plan our work and perform it safely. We take responsibility for the safety of ourselves, coworkers, and guests.
- **Security:** We protect people, property, information, computing systems, and facilities.
- **Health:** We protect human health within our boundaries and in the surrounding community.
- **Compliance:** We achieve and maintain compliance with applicable ESSH requirements.
- **Community:** We maintain open, proactive, and constructive relationships with our employees, neighbors, regulators, DOE, and our other stakeholders.
- **Continual Improvement:** We continually improve ESSH performance.

2.3 PLANNING

The planning requirements of the ISO 14001 Standard require BNL to identify the environmental aspects and impacts of its activities, products, and services; to evaluate applicable legal and other requirements; to establish objectives and targets; and to create action plans to achieve the objectives and targets.

2.3.1 Environmental Aspects

An "environmental aspect" is any element of an organization's activities, products, and services that can interact with the environment. As required by the ISO 14001 Standard, BNL evaluates its operations, identifies the aspects that can impact the environment, and determines which of those impacts are significant. The Laboratory's criteria for significance are based on actual and perceived impacts of its operations and on regulatory requirements. BNL utilizes several processes to identify and review environmental aspects. Key among these is the Process Assessment Procedure. This is an evaluation that is documented on a Process Assessment Form, which consists of a written process description, a detailed process flow diagram, a regulatory determination of all process inputs and outputs, identification of pollution prevention opportunities, and identification of any assessment, prevention, and control measures that should be considered. Environmental professionals work closely with Laboratory personnel to ensure that environmental requirements are integrated into each process. Aspects and impacts are evaluated annually to ensure that they continue to reflect stakeholder concerns and changes in regulatory requirements.

2.3.2 Legal and Other Requirements

To implement the compliance commitments of the ESSH Policy and to meet its legal requirements, BNL has systems in place to review changes in federal, state, or local environmental regulations and to communicate those changes to affected staff. Laboratory-wide procedures for documenting these reviews and recording the actions required to ensure compliance are available to all staff through BNL's web-based Standards-Based Management System (SBMS) subject areas.

2.3.3 Objectives and Targets

The establishment of environmental objectives and targets is accomplished through a Performance Based Management System. This system is designed to develop, align, balance, and implement the Laboratory's strategic objectives, including environmental objectives. The system drives BNL's improvement agenda by establishing a prioritized set of key objectives, called the Performance Evaluation Management Plan. Annually, BSA works closely with DOE to clearly define expectations and performance measures. Factors for selecting environmental priorities include:

- Significant environmental aspects
- Risk and vulnerability (primarily, threat to the environment)
- Legal requirements (laws, regulations, permits, enforcement actions, and memorandums of agreement)
- Commitments (in the ESSH Policy) to regulatory agencies, and to the public
- Importance to DOE, the public, employees, and other stakeholders

Laboratory-level objectives and targets are developed on a fiscal year (FY) schedule. In FY08 (October 1, 2007 through September 30, 2008), BNL's environmental objectives included:

- Implement Executive Order 13423 and support it's energy reduction goals
- Continue to reduce mercury inventory
- Improve the Environmentally Preferable Purchasing Program
- Improve the Pollution Prevention Program
- Continue nuclear footprint reduction
- Improve electronics stewardship

2.3.4 Environmental Management Programs

Each organization within BNL develops an action plan detailing how they will achieve their environmental objectives and targets and commit the resources necessary to successfully implement both Laboratory-wide and facility-specific programs. BNL has a budgeting system designed to ensure that priorities are balanced and to provide resources essential to the implementation and control of the EMS. The Laboratory continues to review, develop, and fund important environmental programs to further integrate environmental stewardship into all facets of its missions.

2.3.4.1 Compliance

BNL has an extensive program to ensure that the Laboratory remains in full compliance with all applicable environmental regulatory requirements and permits. Legislated compliance is outlined by the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAPs), Clean Water Act (e.g., State Pollutant Discharge Elimination System [SPDES]), Safe Drinking Water Act (SDWA), Resource Conservation and Recovery Act (RCRA), and other programs. Other compliance initiatives at the Laboratory involve special projects, such as upgrading petroleum and chemical storage tank facilities, upgrading the sanitary sewer system, closing underground injection control devices, retrofitting or replacing air conditioning equipment refrigerants, and managing legacy facilities. See Chapter 3 for a list of regulatory programs to which BNL subscribes, and a thorough discussion of these programs and their status.

2.3.4.2 Groundwater Protection

BNL's Groundwater Protection Management Program is designed to prevent negative impacts to groundwater and to restore groundwater quality by integrating pollution prevention efforts, monitoring groundwater restoration projects, and communicating performance. The Laboratory has also developed a Groundwater Protection Contingency Plan that defines an orderly process for quickly taking corrective actions in response to unexpected monitoring results. Key elements of the groundwater program are full, timely disclosure of any off-normal occurrences, and regular communication on the performance of the program. Chapter 7 and SER Volume II, Groundwater Status Report, provide additional details about this program, its performance, and monitoring results for 2008.

2.3.4.3 Waste Management

As a byproduct of the world-class research it conducts, BNL generates a large range of wastes. These wastes include materials common to many businesses and industries, such as aerosol cans, batteries, paints, and oils. However, the Laboratory's unique scientific activities also generate waste streams that are subject to additional regulation and special handling, including radioactive, hazardous, and mixed waste.

Collecting, storing, transporting, and disposing of waste generated at the Laboratory is the responsibility of BNL's Waste Management Facility (WMF). This modern facility was designed for handling hazardous, industrial, radioactive, and mixed waste and is comprised of three staging areas: a facility for hazardous waste, regulated by RCRA; a mixed-waste building for material that is both hazardous and radioactive; and a reclamation building for radioactive material. The RCRA and mixed-waste buildings are managed under a permit issued by the New York State Department of Environmental Conservation (NYSDEC). These buildings are used for short-term storage of waste before it is packaged or consolidated for off-site shipment to permitted treatment and disposal facilities. Due to the relatively small quantities and infrequent generation of mixed waste, BNL is seeking to reduce its waste storage footprint by consolidating hazardous and mixed wastes into its RCRA waste building. This will enable the eventual closure of the mixed waste building and its removal from the NYSDEC Permit. In 2008, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 5.5 tons
- Mixed waste: 12 ft^3
- Radioactive waste: 1,738 ft^3

Hazardous waste from routine operations in 2008 showed a small increase with respect to 2007 generation rates, as shown in Figure 2-1a, due to increased photowaste generation and the disposal of approximately 2,000 pounds of spent plating baths within BNL's Instrumentation Division. The decrease in routine mixed waste generation, as shown in 2-1b, can be attributed primarily to decreased generation within the Collider–Accelerator Department, which is normally associated with the dismantling/reconstruction of beamlines. As shown in Figure 2-1c, the radioactive waste quantity for routine operations also decreased, again with the Collider–Accelerator Department being the primary generator. These figures do not include wastes generated from nonroutine or one-time events and wastes generated from environmental restoration activities.

Routine operations are defined as ongoing industrial and experimental operations. BNL is currently cleaning up facilities and areas containing radioactive and chemical contamination resulting from long-past operations. Waste recovered through restoration and decommissioning activities is managed by the Environmental Restoration Projects (ERP) Division, with assistance from BNL's Environmental Protection Division (EPD).

In 2008, EPD continued surveillance and maintenance operations for the Brookhaven Medical Research Reactor (BMRR) and removed some of the equipment and components from the former Hot Laundry and Decontamination Facility in Building 650. Waste generation activity associated with the BMRR and the Decontamination Facility is reflected in the nonroutine waste values. Other nonroutine waste includes construction and demolition waste, legacy waste, lead-painted debris, lead shielding, and polychlorinated biphenyl (PCB) waste. Figures 2-1d through 2-1f show wastes generated under the ERP Division, as well as nonroutine operations. Waste generation from these activities has varied significantly from year to year. This was expected, as environmental restoration activities moved from remedial investigations and feasibility studies to remedial actions, which change annually based on the progress of the Laboratory's cleanup schedule. Nonroutine hazardous waste generation decreased substantially in 2008, as the project to remove some lead-contaminated soil from the former skeet range was completed.

2.3.4.4 Pollution Prevention and Minimization

The BNL Pollution Prevention (P2) Program is an essential element for the successful accomplishment of the Laboratory's broad mission. The P2 Program reflects the 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 Laboratory's operating philosophy.

During 2008, two DOE Orders were issued which incorporated the goals of Presidential Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management, released in 2007. DOE Order 430.2B, Departmental Energy, Utilities, and Transportation Management, was issued in February 2008. This DOE Order establishes federal requirements for energy efficiency and conservation, renewable energy, fleet management, water conservation, and sustainable buildings. DOE Order 450.1A, Environmental Protection Program, was issued in June 2008. This DOE Order establishes federal requirements for pollution prevention, reduction of toxic chemical use, purchasing of environmentally preferred products, electronic stewardship, and implementation of an Environmental Management System (EMS). These requirements will direct the future of BNL's P2 program and,

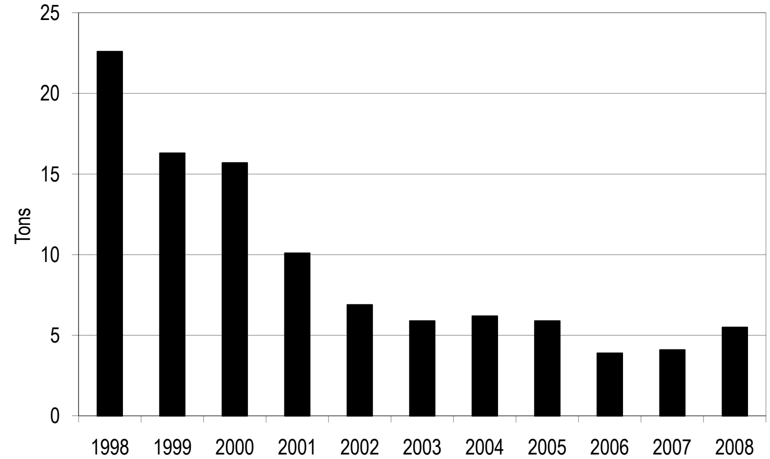

Figure 2-1a. Hazardous Waste Generation from Routine Operations, 1998 – 2008.

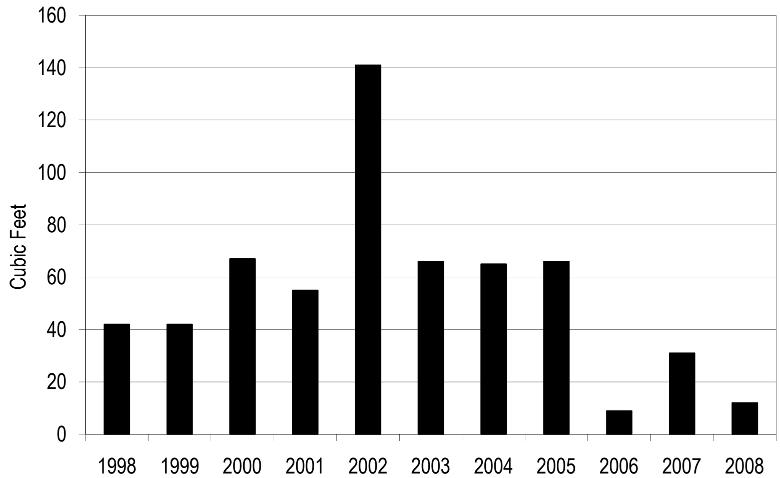

Figure 2-1b. Mixed Waste Generation from Routine Operations, 1998 – 2008.

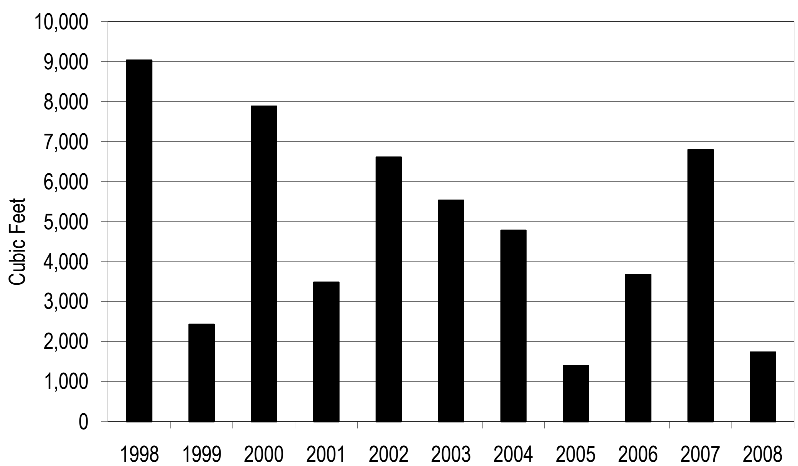

Figure 2-1c. Radioactive Waste Generation from Routine Operations, 1998 – 2008.

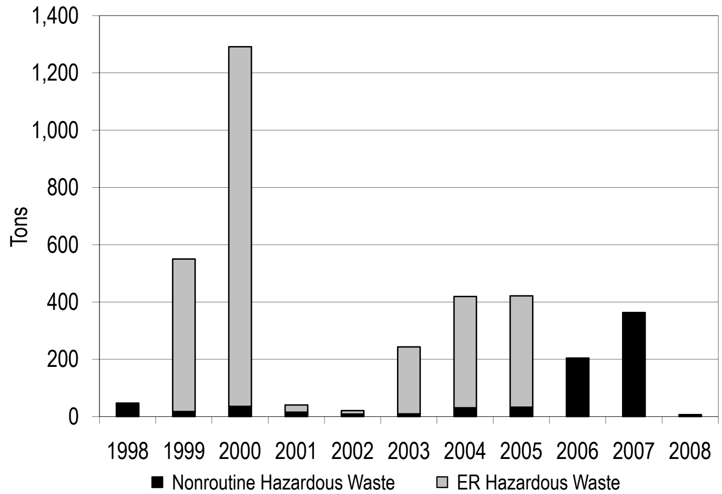

Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 1998 – 2008.

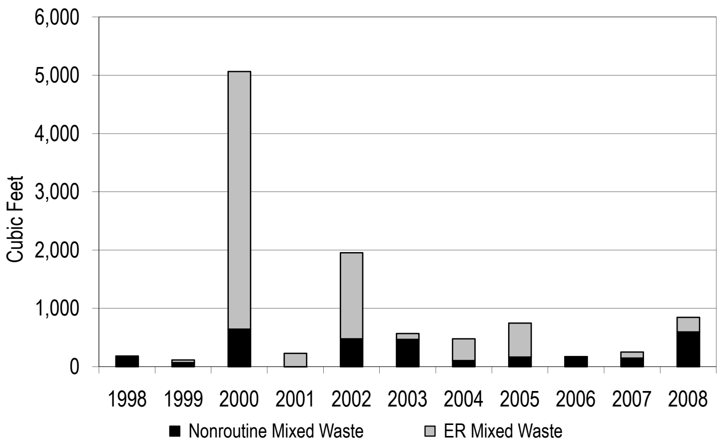

Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 1998 – 2008.

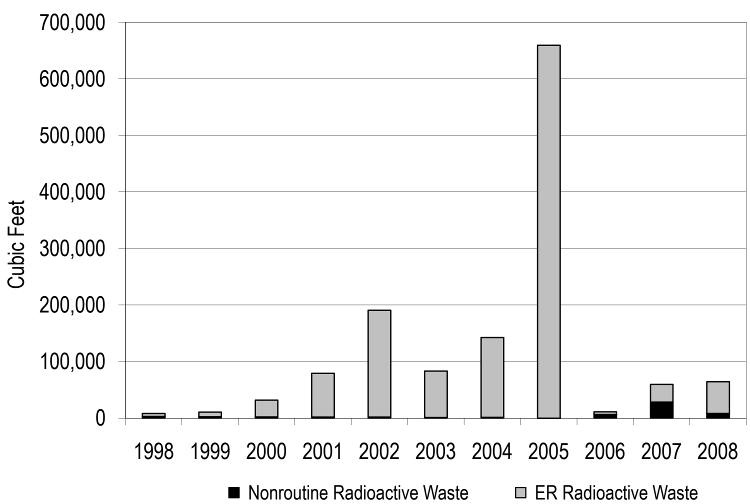

Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 1998 – 2008.

as discussed below, most have already been incorporated within the program.

Pollution prevention and waste reduction goals have been incorporated into the DOE contract with BSA, into BNL's ESSH Policy, and into the Performance Evaluation Management Plan associated with the Laboratory's operating contract with DOE. Key elements of the P2 Program include:

- Eliminate or reduce emissions, effluents, and waste at the source where possible, and ensure that they are "as low as reasonably achievable" (i.e., uphold the E-ALARA policy)
- Procure environmentally preferable products (known as "affirmative procurement")
- Conserve natural resources and energy
- Reuse and recycle materials
- Achieve or exceed BNL/DOE waste minimization, P2, recycling, and affirmative procurement goals
- Comply with applicable requirements (e.g., New York State Hazardous Waste Reduction Goal, Executive Orders, etc.)
- Reduce waste management costs
- Implement P2 projects
- Improve employee and community awareness of P2 goals, plans, and progress

Fifteen P2 proposals were submitted to the BNL P2 Council for funding in fiscal year 2008. Five proposals were funded, for a combined investment of approximately $16,000. The anticipated annual savings from these projects is estimated at $13,867, for an average payback period of approximately 1.3 years. The BNL P2 and recycling programs have achieved significant reductions in waste generated by routine operations, as shown in Figures 2-1a through 2-1c. This continues a positive trend and is further evidence that pollution prevention planning is well integrated into the Laboratory's work planning process. These positive trends are also driven by the EMS emphasis on preventing pollution and establishing objectives and targets to reduce environmental impacts.

Table 2-2 describes the P2 projects implemented through 2008 and provides the number of pounds of materials reduced, reused, or recycled, as well as the estimated cost benefit of each project.

The implementation of pollution prevention opportunities, recycling programs, and conservation initiatives has significantly reduced both waste volumes and management costs. In 2008, these efforts resulted in more than $1.8 million in cost avoidance or savings and approximately 9.7 million pounds of materials being reduced, recycled, or reused annually.

The Laboratory also has an active and successful solid waste recycling program, which involves all employees. In 2008, BNL collected more than 150 tons of office paper for recycling. Cardboard, bottles and cans, construction debris, motor oil, scrap metals, lead, automotive batteries, electronic scrap, fluorescent light bulbs, drill press machine coolant, and

Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs.

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2008	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Recycling containers	Recycling	600	Industrial waste	3,000	$3,253	$0	Purchased 34 sets of recycling containers to increase recycling rates in conference rooms.
Timer switches*	Energy conservation	N/A	Greenhouse gas	N/A	$3,415	$5,386	Installation of motion detector and IR lighting in in Building 535 labs.
Water timers	Water conservation	80,000	Potable water	N/A	$580	$164	Water timers allow the taps to be shut off after a specific amount of time running or a specified number of gallons is released, saving water and energy required to run the still.
Motion sensors for labs*	Energy conservation	N/A	Greenhouse gas	N/A	$4,320	$5,817	Installation of motion detector lighting in common areas of Buildings 490 and 463.
"Bio Circle Cleaner" parts washer	Substitution	640	Hazardous waste	$10,000	$4,461	$10,000	Eliminates the need for toxic solvents, chemical storage, and disposal associated with the cleaning of vacuum parts.
Aerosol can disposal system	Recycling	528	Hazardous waste	$12,000	$0	$12,000	Empty aerosol cans are recycled as scrap, rather then sent to the Waste Management Division as hazardous waste. Eight units (F&O=5; CA=1; NSLS=1; BES =1) each handle 66 lbs of hazardous waste.
Portable closed-head drum mixer	Neutralization	1,600	Hazardous waste	$9,720	$0	$9,720	The National Synchrotron Light Source (NSLS) bought a closed drum mixer to neutralize Rydlyme, used to descale cooling pipes.

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Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs *(continued)*.

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2008	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Formaldetox	Source reduction	8	Nonhazardous waste (neutralized approximately 1 gallon)	$25	$0	$25	Neutralizes nonhazardous para-formaldehyde, chlorix, bleach, and rat blood.
HPLC solvent recycler	Reuse	110	Hazardous waste	$2,500	$0	$6,755	Allows reuse of approximately 50 liters of solvent and saves approximately 50 labor hours.
Propane cylinder de-valver	Recycling	75	Hazardous waste	$7,500	$0	$7,500	The Collider Accelerator Division bought a propane cylinder de-valver to avoid sending cylinders to a disposal vendor at $75 each; they are now recycled as scrap.
Fluorescently labeled oligonucleotides	Waste minimization	3,144	Radiological waste (396 ft3); Mixed waste (35 galllons); Hazardous Waste (108 gallons)	$67,600	$0	$67,600	This project was cost-shared with Biology. The process avoids the use of radioactivity, thus avoiding radiological waste generation. This process won a 2008 DOE P2 Star Award.
Electronic recycling	Recycling	106,545	E-waste	N/A	$2,300	N/A	The Laboratory has partnered with a government-based e-waste recycler (UNICOR) which gurantees that its e-wate is recycled in the most environmentally friendly manor. BNL pays shipping fees to the recycling facility.
Building demolition recycling	Recycling	7,200,000	Industrial waste	$327,600	$32,000	$295,600	On-site demolition products (steel and concrete) are segregated, recycled, and reused.
System One parts cleaner	Substitution	640	Hazardous waste	$10,000	$0	$10,000	Plant Engineering bought a System One parts washer to re-distill dirty solvent, eliminating the need for a vendor, such as Safety Kleen. Removed grit and sludge are mixed with the waste oil.
Photon-counting spectro-fluorimeter	Substitution	54	Mixed waste (2 ft^3)	$29,792	$0	$79,792	Eliminated the need for radioactive assays and their radioactive waste. Savings include 1,000 work-hours and savings on material costs.
Replacement of mercury utility devices	Substitution	40	Mercury	$2,350	$4,000	$2,350	Approximately 48 lbs of mercury-containing devices were removed from utility devices during 2008. Savings are based on the cost of one mercury spill and cleanup.
Animal bedding conveying system	Composting	84,000	Low-level Radiological Waste	$841,428	$0	$841,428	Animal bedding material is no longer sent to sanitary landfill. It is now conveyed to a dumpster that is emptied or composted at the stump dump.
Plant Engineering grounds vehicle wash system *	Waste minimization	8,000	Oils/grease to soils	$16,000	$3,000	$13,000	This multi-year, multi-department project was completed in 2007 and eliminates the potential of oil and grease being released to soil.

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Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs *(continued)*.

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2008	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Organic solvents	Substitution	678	Hazardous waste	$1,694	$0	$26,000	A Microwave Peptide Synthesizer in Life Sciences significantly reduces the hazardous wastes generated and saves ~1,000 work-hours/year (reflected in cost savings).
Organic solvents	Purification/ reuse	44	Hazardous waste	$110	$0	$3,510	The primary savings of the BES solvent purification system are in not purchasing new solvent and labor savings from not running the stills.
Cooling water	Reuse	63,400	Deionized water	$0	$0	$7,925	A closed-cycle water recycling system for the Building 480 melt spinner saved 7,925 gallons of ultra-pure water and extends the life expectancy of equipment worth $100,000.
Mercury utility devices	Substitution	37	Mercury	$2,300	$0	$2,300	Plant Engineering replaced mercury-containing utility devices with mercury-free equipment in 2007. Savings are based on the cost of one mercury spill and cleanup.
Radioactive emissions	Emission reduction	0	Radioactive emissions	$0	$0	$0	A shroud was installed over the 16-inch diameter shaft in the Hot Cell of the Brookhaven Linac Isotope Producer, isolating cooling water from the rapidly moving air of the exhaust system and allowing radiological decay within the water system. Slowing the diffusion into the hot cell air will effectively reduce gaseous emissions into the exhaust stack, as these radionuclides have very short half lives. The shroud/ enclosure has been instrumental in reducing short-lived radioactive gaseous emissions. Beyond the environmental benefits associated with the project and due to the efficiency of the enclosure in reducing emissions, the facility has been able to stay below the emissions level that would require additional regulatory burdens.
Radioactive waste generated through wet chemistry	Waste minimization	30	Mixed waste/ Liquid radioactive waste	$17,600	$0	$22,500	The use of a Kinetic Phosphorescence Analyzer (KPA) system for uranium analysis eliminated mixed waste generation in a chemistry lab, reduced 90 percent of the volume of liquid waste, 90 percent of radioactive material handled, minimized exposure to uranium by Laboratory personnel, and decreased labor costs by 75 percent.
Radioactive waste from labeled chemicals	Waste minimization/ volume reduction	0	Solid radioactive waste	$2,168	$0	$2,168	A vial crusher for glass vials, pipettes, and other glassware reduces the volume of rad waste.

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Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs *(continued).*

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2008	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Radioactive and mixed wastes from radio-labeled chemicals	Waste minimization	112	Mixed waste	$27,690	$0	$27,690	Use of a microplate scintillation counter generates less mixed waste.
Electrophoretic Mini-Gels	Microscale chemical use	2,200	Hazardous waste - lab pack	$11,500	$0	$11,500	Minimizing silver waste from silver-staining electrophoretic mini-gels saves waste disposal costs and lowers material purchase costs ($6,000).
Film and other radioisotopic imaging	Substitution	300	Hazardous waste/ Industrial waste	$5,468	$0	$5,468	Replacement of film-based autoradiography and other radioisotopic imaging with a Phosphor Imager reduced waste generation by 200 lbs of hazardous waste and 100 lbs of industrial waste. Additional projected savings are in annual supply costs and labor reduction.
Lead acid batteries	Recycled	7,440	Universal waste	$30,132	$0	$30,132	Avoids hazardous waste disposal costs for approximately 40 lbs of lead per battery.
Ion exchange wastewater	Source reduction	1,250	Hazardous and sanitary wastewater	$3,125	$0	$3,125	Prefilters added to the deionization system polish makeup water entering the ion exchange system. This extends the useful life of the ion exchange resins, requiring less frequent regeneration. The regeneration process generates hazardous and sanitary waste.
Short half-life waste	Decay in storage	490	Radioactive waste	$16,389	$0	$16,389	Short half-life isotopes, particularly iodine-125 and phosphorus-32, are often used in life sciences experiments. In 2007, wastes from these operations (21.5 ft3 and 133 lbs of liquid) were managed in accordance with BNL decay-in-storage requirements, rendering the wastes eligible for volumetric release.
Cooling Tower chemicals	Source reduction	9,563	Industrial waste	$22,500	$0	$22,500	Ozone water treatment units were installed on cooling towers at SEM, the National Space Radiation Laboratory, and the Relativistic Heavy Ion Collider Reseach Facility for biological control of cooling water. These systems eliminate the need for water treatment chemicals (typically toxic biocides), save labor, and reduce analytical costs for monitoring cooling tower blowdown.
Blasocut machining coolant	Recycled/ Reused	26,720	Industrial waste	$71,154	$0	$76,754	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it Laboratory-wide. In 2008, 3,340 gal (26,720 lb) of Blasocut lubricant were recycled. Recycling involves aeration, centrifuge, and filtration. This avoids cost of disposal as industrial waste and an avoided cost of buying seven drums of concentrate ($800/drum) and 67 empty drums for shipping ($50/drum).

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Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs *(concluded).*

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2008	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details *
Used motor oil	Energy recovery	12,000	Industrial waste	$31,860	$0	$31,860	Used motor oil from the motor pool and the on-site gas station is given to Strebel's Laundry Service to fire their boilers. In 2008, they collected 1,500 gallons of oil at no charge to BNL, which avoided the costs for disposal and 30 shipping drums ($50/drum).
Office paper	Recycled	301,180	Industrial waste	$15,963	$0	$15,963	Cost avoidance based on $106/ton for disposal as trash.
Cardboard	Recycled	294,220	Industrial waste	$15,594	$0	$15,594	Cost avoidance based on $106/ton for disposal as trash.
Metals	Recycled	920,610	Industrial waste	$48,792	$0	$140,853	Cost avoidance based on $106/ton for disposal as trash, plus $150/ton revenue.
Bottles/cans	Recycled	39,140	Industrial waste	$2,074	$0	$2,074	Cost avoidance based on $106/ton for disposal as trash.
Construction debris	Recycled	604,760	Industrial waste	$13,607	$0	$13,607	Cost avoidance based on $45/ton difference for disposal as trash
	TOTALS	**9,688,918**		**$1,666,235**	**$41,300**	**$1,823,682**	

* Cost savings of projects funded by the BNL Pollution Prevention Council will be tracked for 3 years.

antifreeze were also recycled. A new metric incorporated during 2008 was the internal reuse of electronic equipment. During 2008, 16 tons of computer equipment were reused internally. Table 2-3 shows the total number of tons (or units) of the materials recycled in 2008.

2.3.4.5 Water Conservation

BNL's water conservation program has achieved dramatic reductions in water use since the mid 1990s. The Laboratory continually evaluates water conservation as part of facility upgrades or new construction initiatives. These efforts include more efficient and expanded use of chilled water for cooling and heating/ventilation and air conditioning (HVAC) systems, and reuse of once-through cooling water for other systems such as cooling towers. The goal is to reduce the consumption of potable water and reduce the possible impact of clean water discharges on Sewage Treatment Plant (STP) operations. Figure 2-2 shows the 10-year trend of water consumption. In each of the past 5 years, the water consumption total was less than half the 1998 total—a reduction of nearly a half-billion gallons per year.

2.3.4.6 Energy Management and Conservation

Since 1979, the Laboratory's Energy Management Group has been working to reduce energy use and costs by identifying cost-effective, energy-efficient projects, monitoring energy use and utility bills, and assisting in obtaining the least expensive energy sources possible. The group is responsible for developing, implementing, and coordinating BNL's Energy Management Plan and assisting DOE in meeting the energy goals in DOE Order 430.2B and the Secretary's Transformational Energy Action Management (TEAM) initiative.

The Laboratory has more than 4 million square feet of building space. Many BNL scientific experiments use particle beams generated and accelerated by electricity, with the particles controlled and aligned by large electromagnets. In 2008, the Laboratory used approximately 233 million kilowatt hours (kWh) of electricity, 708,000 gallons of fuel oil, 36,000 gallons of propane, and 517 million ft^3 of natural gas. Fuel

Table 2-3. BNL Recycling Program Summary.

Recycled Material	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Mixed paper	106	196	204	370	336	246	209	182	185	193	184	177	151
Cardboard	101	103	97	124	132	127	157	176	179	143	135	121	147
Bottles/Cans	15	21	22	21	20	29	19	23	22	22.1	27.7	24.4	19.6
Tires	17	18.6	11.5	15.2	0	0	3.5	12.3	11	12.8	32.5	19.9	34.5
Construction debris	837	799	527	352	243	289	304	334	367	350	297	287	302
Used motor oil (gallons)	4,275	4,600	3,810	3,570	3,295	3,335	1,920	3,920	3,860	4,590	2,780	2,020	1,500
Metals	158	266	64	47	534	38	48	193	128	559	158	382	460
Lead	–	4.4	3.7	0.7	2.5	0	0	–	5	0	0	0	0
Automotive batteries	6.8	4.3	2.1	1.1	2.2	4.8	6.3	4.6	5	4.6	5.5	2.5	2.7
Printer/Toner cartridges (units)	–	–	1,480/175	1,575/510	–	363	449	187	105	0	0	0	3,078
Fluorescent bulbs (units)	13,664	12,846	867	25,291	5,874	17,112	25,067	13,611	12,592	7,930	11,740	25,448	36,741
Blasocut coolant (gallons)	–	–	–	3,575	7,500	10,660	8,180	5,030	6,450	3,890	3,970	2,432	3,340
Antifreeze (gallons)	55	276	448	145	110	200	0	165	325	0	0	0	0
Tritium exit signs (each)	–	–	–	–	185	190	28	181	142	0	0	0	0
Smoke detectors	–	–	–	–	–	171	40	0	0	0	0	0	0
Road base	–	–	–	–	–	–	2,016	0	2,666	0	0	0	0
Electronic reuse	–	–	–	–	–	–	–	–	–	–	–	–	16.3
Scrap electronics	–	–	–	–	–	–	–	–	–	6.1	70.3	40.5	48.9
Animal Bedding (composted)	–	–	–	–	–	–	–	–	–	--	6.3	19.6	42
Metals (building demolition)	–	–	–	–	–	–	8	23	11	6	35	--	
Concrete (building demolition)	–	–	–	–	–	–	891	590	3,000	328	5,505	6,175	
Other construction and debris (building demolition)	–	–	–	–	–	–	790	388	1,200	157	818	--	

Notes:
All units are tons unless otherwise noted.

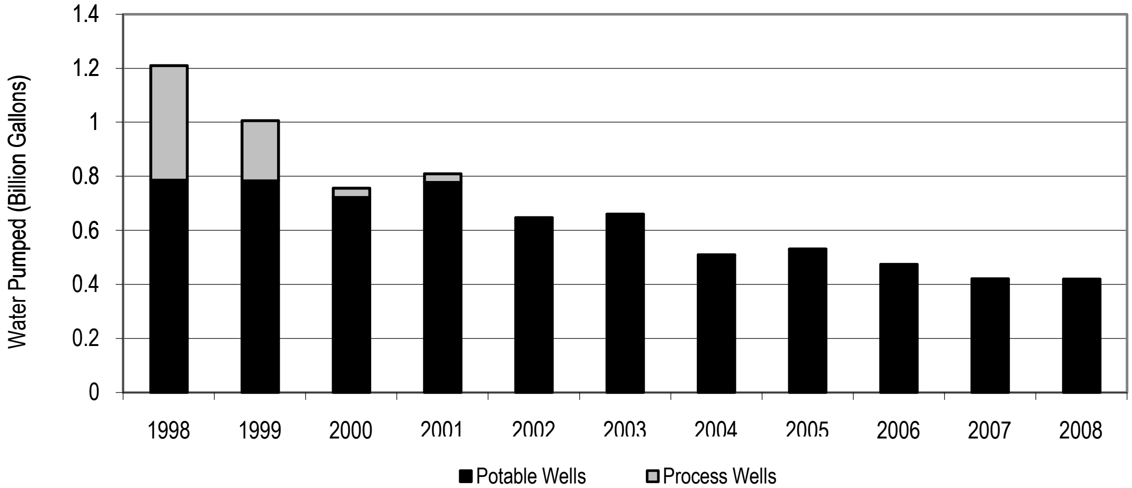

Figure 2-2. BNL Water Consumption Trend, 1998–2008.

oil and natural gas produce steam at the Central Steam Facility (CSF). Responding to market conditions, fuel oil and natural gas were used whenever each respective fuel was least expensive. Additional information on natural gas and fuel oil use can be found in Chapter 4. In addition, biofuels were used in several applications.

BNL is a participant in the New York Independent System Operator (NYISO) Special Case Resource (SCR) Program, which is an electric load reduction curtailment program. Through this program, the Laboratory has agreed to reduce electrical demand during critical days throughout the summer when NYISO expects customer demand to meet or exceed the available supply. In return, BNL receives a rebate for each megawatt reduced on each curtailment day. No curtailment days were requested in 2008, in part due to mild weather. However, mere participation in this program produced a rebate of $45,000. The Laboratory continues to keep electric loads at a minimum during the summer, by scheduling operations at the Relativistic Heavy Ion Collidar (RHIC) to avoid peak demand periods. This scheduling allowed BNL to save $4.2 million in electric costs in 2008 and greatly helps maintain the reliability of the Long Island Power Authority (LIPA) electric system to meet all of its users' needs.

BNL also maintains a contract with the New York Power Authority (NYPA) that resulted in an overall cost avoidance of $19 million in 2008. The Laboratory will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

In 2008, LIPA issued a Request for Proposals for 50 MW of solar photovoltaic (PV) generating projects. The construction of a 37 MW solar array at the Laboratory site by BP Solar was one of four projects selected by LIPA for development. BNL and DOE are in the early stages of planning with the developers and have been assured that any potential project will have minimal environmental impact.

To reduce energy use at non-research facilities, other activities also were undertaken in 2008. These activities included:

- An Initial Proposal for a sitewide Energy Savings Performance Contract (ESPC) audit was completed for the Laboratory by Constellation Energy. BNL is now in the process of determining whether to go forward with the next steps, which include a Detailed Energy Survey/Evaluation and a subsequent long-term contract. The Initial Proposal included projects that will reduce the Laboratory's overall energy intensity (Btu/ft^2) by 11 percent and will save over $2 million/year in energy costs.
- 25 MW of demand was rescheduled to avoid coinciding with the utility summer peak, saving several million dollars in electricity charges.

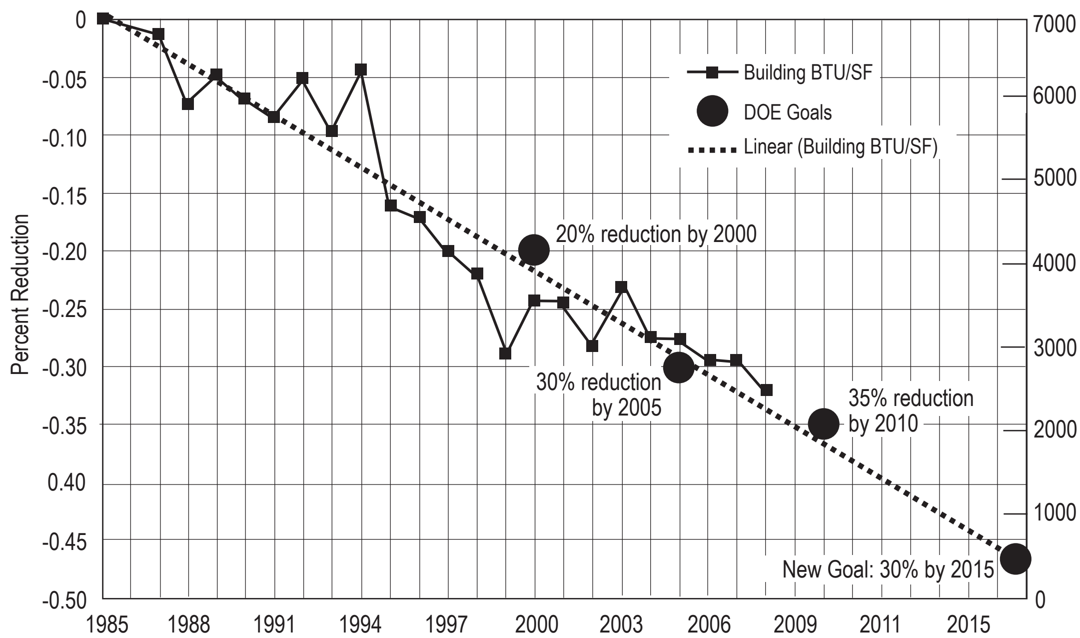

Figure 2-3. BNL Building Energy Performance.

- A demonstration project for a solar hot water combination system at BNL's Brookhaven Center was begun.
- Work continued in the replacement of aging, inefficient T-40 fluorescent lighting fixtures with new, efficient T-8 and T-5 units; two to three hundred fixtures are typically replaced annually, saving tens of thousands of kWhs and reducing costs by several thousand dollars.
- Due to continued conservation efforts, BNL's overall facilities energy usage for FY08 was approximately 11.6 percent less than in FY03, saving over $2.2 million.
- Efficient fuel purchasing strategies (buying and storing oil and burning the least expensive fuel) saved $1.3 million, compared to purchasing only oil as it is consumed.
- The Center for Functional Nanomaterials was completed and received LEED (Leadership in Energy and Environmental Design) silver certification.
- Over 25,000 gge (gasoline gallon equivalents) of natural gas were used in place of gasoline for the Laboratory's vehicle fleet.

The National Energy Conservation Policy Act, as amended by the Federal Energy Management Improvement Act of 1988 and the Energy Policy Acts of 1992 and 2005, requires federal agencies to apply energy conservation measures and to improve federal building design to reduce energy consumption per square foot. Current goals are to reduce energy consumption per square foot, relative to 2003, by 2 percent per year from FY06–FY15. In 2007, an Executive Order increased the target reduction to 3 percent per year, which is a 30 percent reduction by the end of FY2015. Further, DOE Order 430.2B and the Secretary's TEAM initiative have set even more stringent requirements, including renewable energy and transportation fuels that go significantly beyond the previous goal of a 30 percent reduction by 2005, compared to 1985. BNL's energy use per square foot in 2008 was over 30 percent less than in 1985 (see Figure 2-3) and 11.6 percent less than 2003. It is important to note that energy use for buildings and facilities at the Laboratory is largely weather dependent.

2.3.4.7 Natural and Cultural Resource Management Programs

BNL continues to enhance its Natural Resource Management Program in cooperation with the Foundation for Ecological Research in the Northeast (FERN) and the Upton Ecological and Research Reserve. The Laboratory also continues to enhance its Cultural Resource Management Program. A BNL Cultural Resource

Management Plan has been developed to identify and manage properties that are determined to be eligible or potentially eligible for inclusion on the National Register of Historic Places. See Chapter 6 for further information about these programs.

2.3.4.8 Environmental Restoration

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress in 1980. As part of CERCLA, EPA established the National Priorities List, which identifies sites where cleanup of past contamination is required. BNL was placed on the list with 27 other Long Island sites, 12 of which are in Suffolk County.

Each step of the CERCLA cleanup process is reviewed and approved by DOE, EPA, and NYSDEC, under an Interagency Agreement (IAG) contract. This agreement was formalized in 1992. Although not a formal signatory of the IAG, the Suffolk County Department of Health Services (SCDHS) also plays a key role in the review process. Most of the contamination at the Laboratory is associated with past accidental spills and outmoded practices for handling, storing, and disposing of chemical and radiological material.

BNL follows the CERCLA process, which includes the following steps:

- Conduct a Remedial Investigation to characterize the nature and extent of contamination and assess the associated risks
- Prepare a Feasibility Study and Proposed Plan to identify and evaluate remedial action alternatives and present the proposed best alternative
- Issue a Record of Decision (ROD), which is the remedy/corrective action agreed to by DOE, EPA, and NYSDEC
- Perform the Remedial Design/Remedial Action, which includes final design, construction specifications, and carrying out the remedy selected

In 2008, work planning and preparatory activities commenced for decomissioning the Brookhaven Graphite Research Reactor (BGRR). Preparations included awarding the contract and mobilizing the subcontractor for pile removal, asbestos abatement, and removal of interferences in Building 701, such as the freight elevator, to allow for the installation of pile removal equipment and the contamination containment enclosure. Other progress related to the BGRR project included finalizing the remedial design/remedial action (RD/RA) work plans for the graphite pile removal, removal of the biological shield, and installation of an engineered cap and monitoring system.

Progress associated with the High Flux Beam Reactor (HFBR) decommissioning project in 2008 included the finalization and publication of the HFBR Proposed Remedial Action Plan (PRAP). The public comment period for the PRAP extended from January 10 through March 17, 2008. Two information sessions were held on March 4, 2008, and a public meeting was held on March 6, 2008. Comments received during the public comment period were compiled and reviewed. Comments received during the public comment period and DOE responses were included in the draft ROD for the HFBR. Regulatory review of the HFBR ROD is well under way.

The cleanup of the Waste Loading Area (WLA), using the dose-based cleanup goal and methodology specified for the former Hazardous Waste Management Facility (HWMF) in the Operable Unit (OU) I ROD, was completed in accordance with an action memorandum issued in 2007. The WLA is an area along the eastern boundary of the former HWMF. The remediation of this area (approximately two acres) was transferred to the HFBR project scope in 2005.

An action memorandum was issued for the removal and disposal of the HFBR control rod blades and beam plugs as a "non time critical removal action." Preparations for implementing the control rod blade/beam plug removal project, including operational readiness reviews, were conducted in 2008.

The productive operation and maintenance (O&M) of the Laboratory's groundwater treatment systems removed approximately 220 pounds of solvents and 3.4 mCi of strontium-90 (Sr-90) from the sole source aquifer in 2008. Since the operation of the first treatment system in 1996, a cumulative total of approximately

6,120 pounds of solvents and 20 mCi of Sr-90 have been removed from the groundwater. Other progress included the identification of a source of volatile organic compound groundwater contamination at the former Building 96 area. Evacuation and disposal of soils containing high levels of contamination is planned to ensure that groundwater cleanup objectives will be met. Post-cleanup monitoring of the Peconic River surface water, sediment, fish, and wetland vegetation continued and the results were reported in the Annual Peconic River Monitoring Report and are summarized in Chapter 6. The groundwater systems operate in accordance with the O&M manuals, while the Peconic and surface soil cleanup areas are monitored via the OU I Soils and OU V Long-Term Monitoring and Maintenance Plan. Institutional controls are also monitored and maintained for the cleanup areas in accordance with the RODs to help ensure the remedies remain protective of human health and the environment. An annual evaluation of these controls is submitted to the regulators.

Table 2-4 provides a description of each operable unit and a summary of environmental restoration actions taken. See Chapter 7 and SER Volume II, Groundwater Status Report, for further details.

Table 2-4. Summary of BNL 2008 Environmental Restoration Activities.

Project	Description	Environmental Restoration Program Actions
Soil Projects	Operable Unit (OU) I OU II OU VII	▪ Performed monitoring and maintenance of institutional controls for cleanup areas. An annual evaluation of compliance with the controls was submitted to the regulators. ▪ Completed remediation of radiologically contaminated soil at the Waste Loading area, including rail shipments of all waste for disposal.
Groundwater Projects	OU I OU II	▪ Continued operation of 14 groundwater treatment systems that treat volatile organic compounds (VOCs) and strontium-90 (Sr-90). ▪ Continued monitoring and operation of the High Flux Beam Reactor (HFBR) tritium pump and recharge system. ▪ Two groundwater treatment systems continued pulse pumping due to low VOC concentrations in the groundwater near the pumping wells. ▪ One groundwater treatment system and 8 individual extraction wells were placed in standby mode. ▪ The source of the Building 96 VOC plume was identified and delineated during 2008 following a combined soil boring and soil gas characterization effort. A small area of contaminated soils located in the unsaturated zone south of the former Building 96 is planned for excavation and off-site disposal of soils. A draft Explanation of Significant Differences documenting the proposed source area excavation was prepared for submission in 2009. All four Building 96 groundwater treatment system extraction wells were placed back into service. ▪ Continued the installation of temporary wells to characterize Sr-90 in the Waste Concentration Facility (WCF) plume. This will support the installation of several additional extraction wells that are necessary to achieve cleanup goals. ▪ Continued monitoring the g-2 Tritium Groundwater Plume via temporary and permanent monitoring wells. ▪ During 2008, 1.5 billion gallons of groundwater were treated and 220 pounds of VOCs were removed. Since the first groundwater treatment system started operating in December 1996, approximately 6,117 pounds of VOCs have been removed from more than 14.4 billion gallons of groundwater.
	OU IV	▪ Continued groundwater monitoring.
	OU VI	▪ Continued operation of a groundwater treatment system to treat ethylene dibromide that has migrated beyond BNL property in Manorville.
	Groundwater Monitoring	▪ Completed the BNL 2008 Groundwater Status Report. ▪ Collected and analyzed 2,170 groundwater samples from 860 monitoring wells. ▪ Updated the Environmental Monitoring Plan.
Peconic River	OU V	▪ Performed third year of long-term post-cleanup monitoring of Peconic River surface water, sediment, fish, and wetland vegetation (including phragmities removal). ▪ Issued Final 2007 Peconic River Monitoring Report and submitted the draft 2008 report to regulators for review.

(continued on next page)

Table 2-4. Summary of BNL 2008 Environmental Restoration Activities *(concluded).*

Project	Description	Environmental Restoration Program Actions
Reactors	Brookhaven Graphite Research Reactor (BGRR)	▪ Completed Graphite Pile inspections. ▪ Detailed Planning for Graphite Pile and Bioshield removal. ▪ Documented Safety Analysis and Technical Safety Requirements approved by DOE. ▪ Completed Building 701 preparatory work including: overhaul of overhead crane; high-bay ventilation system modification; and perimeter fencing installation. ▪ Awarded contract for Graphite Pile and BioShield removal in December 2007.
	High Flux Beam Reactor (HFBR)	▪ Developed detailed procedures for the removal and disposal of the control rod blades and beam plugs. ▪ Prepared systems for control rod blade (CRB) removal by filling reactor vessel, primary system, and fuel canal with water. ▪ Installed water cleanup systems for reactor vessel and fuel canal. ▪ Conducted dry runs using spare CRB and drive components to demonstrate and refine techniques/procedures and develop proficiency using long-handled tools. ▪ Implemented revised Nuclear Safety Basis establishing the HFBR as a Hazard Category 3 nuclear facility. ▪ Completed remediation of the Waste Loading area.
	Brookhaven Medical Research Reactor (BMRR) (Project managed by the BNL Environmental and Waste Management Services Division)	▪ Continued surveillance and maintenance activities at the BMRR. ▪ Removed and disposed of the primary and overflow resin vessels from the BMRR.

2.3.4.9 EPA Performance Track Program

BNL was accepted into the EPA's Performance Track (PTrack) Program in 2004. This program recognizes top environmental performance among participating U.S. facilities of all types, sizes, and complexity, both public and private. It is considered the "gold standard" for facility-based environmental performance—a standard that participating members strive to attain as they "meet or exceed their performance commitment." Under this program, partners provide leadership in many areas, including preventing pollution at its source. The PTrack Program requires that sites commit to several improvement goals for a 3-year period and report on the progress of the goals annually. In 2007, BNL renewed its membership to the PTrack program and established four new goals. The performance under these goals is summarized below.

- *Reduce BNL's Non-Transportation Energy Consumption:* During the first year of performance under these new goals, BNL reduced the overall metric tons of greenhouse gas emissions by 17,000 metric tons of CO_2. Efforts to achieve these reductions included reduced electricity consumption and the use of biobased fuel oils (B-20) in satellite boilers. Specific energy reduction initiatives included replacing older refrigeration compressors at the RHIC facility to gain efficiency, and modifications to the cryogenic piping systems to improve overall system reliability and efficiency and to reduce power demands.
- *Initiate a Biobased Fuel Program for Heavy Equipment:* The goal of this measure is to replace conventional diesel fuels with biobased blends for use in heavy equipment. This goal saw little progress in the first year due to concerns for equipment warranties. These issues are being negotiated with the equipment suppliers.
- *Achieve 95 Percent E-PEAT Registered Products for All Computer Acquisitions:* BNL's commitment is to ensure that 95 percent of all purchased computers and accessories are registered silver under the Electronic Procurement Environmental Assessment Tool (E-PEAT). In the first year, only 40 percent of all computer purchases were E-PEAT registered. BNL will continue to work with computer suppliers and requisitioners to improve this statistic in future years.

- *Reduce BNL's Toxic Releases through Effective Biosolids Management:* BNL made significant achievements in this goal in 2008, including receiving NYSDEC approval for the disposal of accumulated biosolids and sand filter media at a conventional Subtitle D landfill, and the recharacterization of routinely generated biosolids as nonradioactive. By recharacterizing this waste stream, routine disposal of the accumulated sludge can occur, preventing excessive build up of heavy metals.

2.4 IMPLEMENTING THE ENVIRONMENTAL MANAGEMENT SYSTEM

2.4.1 Structure and Responsibility

All employees at BNL have clearly defined roles and responsibilities in key areas, including environmental protection. Employees are required to develop and sign their own Roles, Responsibilities, Accountabilities, and Authorities (R2A2) document, which must also be signed by two levels of supervision. BSA has clearly defined expectations for management and staff which must be included in this document. Under the BSA performance-based management model, senior managers must communicate their expectation that all line managers and staff take full responsibility for their actions and be held accountable for ESSH performance. Environmental and waste management technical support personnel assist the line organizations with identifying and carrying out their environmental responsibilities. The Environmental Compliance Representative Program, initiated in 1998, is an effective means of integrating environmental planning and pollution prevention into the work planning processes of the line organizations. A comprehensive training program for staff, visiting scientists, and contractor personnel is also in place, thus ensuring that all personnel are aware of their ESSH responsibilities.

2.4.2 Communication and Community Involvement

Communication and community involvement are commitments under BNL's EMS. The Laboratory maintains relationships with its employees, key stakeholders, neighbors, elected officials, regulators, and other community members. The goals are to provide an understanding of BNL's science and operations, including environmental stewardship and restoration activities, and to incorporate community input into the Laboratory's decision-making.

BNL staff participates in or conducts: on- and off-site meetings, which include discussions, talks, presentations, and roundtables; workshops; local civic association meetings; canvassing surrounding neighborhoods; Laboratory tours; and informal information sessions and formal public meetings held during public comment periods for environmental projects.

2.4.2.1 Communication Forums

To facilitate effective dialogue between the Laboratory and key stakeholders, several forums for communication and involvement have been established:

- The Brookhaven Executive Roundtable (BER), established in 1997 by DOE's Brookhaven Site Office, meets routinely to update local, state, and federal elected officials and regulatory agencies on environmental and operational issues, as well as on scientific discoveries and initiatives.
- The Community Advisory Council (CAC), established by BNL in 1998, advises the Laboratory Director, primarily on environmental, health, and safety issues related to the Laboratory that are important to the community. The CAC is composed of approximately 27 member organizations representing business, civic, education, employee, community, environmental, and health organizations. The CAC sets its own agenda in cooperation with the Laboratory and meets monthly in sessions that are open to the public.
- Weekly phone calls with regulators keep them up-to-date on project status, obtain feedback and input, and provide an opportunity to discuss emerging environmental findings.
- The Community Relations Office's Envoy Program educates employee volunteers regarding Laboratory issues and provides a link to local community organizations.

Feedback shared by Envoys helps BNL gain a better understanding of local community concerns.

- The Speakers' Bureau Program of the Community Relations Office provides speakers for educational and other organizations interested in the Laboratory.
- BNL's Summer Sundays Program enables the Laboratory to welcome the public to visit different science facilities, and enjoy hands-on activities, talks, and special activities on several Sundays each summer.
- The Laboratory participates in various annual events, such as a week-long celebration in honor of Earth Day, Earth Day Festivals, and the Longwood Fair.
- Lunchtime tours are held once a month and offer employees the opportunity to learn about the Laboratory's science facilities, program areas, and activities outside the scope of their jobs.
- The Laboratory's research, history, and natural environment, as well as cleanup projects, have all been topics covered under BNL's brown-bag lunch meetings. Held periodically with employees, they also cover specific topics of interest such as health benefits or wildlife management concerns.
- BNL's Media and Communications Office issues press releases and publishes *The Bulletin*, a weekly employee newsletter. A Director's Office web-based publication is issued bi-weekly focusing on topics important to the administration.
- The Laboratory maintains an informative website at http://www.bnl.gov, where these publications, as well as extensive information about BNL's science and operations, past and present, are posted. In addition, employees and the community can subscribe to the Laboratory's e-mail update service at http://lists.bnl.gov/mailman/listinfo/bnl-announce-1.

2.4.2.2 Community Involvement in Cleanup Projects

In 2008, BNL stakeholders participated in the decision-making process for the High Flux Beam Reactor (HFBR) decommissioning project. The HFBR was a research reactor that operated at BNL between 1965 and 1996. Used solely for scientific research, the HFBR provided neutrons for experiments in materials science, chemistry, biology, and physics. During a shutdown for routine maintenance, tritium was discovered in groundwater south of the reactor. Investigations revealed that the source was a small leak in the pool where spent reactor fuel was stored. Operations were suspended and the reactor was permanently closed in 1999. A Proposed Remedial Action Plan (PRAP) was developed after input from the regulators and the community and released for public comment in January 2008. The public comment period specifically spanned three meetings of the CAC, from January 10 through March 17, so that they could review the PRAP in detail and provide comments. At the March CAC meeting, a consensus recommendation was reached and was submitted as the CAC's input to the Laboratory Director; the Laboratory Director forwarded the recommendation to DOE. In addition to CAC participation in the HFBR decision-making process, BER viewed a presentation on the PRAP in January and two Information Sessions and a Public Meeting were held in early March for employees and other stakeholders. Notices of the meetings were published in two regional and five local newspapers. Letters were sent to local civic associations, and the PRAP was mailed to more than 200 individuals, including elected officials. Presentations on the PRAP were given to four civic associations and articles geared toward employees appeared in *The Bulletin* and on the BNL website.

In addition to the HFBR, stakeholders were updated on the progress of other environmental cleanup projects and health and safety issues through briefings and presentations given at monthly CAC and BER meetings throughout the year. One of the emerging topics of interest to the CAC is nanotechnology. Their interest is reflected in the inclusion of several presentations on their agendas. Other environmental topics covered include:

- The Laboratory's 2007 Annual Site Environmental Report and the Groundwater Status Report, Volume II provided the CAC with an overall update on BNL's cleanup projects and gave them specific information on the communication processes related to groundwater remediation, the protection and monitoring of groundwater, and the remediation process, including the operational status of treatment systems, the progress toward achieving cleanup goals, and proposed actions in response to monitoring data.

- Environmental impacts and controls associated with work involving nanomaterials.
- Deer populations at the Laboratory and ecological and safety impacts and options for management.
- Nanotechnology ESH, State of Affairs.
- The 2007 Annual Peconic River monitoring results included data on sediment, surface water, fish, and wetlands sampling. The presentation included information on sampling, data evaluation, data transmission, and implementation of follow-up actions.

In addition to the projects and topics noted above, the CAC drafted a letter to DOE regarding the competition of the BNL Prime Contract. They expressed their thinking that "the continuance of the role of the CAC should be weighed in the evaluation of proposals and should be a condition for the award of the contract for operation of BNL." The CAC also requested and received presentations on two topics they felt were important: climate change and Global and Regional Environmental Threats to Long Island's Central Pine Barrens.

Working closely with the community, employees, elected officials, and regulatory agency representatives, DOE and BNL continue to openly share information and provide feedback on how that input was used.

2.4.3 Monitoring and Measurement

The Laboratory monitors effluents and emissions to ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL's Environmental Monitoring Program is a comprehensive, sitewide program that identifies potential pathways for exposure of the public and employees, evaluates the impact activities have on the environment, and ensures compliance with environmental permit requirements. The monitoring program is reviewed and revised, as necessary or on an annual basis, to reflect changes in permit requirements, changes in facility-specific monitoring activities, or the need to increase or decrease monitoring based on a review of previous analytical results.

As required under DOE Order 450.1A, Environmental Protection Program, BNL prepares an Environmental Monitoring Plan, Triennial Update (BNL 2008), which outlines annual sampling goals by media and frequency. The plan uses the EPA Data Quality Objective approach for documenting the decisions associated with the monitoring program. In addition to the required triennial update, an annual electronic update is also prepared.

As shown in Table 2-5, in 2008 there were 8,283 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges under the Environmental Monitoring Program. Specific sampling programs for the various media are described further in Chapters 3 through 8.

The Environmental Monitoring Program addresses three components: compliance, restoration, and surveillance monitoring.

2.4.3.1 Compliance Monitoring

Compliance monitoring is conducted to ensure that wastewater effluents, air emissions, and groundwater monitoring data comply with regulatory and permit limits issued under the federal Clean Air Act, Clean Water Act, Oil Pollution Act, Safe Drinking Water Act, and the New York State equivalents. Included in compliance monitoring are the following:

- *Air emissions monitoring* is conducted at reactors, accelerators, and other radiological emission sources, as well as the CSF. Real-time, continuous emission monitoring equipment is installed and maintained at some of these facilities, as required by permits and other regulations. At other facilities, samples are collected and analyzed periodically to ensure compliance with regulatory requirements. Analytical data are routinely reported to the permitting authority. See Chapters 3 and 4 for details.

Table 2-5. Summary of BNL 2008 Sampling Program Sorted by Media.

Environmental Media	No. of Sampling Events (a)	Purpose
Groundwater	1,901 ER (b) 269 ES/C (c)	Groundwater is monitored to evaluate impacts from past and present operations on groundwater quality, under the Environmental Restoration, Environmental Surveillance, and Compliance sampling programs. See Chapter 7 and SER Volume II, Groundwater Status Report for further detail.
On-Site Recharge Basins	73	Recharge basins used for wastewater and stormwater disposal are monitored in accordance with discharge permit requirements and for environmental surveillance purposes. See Chapter 5 for further detail.
Potable Water	37 ES 181 C	Potable water wells and the BNL distribution system are monitored routinely for chemical and radiological parameters to ensure compliance with Safe Drinking Water Act requirements. In addition, samples are collected under the Environ-mental Surveillance Program to ensure the source of the Laboratory's potable water is not impacted by contamination. See Chapters 3 and 7 for further detail.
Sewage Treatment Plant (STP)	463	The STP influent and effluent and several upstream and downstream Peconic River stations are monitored routinely for organic, inorganic, and radiological parameters to assess BNL impacts. The number of samples taken depends on flow. For example, samples are scheduled for collection at Station HQ monthly, but if there is no flow, no sample can be collected. See Chapters 3 and 5 for further detail.
Precipitation	12	Precipitation samples are collected from two locations to determine if radioactive emissions have impacted rainfall, and to monitor worldwide fallout from nuclear testing. The data are also used, along with wind speed, wind direction, temperature, and atmospheric stability, to help model atmospheric transport and diffusion of radionuclides. See Chapter 4 for further detail.
Air – Tritium	321	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. These data are used to assess environmental tritium levels. See Chapter 4 for further detail.
Air – Particulate	486 ES/C 55 NYSDOH	Samples are collected to assess impacts from BNL operations and to facilitate reporting of emissions to regulatory agencies. Samples are also collected for the New York State Department of Health Services (NYSDOH) as part of their program to assess radiological air concentrations statewide. See Chapter 4 for further detail.
Air – Charcoal	58	Samples are collected to assess impacts from BNL operations and to facilitate reporting of emissions to regulatory agencies. See Chapter 4 for further detail.
Fauna	329	Fish, deer, and small mammals are monitored to assess impacts on wildlife associated with past or current BNL operations. See Chapter 6 for further detail.
Flora	24	Vegetation is sampled to assess possible uptake of contaminants by plants and fauna, since the primary pathway from soil contamination to fauna is via ingestion. See Chapter 6 for further detail.
Soils	284	Soil samples are collected as part of the Natural Resource Management Program to assess faunal uptake, during Environmental Restoration investigative work, during the closure of drywells and underground tanks, and as part of preconstruction background sampling.
Miscellaneous	589	Samples are collected periodically from potable water fixtures and dispensers, manholes, and spills, to assess process waters and sanitary discharges.
Groundwater Treatment Systems and Remediation Monitoring	1,023	Samples are collected from groundwater treatment systems and as long-term monitoring after remediation completion under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program. The Laboratory has 14 operating groundwater treatment systems. See discussion in Chapter 7.
Vehicle Monitor Checks	246	Materials leaving the Laboratory pass through the on-site vehicle monitor that detects if radioactive materials are present. Any radioactive material discovered is properly disposed of through the Waste Management Program. The vehicle monitor is checked on a daily basis.
State Pollutant Discharge Elimination System (SPDES)	283	Samples are collected to ensure that the Laboratory complies with the requirements of the New York State Department of Environmental Conservation (NYSDEC)- issued SPDES permit. Samples are collected at the STP, recharge basins, and four process discharge sub-outfalls to the STP.
Flow Charts	604	Flowcharts are exchanged weekly as part of BNL's SPDES permit requirements to report discharge flow at the recharge basin outfalls.

(continued on next page)

Table 2-5. Summary of BNL 2008 Sampling Program Sorted by Media *(concluded).*

Environmental Media	No. of Sampling Events (a)	Purpose
Floating Petroleum Checks	96 C 12 ES	Tests are performed on select petroleum storage facility monitoring wells to determine if floating petroleum products are present. The number of wells and frequency of testing is determined by NYSDEC licensing requirements (e.g., Major Petroleum Facility), NYSDEC spill response requirements (e.g., Motor Pool area), or other facility-specific sampling and analysis plans.
Radiological Monitor Checks	738	Daily instrumentation checks are conducted on the radiation monitors located in Buildings 569 and 592. These monitors are located 30 minutes upstream and at the STP. Monitoring at these locations allows for diversion of wastes containing radionuclides to prevent their discharge to the Peconic River.
Quality Assurance/Quality Control Samples (QA/QC)	226	To ensure that the concentrations of contaminants reported in the Site Environmental Report are accurate, additional samples are collected. These samples detect if contaminants are introduced during sampling, transportation, or analysis of the samples. QA/QC samples are also sent to the contract analytical laboratories to ensure their processes give valid, reproducible results.
Total number of sampling events	**8,310**	The total number of sampling events includes all samples identified in the Environmental Monitoring Plan (BNL 2008), as well as samples collected to monitor Environmental Restoration (CERCLA) projects, air and water treatment system processes, and by the Environmental Protection Division Field Sampling Team as special requests. The number does not include samples taken by Waste Management personnel, waste generators, or Environmental Compliance Representatives for waste characterization purposes.

Notes:
(a) A sampling event is the collection of samples from a single georeferenced location. Multiple samples for different analyses (i.e., tritium, gross alpha, gross beta, and volatile organic compounds) can be collected during a single sample event.
(b) Includes 86 temporary wells; many of which are used to collect multiple samples at different depth intervals.
(c) Includes 29 temporary wells, many of which are used to collect multiple samples at different depth intervals.
C = Compliance
ER = Environmental Restoration (CERCLA)
ES = Environmental Surveillance

- *Wastewater monitoring* is performed at the point of discharge to ensure that the effluent complies with release limits in the Laboratory's SPDES permits. Twenty-four point-source discharges are monitored under the BNL program: 12 under the ER Program and 12 under the SPDES permit. As required by permit conditions, samples are collected daily, weekly, monthly, or quarterly and monitored for organic, inorganic, and radiological parameters. Monthly reports that provide analytical results and an assessment of compliance for that reporting period are filed with the permitting agency. See Chapter 3, Section 3.6 for details.
- *Groundwater monitoring* is performed to comply with regulatory operating permits. Specifically, monitoring of groundwater is required under the Major Petroleum Facility License for the CSF and the RCRA permit for the WMF. Extensive groundwater monitoring is also conducted under the CERCLA program (described in Section 2.4.3.2 below). Additionally, to ensure that the Laboratory maintains a safe drinking water supply, BNL's potable water supply is monitored as required by the SDWA, which is administered by the SCDHS.

2.4.3.2 Restoration Monitoring

Restoration monitoring is performed to determine the overall impact of past operations, to delineate the real extent of contamination, and to ensure that Removal Actions are effective and remedial systems are performing as designed under CERCLA.

This program typically involves collecting soil and groundwater samples to determine the lateral and vertical extent of the contaminated area. Samples are analyzed for organic, inorganic, and radiological contaminants, and the analytical results are compared with guidance, standards, cleanup goals, or background concentrations. Areas where impacts have been confirmed are fully characterized and, if necessary, remediated to mitigate continuing impacts. Follow-up monitoring of groundwater is conducted in accordance with an ROD with the regulatory agencies (see Chapter 7 and SER Volume II, Groundwater Status Report, for details).

2.4.3.3 Surveillance Monitoring

Pursuant to DOE Order 450.1, surveillance monitoring is performed in addition to compliance monitoring, to assess potential environmental impacts that could result from routine facility operations. The BNL Surveillance Monitoring Program involves collecting samples of ambient air, surface water, groundwater, flora, fauna, and precipitation. Samples are analyzed for organic, inorganic, and radiological contaminants. Additionally, data collected using thermoluminescent dosimeters (devices to measure radiation exposure) strategically positioned on and off site are routinely reviewed under this program. Control samples (also called background or reference samples) are collected on and off the site to compare Laboratory results to areas that could not have been affected by BNL operations.

The monitoring programs can be broken down further by the relevant law or requirement (e.g., Clean Air Act) and even further by specific environmental media and type of analysis. The results of monitoring and the analysis of the monitoring data are the subject of the remaining chapters of this report. Chapter 3 summarizes environmental requirements and compliance data, Chapters 4 through 8 give details on media-specific monitoring data and analysis, and Chapter 9 provides supporting information for understanding and validating the data shown in this report.

2.4.4 EMS Assessments

To periodically verify that the Laboratory's EMS is operating as intended, audits are conducted as part of BNL's Self-Assessment Program. The audits are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. In addition, compliance with regulatory requirements is verified through routine inspections, operational evaluations, and focused compliance audits. BNL's Self-Assessment Program consists of several processes:

- *Self-assessment* is the systematic evaluation of internal processes and performance. The approach for the environmental self-assessment program includes evaluating programs and processes within organizations that have environmental aspects. Conformance to the Laboratory's EMS requirements is verified, progress toward achieving environmental objectives is monitored, operations are inspected to verify compliance with regulatory requirements, and the overall effectiveness of the EMS is evaluated. BNL environmental staff routinely participate in these assessments. Laboratory management conducts assessments to evaluate BNL environmental performance from a programmatic perspective, to determine if there are Laboratory-wide issues that require attention, and to facilitate the identification and communication of "best management" practices used in one part of the Laboratory that could improve performance in other parts. BNL management also routinely evaluates progress on key environmental improvement projects. The Laboratory and DOE periodically perform assessments to facilitate the efficiency of assessment activities and ensure that the approach to performing the assessments meets DOE expectations.
- *Independent assessments* are performed by BNL staff members who do not have line responsibility for the work processes involved, to ensure that operations are in compliance with Laboratory requirements. These assessments verify the effectiveness and adequacy of management processes (including self-assessment programs) at the division, department, directorate, and Laboratory levels. Special investigations are also conducted to identify the root causes of problems, as well as identify corrective actions and lessons learned.

The Laboratory's Self-Assessment Program is augmented by programmatic, external audits conducted by DOE. BSA staff and subcontractors also perform periodic independent reviews. An independent third party conducts ISO 14001 registration audits of BNL's EMS. The Laboratory is also subject to extensive oversight by external regulatory agencies (see Chapter 3 for details). Results of all assessment activities related to environmental performance are included, as appropriate, throughout this report.

2.5 ENVIRONMENTAL STEWARDSHIP AT BNL

BNL has unprecedented knowledge of its potential environmental vulnerabilities and current operations due to ongoing process evaluations, the work planning and control system, and the management systems for groundwater protection, environmental restoration, and information management. Compliance assurance programs have improved the Laboratory's compliance status; pollution prevention projects have reduced costs, minimized waste generation, and reused and recycled significant quantities of materials.

BNL is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and progress. To regain and maintain stakeholder trust, the Laboratory will continue to deliver on commitments and demonstrate improvements in environmental performance. The Site Environmental Report is an important communication mechanism, as it summarizes BNL's environmental programs and performance each year. Additional information about the Laboratory's environmental programs is available on BNL's website at http://www.bnl.gov. The Laboratory continues to pursue other ways to communicate timely data in a more user-friendly, visual manner.

BNL's EMS is viewed as exemplary within DOE. Due to external recognition of the Laboratory's knowledge and unique experience implementing the EMS program, several DOE facilities and private universities have invited BNL to extend its outreach activities and share its experiences, lessons learned, and successes. The Laboratory's environmental programs and projects have been recognized with international, national, and regional awards.

Audits have consistently observed a high level of management involvement, commitment, and support for environmental protection and the EMS. Audits and EMS management reviews have noted the following improvements made since BSA began managing BNL:

- The EMS has been strengthened, integrated with other Laboratory management systems, and formalized.
- Line ownership for environmental stewardship has been established, key roles and responsibilities have been identified and clarified, and expectations have been made explicit.
- A comprehensive environmental training program has been implemented.
- From the process evaluation project, BNL has improved its understanding of environmental aspects, waste streams, and applicable requirements.
- There is much greater formality with regard to control of EMS documents, manuals, and procedures. Procedures and requirements have been updated, and environmental management programs have been improved.
- The Laboratory has been very successful in achieving its environmental goals. There have been successes in ISO 14001 registration and recertification, compliance improvements (e.g., facility modifications, implementation of SBMS, enhanced operational controls), and increased environmental knowledge and awareness on the part of management, employees, contractors, and visitors.
- Communication on environmental issues has improved, occurs at the highest levels of management, and reporting is more formal. Managers are better informed about environmental aspects, issues, and performance.
- Core EMS teams representing many organizations have been formed. A consensus process is used to develop the system, improving acceptance and support.
- There has been strong implementation of the EMS throughout the organizations, and cultural change has been notable.

For more than 50 years, the unique, leading-edge research facilities and scientific staff at BNL have made many innovative scientific contributions possible. Today, BNL continues its research mission while focusing on cleaning up and protecting the environment. The Laboratory's environmental motto, which was generated in an employee suggestion contest, is "Exploring Earth's Mysteries … Protecting Its Future," and reflects the Laboratory's desire to balance world-class research with environmentally responsible operations.

REFERENCES AND BIBLIOGRAPHY

BNL. 2005. *Community Involvement Policy and Plan*. Brookhaven National Laboratory, Upton, NY.

BNL. 2003a. *BNL Energy Management Plan.* Brookhaven National Laboratory, Upton, NY.

BNL. 2003b. *Natural Resource Management Plan for Brookhaven National Laboratory.* BNL-71870-2003. Brookhaven National Laboratory, Upton, NY.

BNL. 2003c. *Wildland Fire Management Plan for Brookhaven National Laboratory.* BNL-71629-2003. Brookhaven National Laboratory, Upton, NY.

BNL. 2009. *BNL Environmental Monitoring Plan 2009, Triennial Update.* Brookhaven National Laboratory, Upton, NY.

DOE Order 430.2B, 2008. Departmental Energy, Utilities, and Transportation Management. U.S. Deparment of Energy, Washington, DC, February 27, 2008.

DOE Order 450.1A. 2008. *Environmental Protection Program.* U.S. Department of Energy, Washington, DC. June 4. 2008.

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

ISO. 2004. ISO 14001, *Environmental Management Systems – Specification with Guidance for Use.* First Edition. International Organization for Standardization. Geneva, Switzerland.

Compliance Status

3

Brookhaven National Laboratory (BNL) is subject to more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; 17 equivalency permits for operation of 14 groundwater remediation systems; and several other binding agreements. In 2008, the Laboratory operated in compliance with most of the requirements defined in these governing documents. Instances of noncompliance were reported to regulatory agencies and corrected expeditiously. Routine inspections conducted during the year found no significant instances of noncompliance; however, minor deficiencies were noted during inspections conducted by the New York State Department of Environmental Conservation (NYSDEC).

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility were all within permit limits. There were no opacity excursions noted for the entire year. Approximately 1,230 pounds of ozone-depleting refrigerants were recovered for eventual reuse by other DOE facilities or other federal agencies. These reductions included the disposition of 10 cylinders of Halon 1301 from fixed fire suppression systems that were removed from operation. Additionally, approximately 4,500 pounds of Ozone Depleting Substances (ODS) were transferred to the Department of Defense ODS Reserve. Monitoring BNL's potable water system showed that all drinking water requirements were met. During 2008, most of the liquid effluents discharged to surface water and groundwater met applicable New York State Pollutant Discharge Elimination System permit requirements. Three minor excursions above permit limits were reported for the year. Two of the three occurred at the Sewage Treatment Plant and were due to slightly elevated levels of nitrogen. The third was the recording of high pH in the water discharged from a cooling tower. The permit excursions were reported to NYSDEC and the Suffolk County Department of Health Services. Groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

Laboratory efforts to minimize spills of materials continued in 2008. There were nine reportable spills of petroleum products, antifreeze, or chemicals. While the total number of spills remained the same as 2007, there were 25 percent fewer reportable spills (nine compared to 12) in 2008. All releases were cleaned up to the satisfaction of the New York State Department of Environmental Conservation.

BNL participated in 11 environmental inspections by external regulatory agencies in 2008. These inspections included petroleum and chemical storage, Sewage Treatment Plant operations, other regulated outfalls and recharge basins, hazardous waste management facilities, and the potable water system. Immediate corrective actions were taken to address all issues raised during these inspections. A Notice of Violation was issued for labeling deficiencies identified during the RCRA annual inspection by the NYSDEC.

3.1 COMPLIANCE WITH REQUIREMENTS

The federal, state, and local environmental statutes and regulations that BNL operates under are summarized in Table 3-1, along with a discussion of the Laboratory's compliance status with each. A list of all applicable environmental regulations is contained in Appendix D.

3.2 ENVIRONMENTAL PERMITS

3.2.1 Existing Permits

Many processes and facilities at BNL operate under permits issued by environmental regulatory agencies. Table 3-2 provides a complete list of the existing permits, some of which are briefly described below.

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370	The Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) of inactive hazardous waste disposal sites. Regulators include EPA, DOE, and the New York State Department of Environmental Conservation (NYSDEC).	In 1989, BNL entered into a tri-party agreement with EPA, NYSDEC, and DOE. BNL site remediation is conducted by the Environmental Restoration Program in accordance with milestones established under this agreement. In 2005, BNL completed the restoration portion of the cleanup project and entered the surveillance and maintenance mode. Reactor D&D will continue under the CERCLA program in 2009.	2.3.4.8
Council for Env. Quality: 40 CFR 1500–1508 DOE: 10 CFR 1021	The National Environmental Policy Act (NEPA) requires federal agencies to follow a prescribed process to anticipate the impacts on the environment of proposed major federal actions and alternatives. DOE codified its implementation of NEPA in 10 CFR 1021 1021.	BNL is in full compliance with NEPA requirements. The Laboratory has established sitewide procedures for implementing the NEPA requirements.	3.3
Advisory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800 16 USC 470	The National Historic Preservation Act (NHPA) identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places, commonly known as the National Register. Such properties can be archeological sites or historic structures, documents, records, or objects. NHPA is administered by state historic preservation offices (SHPOs; in New York State, NYSHPO). At BNL, structures that may be subject to NHPA include the High Flux Beam Reactor (HFBR), the Brookhaven Graphite Research Reactor (BGRR) complex, World War I training trenches near the Relativistic Heavy Ion Collider project, and the former Cosmotron building.	The HFBR, BGRR complex, and World War I trenches are eligible for inclusion in the National Register. The former Cosmotron building was identified as potentially eligible in an April 1991 letter from NYSHPO. Any proposed activities involving these facilities must be identified through the NEPA process and evaluated to determine if the action would affect the features that make the facility eligible. Some actions required for D&D of the BGRR were determined to affect its eligibility, and mitigative actions are proceeding according to a Memorandum of Agreement between DOE and NYSHPO. BNL has a Cultural Resource Management Plan to ensure compliance with cultural resource regulations.	3.4
EPA: 40 CFR 50-0 40 CFR 82 NYSDEC: 6 NYCRR 200–257 6 NYCRR 307	The Clean Air Act (CAA) and the NY State Environmental Conservation Laws regulate the release of air pollutants through permits and air quality limits. Emissions of radionuclides are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutants (NESHAPs) authorizations.	All air emission sources are incorporated into the BNL Title V permit or have been exempted under the New York State air program, which is codified under the New York Codes, Rules, and Regulations (NYCRR). Radiological air emission sources are registered with the EPA.	3.5
EPA: 40 CFR 109–140 40 CFR 230, 231 40 CFR 401, 403 NYSDEC: 6 NYCRR 700–703 6 NYCRR 750	The Clean Water Act (CWA) and NY State Environmental Conservation Laws seek to improve surface water quality by establishing standards and a system of permits. Wastewater discharges are regulated by NYSDEC permits through the State Pollutant Discharge Elimination System (SPDES).	At BNL, permitted discharges include treated sanitary waste, and cooling tower and stormwater discharges. With the exception of three excursions, these discharges met the SPDES permit limits in 2008.	3.6
EPA: 40 CFR 141–149 NYSDOH: 10 NYCRR 5	The Safe Drinking Water Act (SDWA) and New York State Department of Health (NYSDOH) standards for public water supplies establish minimum drinking water standards and monitoring requirements. SDWA requirements are enforced by the Suffolk County Department of Health Services (SCDHS).	BNL maintains a sitewide public water supply. This water supply met all primary drinking water standards, as well as operational and maintenance requirements in 2008.	3.7

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL *(continued).*

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 112 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370 40 CFR 372	The Oil Pollution Act, the Emergency Planning and Community Right-to-Know Act (EPCRA), and the Superfund Amendment Reauthorization Act (SARA) require facilities with large quantities of petroleum products or chemicals to prepare emergency plans and report their inventories to EPA, the state, and local emergency planning groups.	Since some facilities at BNL store or use chemicals or petroleum in quantities exceeding threshold planning quantities, the Laboratory is subject to these requirements. BNL fully complies with all reporting and emergency planning requirements.	3.8.1 3.8.2 3.8.3
EPA: 40 CFR 280 NYSDEC: 6 NYCRR 595–597 6 NYCRR 611–613 SCDHS: SCSC Article 12	Federal, state, and local regulations govern the storage of chemicals and petroleum products to prevent releases of these materials to the environment. Suffolk County Safety Codes (SCSCs) are more stringent than federal and state regulations.	The regulations require that these materials be managed in facilities equipped with secondary containment, overfill protection, and leak detection. BNL complies with all federal and state requirements and has achieved conformance to county codes.	3.8.4 3.8.5 3.8.6
EPA: 40 CFR 260–280 NYSDEC: 6 NYCRR 360–372	The Resource Conservation Recovery Act (RCRA) and New York State 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 a permitted waste management facility.	3.9
EPA: 40 CFR 700–763	The Toxic Substances Control Act (TSCA) regulates the manufacture, use, and distribution of all chemicals.	BNL manages all TSCA-regulated materials, including PCBs, in compliance with all requirements.	3.10
EPA: 40 CFR 162–171(f) NYSDEC: 6 NYCRR 320 6 NYCRR 325–329	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and corresponding NY State regulations govern the manufacture, use, storage, and disposal of pesticides and herbicides, as well as the pesticide containers and residuals.	BNL employs NY State-certified pesticide applicators to apply pesticides and herbicides. Each applicator attends training, as needed, to maintain current certification and files an annual report to the state detailing the types and quantity of pesticides applied.	3.11
DOE: 10 CFR 1022 NYSDEC: 6 NYCRR 663 6 NYCRR 666	DOE regulations require its facilities to comply with floodplain/wetland review requirements. The New York State Fresh Water Wetlands and Wild, Scenic, and Recreational Rivers rules govern development in the state's natural waterways. Development or projects within a half-mile of regulated waters must have NYSDEC permits.	BNL is in the Peconic River watershed and has several jurisdictional wetlands; consequently, development of locations in the north and east of the site requires NYSDEC permits and review for compliance under DOE wetland/floodplain regulations. In 2008, there were two projects permitted under the NYS Fresh Water Program.	3.12
U.S. Fish & Wildlife Service: 50 CFR 17 NYSDEC: 6 NYCRR 182	The Endangered Species Act and corresponding New York State regulations prohibit activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat.	BNL is host to numerous species of flaura and fauna. Many species have been categorized by NYS as endangered, threatened, or of special concern. The Laboratory's Natural Resource Management Plan outlines activities to protect these vulnerable species and their habitats (see Chapter 6).	3.13
U.S. Fish & Wildlife Service: Migratory Bird Treaty Act 16 USC 703-712 The Bald and Golden Eagle Protection Act 16 USC 668 a-d	The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing, or possessing migratory birds is unlawful. Birds protected under the act include all common songbirds, waterfowl, shorebirds, hawks, owls, eagles, ravens, crows, native doves and pigeons, swifts, martins, swallows, and others, and includes their body parts (feathers, plumes etc), nests, and eggs. The Bald and Golden Eagle Protection Act (BGEPA) prohibits any form of possession or taking of both bald and golden eagles.	Compliance with the MBTA and the BGEPA are documented through the BNL Natural Resource Management Plan. The plan includes provisions for enhancing local habitat through the control of invasive species, planting of native grasses as food sources, and construction of nesting sites. All construction activities, including demolition, are reviewed to ensure no impacts to nesting individuals.	3.13

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL *(continued).*

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
DOE: Manual 231.1-1A	The Environment, Safety, and Health Reporting program objective is to ensure timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the Department. Included in the order are the requirements for the Occurrence Reporting and Processing of Operations Program (ORPS).	BNL prepares an annual Site Environmental Report and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and Occupational Health and Safety Administration (OSHA) reports. The Laboratory developed the ORPS Subject Area for staff and management who perform specific duties related to discovery, response, notification, investigation, and reporting of occurrences to BNL and DOE management. The ORPS Subject Area is supported by: Occurrence Reporting Program Description, Critiques Subject Area, Occurrence Categorizer's Procedure, and the ORPS Office Procedure.	All chapters
DOE: Order 414.1 10 CFR 830, Subpart A Policy 450.5	The Quality Assurance (QA) program objective is to establish an effective management system using the performance requirements of this Order, coupled with technical standards, where appropriate, to ensure: senior management provides planning, organization, direction, control, and support to achieve DOE objectives; line organizations achieve and maintain quality while minimizing safety and health risks and environmental impacts, and maximizing reliability and performance; line organizations have a basic management system in place supporting this Order; and each DOE element reviews, evaluates, and improves its overall performance and that of its contractors using a rigorous assessment process based on an approved QA Program.	BNL has a Quality Management (QM) system to implement quality management methodology throughout its management systems and associated processes to: 1) plan and perform Laboratory operations reliably and effectively to minimize the impact on the safety and health of humans and on the environment; 2) standardize processes and support continuous improvement in all aspects of Laboratory operations; and 3) enable the delivery of products and services that meet customers' requirements and expectations. Having a comprehensive program ensures that all environmental monitoring data meet QA and quality control requirements. Samples are collected and analyzed using standard operating procedures, to ensure representative samples and reliable, defensible data. Quality control in the analytical labs is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated according to project-specific quality objectives before they are used to support decision making.	Chapter 9
DOE: Order 435.1	The Radioactive Waste Management Program objective is to ensure that all DOE radioactive waste is managed in a manner that protects workers, public health and safety, and the environment. Order 435.1 requires all DOE organizations that generate radioactive waste to implement a waste certification program. DOE Laboratories must develop a Radioactive Waste Management Basis (RWMB) Program Description, which includes exemption and timeframe requirements for staging and storing both routine and non-routine radioactive wastes.	The BNL Waste Certification Program Plan (WCPP) in the RWMB Program Description defines the Radioactive Waste Management Program's structure, logic, and methodology for waste certification. New or modified operations or activities that do not fall within the scope of the RWMB Program Description must be documented and approved before implementation. The Laboratory's RWMB Program Description describes the BNL policies, procedures, plans, and controls demonstrating that BNL has the management systems, administrative controls, and physical controls to comply with DOE Order 435.1.	2.3.4.3
DOE: Order 450.1A (former Order 5400.1)	The Environmental Protection Program objective is to implement sound stewardship practices that protect the air, water, land, and other natural and cultural resources affected by DOE operations, in a cost-effective manner, meeting or exceeding applicable environmental; public health; and resource protection laws, regulations, and DOE requirements. DOE facilities meet this objective by implementing an Environmental Management System (EMS) that is part of an Integrated Safety Management System (ISMS). Other components include establishing sound environmental monitoring programs to comply with former DOE Order 5400.1. The Standards-Based Management System (SBMS) provides staff with procedural guidance. In 2008, Order 450.1A was finalized and requires all federal agencies and contractors to include the goals of Executive Order 13423 in their EMS. These goals include energy and water conservation, renewable energy, use of alternate fuels, and other "green" initiatives.	BNL's EMS was officially registered to the ISO 14001:1996 standard in 2001 and recertified to the revised standard in 2004 and 2007. In June 2008, a surveillance audit was conducted that found the BNL EMS to be robust. The BNL ISMS Program Description presents the Laboratory's approach to integrating environment, safety, and health (ES&H) requirements into the processes for planning and conducting work at the Laboratory. It describes BNL's programs, including the SBMS, for accomplishing work safely and provides the road map of the systems and processes. In accordance with DOE Order 450.1A, the Laboratory has included the Executive Order objectives in its Objectives and Targets for 2009. An audit of the EMS by BHSO in December 2008 found that the system should be ready to declare conformance to the requirements of 450.1A by June 2009.	Chapter 2

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL *(concluded).*

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
DOE: Order 5400.5, Change 2	To protect members of the public and the environment against undue risk from radiation, the Radiation Protection of the Public and Environment Program establishes standards and requirements for operations of DOE and DOE contractors.	BNL uses the guidance values provided in DOE Order 5400.5 to ensure that effluents and emissions do not affect the environment or public and worker safety and health, and to ensure that all doses meet the "As Low As Reasonably Achievable" (ALARA) policy.	Chapters 4, 5, 6, and 8

Notes:
CFR = Code of Federal Regulations
NYCRR = New York Codes, Rules, and Regulations
SCSC = Suffolk County Sanitary Code

- State Pollutant Discharge Elimination System (SPDES) permit, issued by the New York State Department of Environmental Conservation (NYSDEC)
- Major Petroleum Facility (MPF) license, issued by NYSDEC
- Resource Conservation and Recovery Act (RCRA) permit, issued by NYSDEC for the Waste Management Facility
- Registration certificate from NYSDEC for tanks storing bulk quantities of hazardous substances
- Seven radiological emission authorizations issued by the United States Environmental Protection Agency (EPA) under the National Emission Standards for Hazardous Air Pollutants (NESHAPs)
- Air emissions permit, issued by NYSDEC under Title V of the Clean Air Act Amendments authorizing the operation of 37 emission sources
- Two permits issued by NYSDEC for construction activities within the Peconic River corridor
- An EPA Underground Injection Control (UIC) Area permit for the operation of 90 UIC wells
- Permit for the operation of six domestic water supply wells, issued by NYSDEC
- Seventeen equivalency permits for the operation of 14 groundwater remediation systems installed under the Interagency Agreement (Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA])

3.2.2 New or Modified Permits

3.2.2.1 Air Emissions Permits

Air emissions permits are granted by NYSDEC. The Title V permit consolidates all applicable federal and state requirements for BNL's regulated emission sources into a single document. The Laboratory has a variety of nonradioactive air emission sources covered under the permit that are subject to federal or state regulations. Section 3.5 describes the more significant sources and the methods used by the Laboratory to comply with the applicable regulatory requirements. In June 2008, BNL's Title V permit was renewed by NYSDEC after a two-year review. The renewed permit includes numerous changes to reflect the removal of certain processes previously included in the permit, as well as the addition of new processes. These changes are reflected in Table 3-2.

Air emissions permits are also issued as "equivalency" permits for the installation and operation of groundwater remediation systems under CERCLA, or as changes to the BNL Title V operating permit. During 2008, no CERCLA air equivalency permits were issued or revised.

3.2.2.2 SPDES Permits

In 2007, NYSDEC initiated a review and renewal of the BNL SPDES permit because more than 10 years had passed since the last comprehensive review. The Laboratory completed an application and submitted it to NYSDEC in August 2007. In December 2008, NYSDEC requested additional clarifying information regarding the use and discharge to the sewage

Table 3-2. BNL Environmental Permits.

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
EPA - NESHAPs	510	Calorimeter Enclosure	BNL-689-01	None	NA	NA
EPA - NESHAPs	705	Building Ventilation	BNL-288-01	None	NA	NA
EPA - NESHAPs	820	Accelerator Test Facility	BNL-589-01	None	NA	NA
EPA - NESHAPs	AGS	AGS Booster - Accelerator	BNL-188-01	None	NA	NA
EPA - NESHAPs	RHIC	Accelerator	BNL-389-01	None	NA	NA
EPA - SDWA	BNL	Underground Injection Control	NYU500001	11-Feb-11	NA	NA
NYSDEC - Air Equivalency	517	Middle Road System	1-51-009	NA	NA	NA
NYSDEC - Air Equivalency	518	South Boundary System	1-51-009	NA	NA	NA
NYSDEC - Air Equivalency	598	OU I Remediation System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	539	Western South Boundary System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	TR 867	T-96 Remediation System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	517	Middle Road System	1-51-009	NA	NA	NA
NYSDEC - SPDES Equivalency	518	South Boundary System	1-51-009	NA	NA	NA
NYSDEC - SPDES Equivalency	539	West South Boundary System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	598	OU I Remediation System	1-52-009	31-Oct-06	NA	NA
NYSDEC - SPDES Equivalency	598	Tritium Remediation System	1-52-009	04-May-11	NA	NA
NYSDEC - SPDES Equivalency	670	Sr-90 Treatment System	None	25-Feb-13	NA	NA
NYSDEC - SPDES Equivalency	TR 829	Carbon Tetrachloride System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-4	Airport/LIPA Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-2	Industrial Park East Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-5	North St./North St. East Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-6	Ethylene Di-Bromide Treatment System	None	01-Aug-09	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System - BGRR/WCF	None	01-Jan-10	NA	NA
NYSDEC - SPDES Equivalency	TR 867	T-96 Remediation System	1-52-009	09-Mar-13	NA	NA
NYSDEC - Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-09	NA	NA
NYSDEC - LI Well Permit	BNL	Domestic Potable/Process Wells	1-4722-00032/00113	13-Sep-18	NA	NA
NYSDEC - Air Quality	197	Lithographic Printing Presses	1-4722-00032/00115	29-Jun-13	U-LITHO	19709-10
NYSDEC - Air Quality	423	Metal Parts Cleaning Tanks	1-4722-00032/00115	29-Jun-13	U-METAL	42308
NYSDEC - Air Quality	423	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	29-Jun-13	U-FUELS	42309-10
NYSDEC - Air Quality	423	Motor Vehicle A/C Servicing	1-4722-00032/00115	29-Jun-13	U-MVACS	MVAC1- 4
NYSDEC - Air Quality	244	Paint Spray Booth	1-4722-00032/00115	29-Jun-13	U-PAINT	244-02
NYSDEC - Air Quality	244	Flammable Liquid Storage Cabinet	1-4722-00032/00115	29-Jun-13	U-PAINT	244 AE
NYSDEC - Air Quality	479	Metal Parts Cleaning Tank	1-4722-00032/00115	29-Jun-13	U-METAL	47908
NYSDEC - Air Quality	510	Spin Coating Operation	1-4722-00032/00115	29-Jun-13	U-INSIG	510 AR
NYSDEC - Air Quality	801	Target Processing Laboratory	1-4722-00032/00115	29-Jun-13	U-INSIG	80101
NYSDEC - Air Quality	Site	Aerosol Can Processing Units	1-4722-00032/00115	29-Jun-13	U-INSIG	AEROS
NYSDEC - Air Quality	498	Aqueous Cleaning Facility	1-4722-00032/00115	29-Jun-13	U-METAL	49801
NYSDEC - Air Quality	535B	Plating Tanks	1-4722-00032/00115	29-Jun-13	U-INSIG	53501
NYSDEC - Air Quality	535B	Etching Machine	1-4722-00032/00115	29-Jun-13	U-INSIG	53502
NYSDEC - Air Quality	535B	Printed Circuit Board Process	1-4722-00032/00115	29-Jun-13	U-INSIG	53503
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61007	61007

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Table 3-2. BNL Environmental Permits *(concluded)*.

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	29-Jun-13	U-METAL	61008
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	29-Jun-13	U-61005	6101A
NYSDEC - Air Quality	630	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	29-Jun-13	U-FUELS	63001-03
NYSDEC - Air Quality	630	Parts Cleaning Tray	1-4722-00032/00115	29-Jun-13	U-METAL	630 AB
NYSDEC - Air Quality	902	Epoxy Coating/Curing Exhaust	1-4722-00032/00115	29-Jun-13	U-COILS	90206
NYSDEC - Air Quality	903	Metal Parts Cleaning Tank	1-4722-00032/00115	29-Jun-13	U-METAL	90304
NYSDEC - Air Quality	919B	Electroplating Operation	1-4722-00032/00115	29-Jun-13	U-INSIG	91904
NYSDEC - Air Quality	630	Parts Cleaning Tray	1-4722-00032/00115	29-Jun-13	U-METAL	630 AD
NYSDEC - Air Quality	922	Electroplating Operation	1-4722-00032/00115	29-Jun-13	U-INSIG	92204
NYSDEC - Air Quality	923	Electronic Equipment Cleaning	1-4722-00032/00115	29-Jun-13	U-METAL	9231A
NYSDEC - Air Quality	923	Parts Drying Oven	1-4722-00032/00115	29-Jun-13	U-METAL	9231B
NYSDEC - Air Quality	924	Magnet Coil Production Press	1-4722-00032/00115	29-Jun-13	U-INSIG	92402
NYSDEC - Air Quality	924	Vapor/Ultrasonic Degreasing Unit	1-4722-00032/00115	29-Jun-13	U-METAL	92404
NYSDEC - Air Quality	Site	Halon 1211 Portable Extinguishers	1-4722-00032/00115	29-Jun-13	U-HALON	H1211
NYSDEC - Air Quality	Site	Halon 1301 Fire Suppression Systems	1-4722-00032/00115	29-Jun-13	U-HALON	H1301
NYSDEC - Air Quality	Site	Packaged A/C Units	1-4722-00032/00115	29-Jun-13	U-RFRIG	PKG01-02
NYSDEC - Air Quality	Site	Reciprocating Chillers	1-4722-00032/00115	29-Jun-13	U-RFRIG	REC01-53
NYSDEC - Air Quality	Site	Rotary Screw Chillers	1-4722-00032/00115	29-Jun-13	U-RFRIG	ROTO1-11
NYSDEC - Air Quality	Site	Split A/C Units	1-4722-00032/00115	29-Jun-13	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal Chillers	1-4722-00032/00115	29-Jun-13	U-RFRIG	CEN01-24
NYSDEC - Hazardous Waste	WMF	Waste Management	1-4722-00032/00102	19-Nov-16	NA	NA
NYSDEC - NESHAPs	REF	Radiation Effects/Neutral Beam	BNL-789-01	None	NA	NA
NYSDEC - NESHAPs	RTF	Radiation Therapy Facility	BNL-489-01	None	NA	NA
NYSDEC - Water Quality	CSF	Major Petroleum Facility	1-1700	31-Mar-12	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	NY-0005835	01-Mar-10	NA	NA
NYSDEC - Water Quality	1010	Install A/C @ 1010A and 1012A	1-4722-00032/00139	31-May-12	NA	NA
NYSDEC - Water Quality	1004	Installation of Blockhouse	1-4722-00032/00140	29-Jan-13	NA	NA

Notes:
A/C = Air Conditioning
AGS = Alternating Gradient Synchrotron
BGRR = Brookhaven Graphite Research Reactor
CSF = Central Steam Facility
EPA = Environmental Protection Agency
LIPA = Long Island Power Authority
NA = Not Applicable
NESHAPs = National Emission Standards for Hazardous Air Pollutants
NYSDEC = New York State Department of Environmental Conservation
OU = Operable Unit
RTF = Radiation Therapy Facility
RHIC = Relativistic Heavy Ion Collidar
SDWA = Safe Drinking Water Act
SPDES = State Pollutant Discharge Elimination System
Sr-90 = Strontium-90
STP = Sewage Treatment Plant
WCF = Waste Concentration Facility
WMF = Waste Management Facility

treatment plant and other outfalls of corrosion-control chemicals used in cooling water systems. A revised permit is expected shortly.

3.2.2.3 NESHAPs Authorization

In 2008, BNL petitioned EPA to raise the emissions threshold for the Brookhaven Linear Isotope Production (BLIP) facility to ensure that a nationwide need for radioisotopes used in medical imaging studies could be met without exceeding the original emissions limit. If the original limit had been exceeded, a requirement for continuous emissions monitoring would have been triggered. After due consideration, EPA raised the limit from 0.1 mrem in the year to 0.2 mrem in the year. Even with an increase to 0.2 mrem, the emissions from this facility are still well below the EPA air emissions pathway limit of 10 mrem for a year.

3.3 NEPA ASSESSMENTS

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the environmental effects of proposed major federal activities. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made.

During 2008, environmental evaluations were completed for 63 proposed projects at BNL. Of these, 58 were considered minor actions requiring no additional documentation. The five remaining projects were addressed by submitting notification forms to DOE, which determined that the projects were covered by existing "Categorical Exclusions" per 10 CFR 1021 or fell within the scope of a previous environmental assessment.

3.4 PRESERVATION LEGISLATION

The Laboratory is subject to several cultural resource laws, most notably the National Historic Preservation Act and the Archeological Resource Protection Act. These laws require agencies to consider the effects of proposed federal actions on historic structures, objects, and documents, as well as cultural or natural places important to Native Americans or other ethnic or cultural groups.

BNL has three structures or sites that are eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, and the World War I Army training trenches associated with Camp Upton. An annual Department of Interior questionnaire regarding historic and cultural resources was submitted in March 2008. Additional activities associated with historic preservation compliance are described in Chapter 6.

3.5 CLEAN AIR ACT

The objectives of the Clean Air Act (CAA), which is administered by EPA and NYSDEC, are to improve or maintain regional ambient air quality through 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

The Laboratory has a variety of conventional, nonradioactive air emission sources that are subject to federal or state regulations. The following subsections describe the more significant sources and the methods used by BNL to comply with the applicable regulatory requirements.

3.5.1.1 Boiler Emissions

BNL has four boilers (Nos. 1A, 5, 6, and 7) at the Central Steam Facility (CSF) that are subject to NYSDEC "Reasonably Available Control Technology" requirements. Three of the boilers can burn either residual fuel oil or natural gas; Boiler 1A burns fuel oil only. In 2008, natural gas was the predominant fuel burned at the CSF. For boilers with maximum operating heat inputs greater than or equal to 50 MMBtu/hr (14.6 MW), the requirements establish emission standards for oxides of nitrogen (NO_x). Boilers with a maximum operating heat input between 50 and 250 MMBtu/hr (14.6 and 73.2 MW) can demonstrate compliance using periodic emission tests or by using continuous emission monitoring equipment. Emission tests conducted in 1995 and again in 2006 confirmed that boilers 1A and 5, both in this size category, met the NO_x emission standards when burning residual fuel oil with low nitrogen content. To ensure continued compliance, an outside contract analytical laboratory analyzes composite samples (collected quarterly) of fuel deliveries. The analyses conducted in 2008 confirmed that the fuel-bound nitrogen content met these requirements. Compliance with the 0.30 lbs/MMBtu NO_x emission standards for boilers 6 and 7 was demonstrated by continuous emission monitoring of the flue gas. In 2008, NO_x emissions from Boilers 6 and 7 averaged 0.122 lbs/MMBtu and 0.100 lbs/MMBtu, respectively. There were no known exceedances of the NO_x emission standard for either boiler.

The Laboratory also maintains continuous opacity monitors for boilers 6 and 7. These monitors measure the transmittance of light through the exhaust gas and report this measurement in percent attenuated. Opacity limitations state that no facility may emit particulates such that the opacity exceeds 20 percent, calculated in 6-minute averages, except for one period not to exceed 27 percent in any one hour. To maintain boiler efficiency, soot that accumulates on the boiler tubes must be removed. This is accomplished by passing a mixture of high-pressure steam and air through the boiler using a series of blowers. In 2008, BNL had no periods when opacity measurements for Boiler 6 or Boiler 7 exceeded the 6-minute, 20 percent average during soot blowing operations.

3.5.1.2 Ozone-Depleting Substances

Refrigerant: The Laboratory's preventative maintenance program requires regular inspection and maintenance of refrigeration and air conditioning equipment that contains ozone-depleting substances such as R-11, R-12, and R-22. All refrigerant recovery and recycling equipment are certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. As a matter of standard practice at BNL, if a refrigerant leak is found, technicians will either immediately repair the leak or isolate it and prepare a work order for the needed repairs. This practice exceeds the leak repair provisions of 40 CFR 82.156. In 2008, approximately 95 pounds of R-22 were recovered and recycled from refrigeration equipment that was serviced.

Halon: Halon 1211 and 1301 are extremely efficient fire suppressants, but are being phased out due to their effect on the earth's ozone layer. In 1998, the Laboratory purchased equipment to comply with the halon recovery and recycling requirements of the CAA, 40 CFR 82 Subpart H. When portable fire extinguishers or fixed systems are removed from service and when halon cylinders are periodically tested, BNL technicians use halon recovery and recycling devices to comply with CAA provisions. The Laboratory transferred 267 portable extinguishers containing a total of 4,523 pounds of Halon 1211 to the Department of Defense Ozone Depletion Substances (ODS) Reserve in 2008. The transferred extinguishers were declared excess property in 2006 and 2007. The transfer was made in accordance with the Class I Ozone Depleting Substances Disposition Guidelines prepared by the DOE Office of Environmental Policy and Guidance. The portable extinguishers became excess property due to changes in operations or when they were replaced by ABC dry-chemical or clean agent FE-36 extinguishers. In 2008, 10 cylinders containing 1,230 pounds of Halon 1301 associated with fixed fire suppression systems were declared excess property because the mission-critical or mission-essential equipment and facilities they protected from damage or loss due to fire have been removed or shut down. The cylinders will be dispositioned to the ODS Reserve in 2009.

3.5.2 Hazardous Air Pollutants

In 1970, the CAA established standards to protect the general public from hazardous air pollutants that may lead to death or an increase in irreversible or incapacitating illnesses. The NESHAPs program was established in 1977 and the governing regulations were updated significantly in 1990. EPA developed NESHAPS to limit the emission of 189 toxic air pollutants. The program includes a list of regulated contaminants, a schedule for implementing control requirements, aggressive technology-based emission standards, industry-specific requirements, special permitting provisions, and a program to address accidental releases. The following subsections describe BNL's compliance with NESHAPs regulations.

3.5.2.1 Maximum Available Control Technology

Based on the Laboratory's periodic review of Maximum Available Control Technology (MACT) standards, it has been determined that none of the existing, proposed, or newly promulgated MACT standards apply to the emissions from existing permitted operations or the anticipated emissions from proposed activities and operations at BNL.

3.5.2.2 Asbestos

In 2008, the Laboratory notified the EPA Region II office regarding removal of materials containing asbestos. During the year, 3,402 linear feet of pipe insulation, 9,297 square feet of floor tile and roofing material, and 20 cubic yards of asbestos-containing debris were removed and dispositioned according to EPA requirements.

3.5.2.3 Radioactive Airborne Emissions

Emissions of radiological contaminants are evaluated and, if necessary, monitored to ensure that they do not impact the environment or people working or residing at or near the Laboratory. A full description of this monitoring conducted in 2008 is provided in Chapter 4. BNL transmitted all data pertaining to radioactive air emissions and dose calculations to EPA in fulfillment of the June 30 annual reporting requirement. As in past years, the maximum off-site dose due to airborne radioactive emissions from the Laboratory continued to be far below the 10 mrem (100 µSv) annual dose limit specified in 40 CFR 61 Subpart H, (see Chapters 4 and 8 for more information on the estimated air dose). Using EPA modeling software, the dose to the hypothetical maximally exposed individual resulting from BNL's airborne emissions was 0.061 mrem (0.6 µSv) in 2008.

3.6 CLEAN WATER ACT

The disposal of wastewater generated by Laboratory operations is regulated under the Clean Water Act (CWA) as implemented by NYSDEC and under DOE Order 5400.5, Radiation Protection of the Public and the Environment. The goals of the CWA are to achieve a level of water quality that promotes the propagation of fish, shellfish, and wildlife; to provide waters suitable for recreational purposes; and to eliminate the discharge of pollutants into surface waters. New York State was delegated CWA authority in 1975. NYSDEC has issued a SPDES permit to regulate wastewater effluents at the Laboratory. This permit was renewed in May 2005, and specifies monitoring requirements and effluent limits for nine of 12 outfalls, as described below. See Figure 5-7 in Chapter 5 for the locations of BNL outfalls.

- Outfall 001 is used to discharge treated effluent from the STP to the Peconic River.
- Outfalls 002, 002B, 003, 005, 006A, 006B, 008, 010, 011, and 012 are recharge basins used to discharge cooling tower blowdown, once-through cooling water, and/or stormwater. Since only stormwater or once-through cooling water are discharged to Outfalls 003, 011, and 012, NYSDEC imposes no monitoring requirements for these discharges.
- Outfall 007 receives backwash water from the potable Water Treatment Plant filter building.
- Outfall 009 consists of numerous subsurface and surface wastewater disposal systems (e.g., drywells) that receive predominantly sanitary waste and steam- and air-compressor condensate discharges. NYSDEC does not require monitoring of this outfall.

Each month, the Laboratory prepares Discharge Monitoring Reports that describe monitoring results, evaluate compliance with permit limitations, and identify corrective measures taken to address permit excursions. These reports are submitted to the NYSDEC central and regional offices and the Suffolk County Department of Health Services (SCDHS). Details of the monitoring program conducted for the groundwater treatment systems and of SPDES equivalency permit performance are provided in SER Volume II, Groundwater Status Report.

In 2007, NYSDEC initiated a comprehensive review of the BNL SPDES permit, requiring the complete characterization of all permitted outfalls and a review of the discharges received by each outfall. Wastewater samples were collected from each outfall and analyzed for a full series of chemical and biological contaminants. The data were submitted to NYSDEC in August. No unexpected contaminants were identified through these analyses. Additional information was requested by NYSDEC in December 2008 regarding chemicals used in cooling water systems to prevent/minimize corrosion.

3.6.1 Sewage Treatment Plant

Sanitary and process wastewater generated by BNL operations is conveyed to the STP for processing before discharge to the Peconic

River. The STP provides tertiary treatment of the waste water and includes the following processes: settling/sedimentation, biological reduction of organic matter, and reduction of nitrogen. Chapter 5 provides a detailed description of the treatment process.

Table 3-3. Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001.

Analyte	Low Report	High Report	Min. Monitoring. Freq.	SPDES Limit	Exceedances	% Compliance*
Max. temperature (°F)	48	81	Daily	90	0	100
pH (SU)	6.3	7.1	Continuous Recorder	Min 5.8, Max. 9.0	0	100
Avg. 5-Day BOD (mg/L)	< 1	< 1	Twice Monthly	10	0	100
Max. 5-Day BOD (mg/L)	< 2	< 2	Twice Monthly	20	0	100
% BOD Removal	> 93	> 99	Monthly	85	0	100
Avg. TSS (mg/L)	< 0.24	< 0.57	Twice Monthly	10	0	100
Max. TSS (mg/L)	< 0.3	< 1.14	Twice Monthly	20	0	100
% TSS Removal	> 97	> 99	Monthly	85	0	100
Settleable solids (ml/L)	0	0	Daily	0.1	0	100
Ammonia nitrogen (mg/L)	< 0.03	0.74	Twice Monthly	2	0	100
Total nitrogen (mg/L)	1.6	11.0 (a)	Twice Monthly	10	2	96
Total phosphorus (mg/L)	0.25	1.58	Twice Monthly	NA	0	100
Cyanide (µg/L)	< 1.5	6.1	Twice Monthly	100	0	100
Copper (mg/L)	0.023	0.116	Twice Monthly	0.15	0	100
Iron (mg/L)	0.048	0.277	Twice Monthly	0.37	0	100
Lead (mg/L)	< 0.001	0.004	Twice Monthly	0.019	0	100
Mercury (µg/L)	< 0.03	0.128	Twice Monthly	0.8	0	100
Methylene chloride (µg/L)	< 2	3.23	Twice Monthly	5	0	100
Nickel (mg/L)	0.005	0.012	Twice Monthly	0.11	0	100
Silver (mg/L)	< 0.001	0.003	Twice Monthly	0.015	0	100
Toluene (µg/L)	< 1.0	< 1.0	Twice Monthly	5	0	100
Zinc (mg/L)	0.03	0.133	Twice Monthly	0.1	0	100
1,1,1-trichloroethane (µg/L)	< 1	< 1	Twice Monthly	5	0	100
2-butanone (µg/L)	1.4	< 5	Twice Monthly	50	0	100
PCBs (µg/L)	< 0.0538	< 0.0538	Quarterly	NA	0	100
Max. Flow (MGD)	0.34	0.84	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.27	0.56	Continuous Recorder	NA	0	100
Avg. Fecal Coliform (MPN/100 ml)	< 1	26	Twice Monthly	200	0	100
Max. Fecal Coliform (MPN/100 ml)	< 2	50	Twice Monthly	400	0	100

Notes:
See Chapter 5, Figure 5-6, for location of Outfall 001.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
BOD = Biological Oxygen Demand
MGD = Million Gallons per Day
MPN = Most Probable Number
NA = Not Applicable
SU = Standard Unit
TSS = Total Suspended Solids
(a) Two permit exceedances of the total nitrogen limits were reported: one in January and one in March
Please refer to Section 3.6.1 for explanations of these permit exceedances.

A summary of SPDES monitoring results for the STP discharge at Outfall 001 is provided in Table 3-3. The relevant SPDES permit limits are also shown. The Laboratory monitors the STP discharge for more than 100 parameters monthly and more than 200 parameters quarterly. BNL's overall compliance with effluent limits was greater than 99 percent in 2008. There were two excursions of the SPDES permit limits for total nitrogen: one occurred in January and one occurred in March. In both cases, the effluent concentrations for total nitrogen were just above the Laboratory's SPDES limit of 10 ppm, with discharges of 11.0 ppm in each instance. All other parameters were within permit limits.

The Laboratory has been investigating the potential sources of elevated nitrogen concentrations observed at the STP. A literature search was conducted to identify contributing causes to the increase in nitrogen levels. The standard two-step process relies on bacteria to reduce the biological load in the wastewater and to reduce the nitrogen levels. The two steps occur in the same treatment vessel. During the first step, wastewater is aerated and aerobic bacteria consume the biological matter and oxidize organic and inorganic nitrogenous compounds to nitrate. In the second step, the aeration blowers are shut off, causing the dissolved oxygen levels to drop and prompting the bacteria to seek other sources of oxygen, such as the nitrate formed in step 1. As bacteria consume oxygen in the nitrate molecules, nitrogen gas is liberated and bubbles out of the system, lowering the nitrogen content of the wastewater. At BNL, nutrient levels in the STP influent are lower than in typical municipal wastewater and too low to support both steps in the nitrogen removal process. In April 2008, the Laboratory began adding waste food scraps from the on-site cafeteria to the STP influent in an effort to increase the level of nutrients. Monitoring of the system performance showed the nutrient levels increased, with a corresponding decrease in nitrogen in the effluent. There were no nitrogen violations for the remainder of the year.

Figures 3-1 through 3-7 plot the 5-year trends for the monthly concentrations of copper, iron, lead, mercury, nickel, silver, and zinc in the STP discharge.

3.6.1.1 Chronic Toxicity Testing

The Laboratory's SPDES permit requires that "whole effluent toxicity" (WET) tests be conducted to ensure that chemicals present in the STP effluent are not toxic to aquatic organisms. BNL's chronic toxicity testing program began in 1993 and continued through 2003. Toxicity testing was postponed in 2004, but was restarted in March 2005 as stipulated in the 2005 SPDES permit renewal. Under the WET testing provisions, samples are collected and tested quarterly. The program consists of seven-day chronic toxicity testing on two freshwater organisms: water fleas and fathead minnows. In each test, sets of 10 of these organisms are exposed to varying concentrations of the STP effluent (100, 50, 25, 12.5, and 6.25 percent) for 7 days. During testing, the growth rate of the fish and rate of reproduction for the water flea are measured and compared to untreated organisms (i.e., controls). The test results are submitted to NYSDEC for review.

Testing continued in 2008 using only the water flea, as there have been no toxic effects shown for the minnow in many years of testing. The cause for reduced water flea reproduction rates has been linked to water hardness and alkalinity levels; consequently, the alkalinity and hardness of the dilution water used in the tests is adjusted to mimic that of the Peconic River. Tests were performed in March, June, September, and December. Test results in March showed reduced water flea reproduction rates; no impacts were identified in the remaining three tests. Because the observed impacts were minor (only evident in one of the four tests conducted), no further toxicity reduction was required. Testing will continue in 2009.

3.6.2 Recharge Basins and Stormwater

Water discharged to Outfalls 002 through 008 and Outfalls 010 through 012 recharges 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 3-4 summarizes the monitoring requirements and performance results for 2008. Review of the data shows that with the exception of a single pH excursion, all discharges were in full compliance with SPDES requirements. In August, routine monitoring of the discharge to Outfall 002B showed the pH of the discharge to be 9.3 Standard Units (SU), which exceeded the permit limit of 9.0 SU. Investigation into the cause of the noncompliant discharge showed the source to be the cooling tower at Building 1004. During extended shutdown periods (e.g., summer months), the water in the tower slowly evaporates and is replaced automatically by tower control systems to maintain the water level in the basin. This continual evaporation/refilling process results in the build-up of salts, especially hydroxide salts, found in the potable water supply. The build-up of hydroxide salts results in an increase in the pH of the water in the tower basin. Water leaking through the make-up water valve was causing a slow overflow from the tower basin to the discharge to Outfall 002B. The valve was replaced to stop the discharge.

3.7 SAFE DRINKING WATER ACT

The extraction and distribution of drinking water is regulated under the federal Safe Drinking Water Act (SDWA). In New York State, implementation of the SDWA is delegated to the New York State Department of Health (NYSDOH) and administered locally by SCDHS. Because BNL provides potable water to more than 25 full-time residents, it is subject to the same requirements as a municipal water supplier. Monitoring requirements are prescribed annually by SCDHS, and a Potable Water Sampling and Analysis Plan (Chaloupka 2008) is prepared by BNL to comply with these requirements.

3.7.1 Potable Water

The Laboratory maintains six water supply wells for on-site distribution of potable water. As required by NYSDOH regulations, BNL monitors the potable wells regularly for bacteria, inorganics, organics, and pesticides. The Laboratory also voluntarily monitors drinking water supplies for radiological contaminants yearly. Tables 3-5 and 3-6 provide the potable water supply monitoring data for 2008. In 2008, only iron and color exceeded New York State Drinking Water Standards (NYS DWS), in samples collected from three of the wells (wells 4, 6, and 7) before distribution. Groundwater from these three wells is treated to reduce naturally occurring iron and reduce the color index of the water. Treatment at the Water Treatment Plant effectively reduces these levels to below NYS DWS limits. To ensure that BNL's water supply continually meets NYS DWS, groundwater is also treated

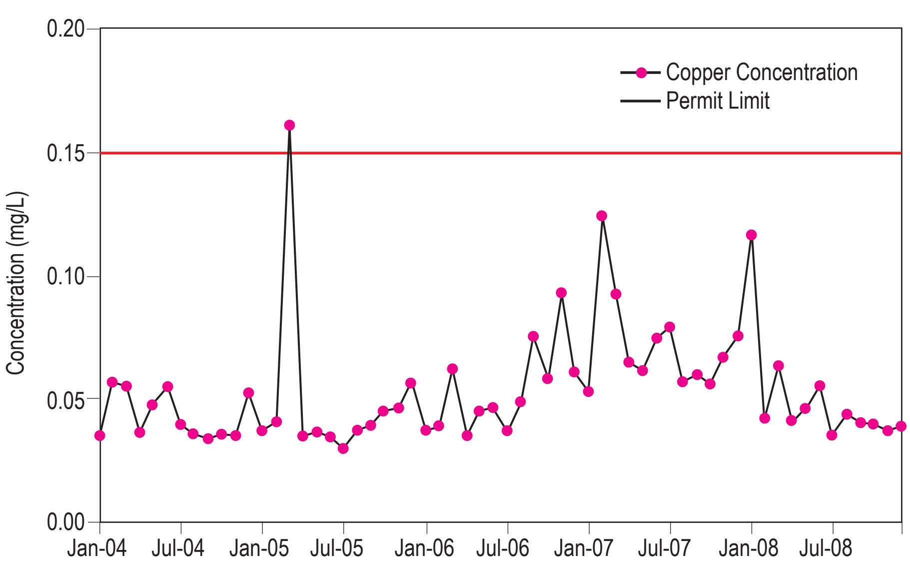


Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2004–2008.

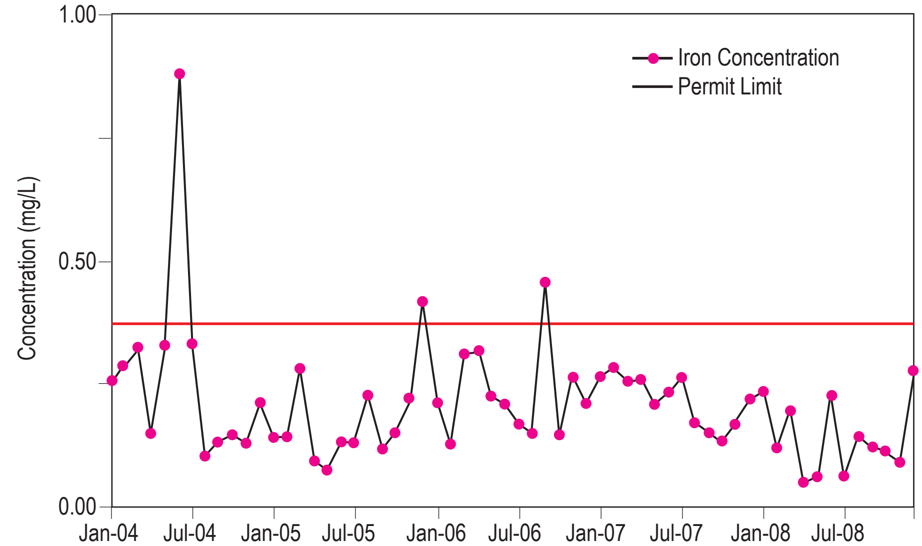


Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2004–2008.

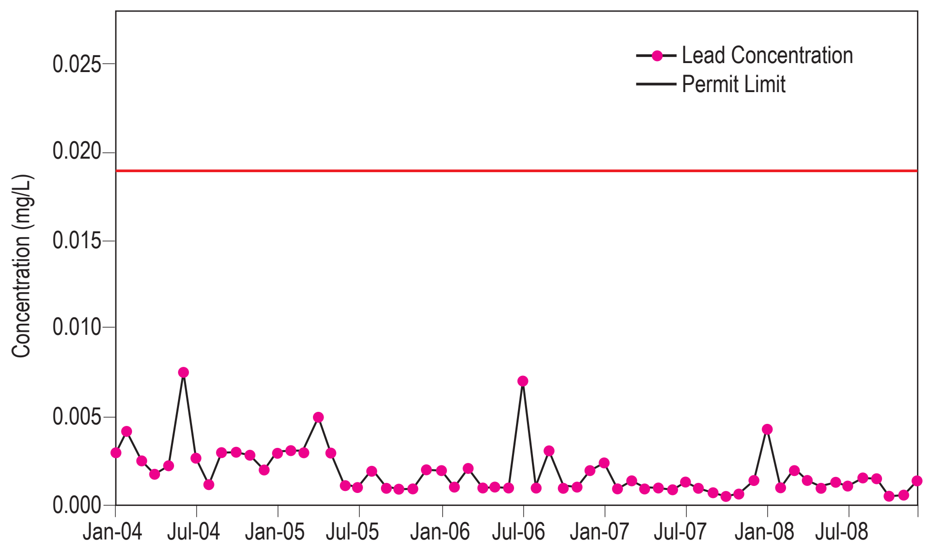


Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2004–2008.

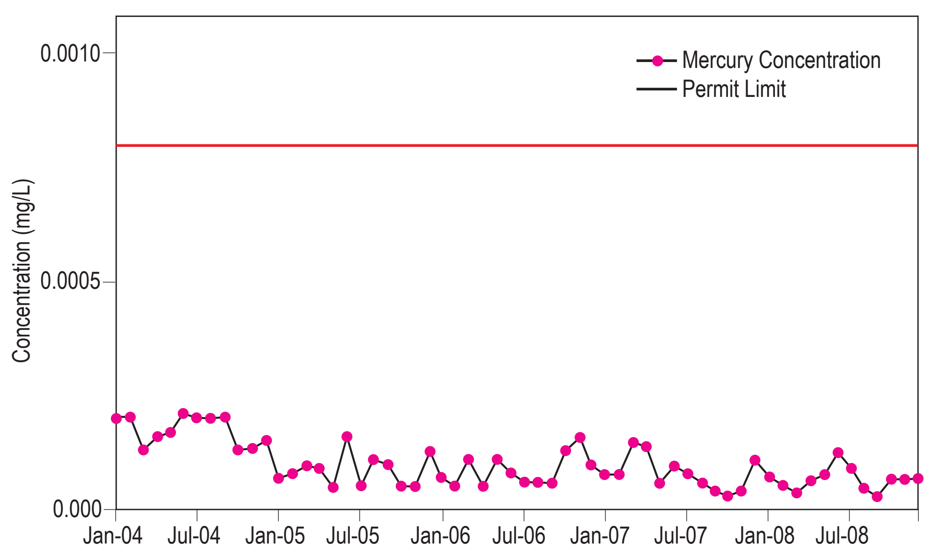


Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2004–2008.

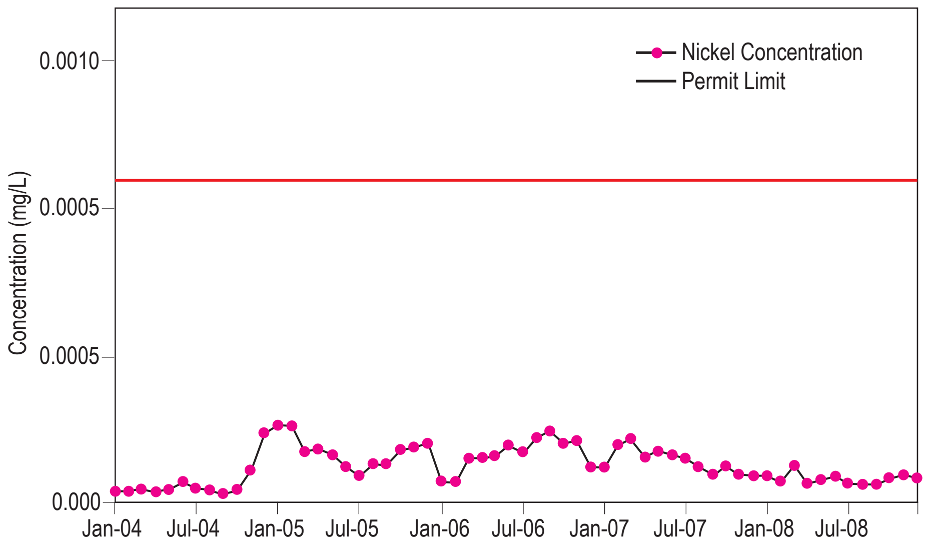


Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2004–2008.

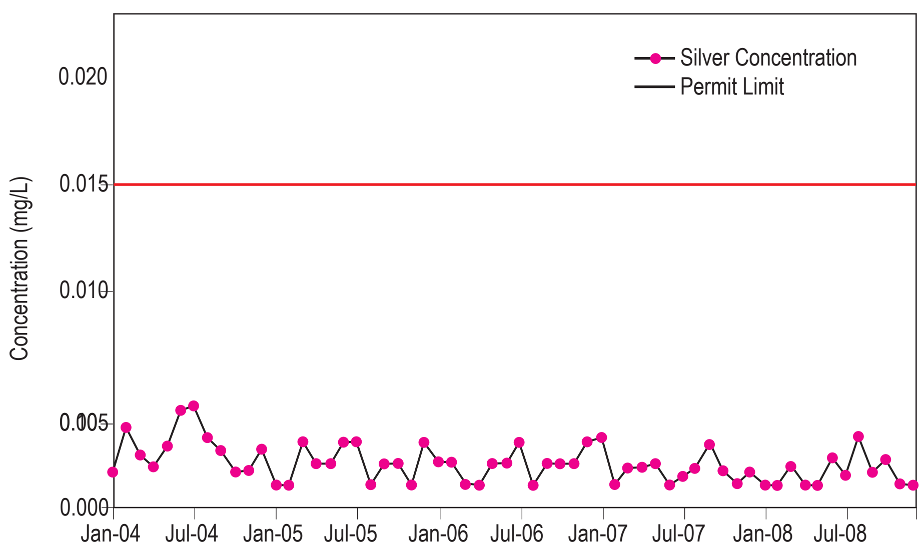
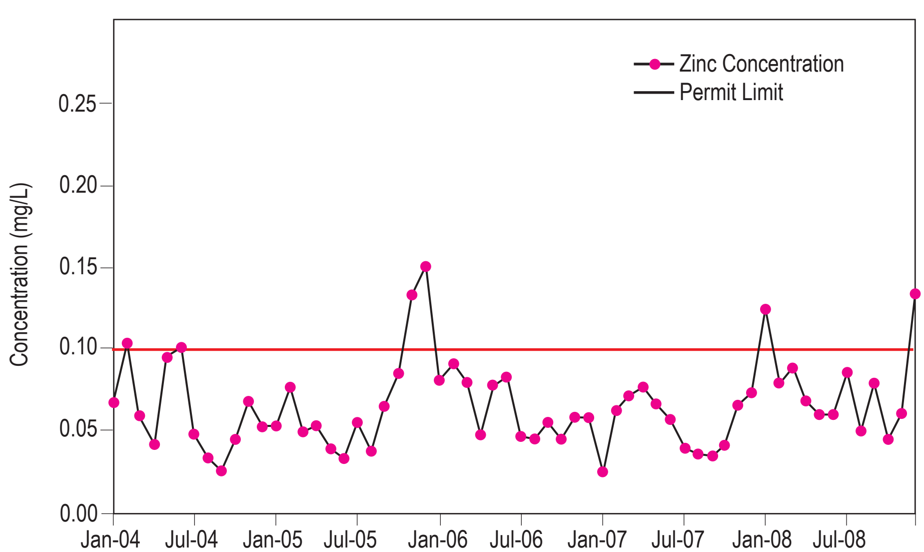


Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2004–2008.



Note:
Per New York State Department of Environmental Conservation guidance, the concentrations of zinc exhibited in the effluent during November 2005 and January and December 2008 were not considered in violation of the State Pollutant Discharge Elimination System effluent limit of 0.1 mg/L, due to rounding off of significant figures.

Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2004–2008.

Table 3-4. Analytical Results for Wastewater Discharges to Outfalls 002, 005 - 008, and 010.

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
Flow (MGD)	*N*	CR	CR	CR	CR	CR	CR	12	12			
	Min.	0.02	0.000	0.13	0.04	0.002	0.12	0.006	0.005	NA		
	Max.	106	0.08	0.52	0.23	0.47	0.36	5.1	2.1	NA	NA	NA
pH (SU)	*Min.*	6.2	6.2	6.7	7	6.6	6.6	6.9	6.4	NA		
	Max.	8.3	9.3	8.3	8.1	8.3	8.8	8.4	8.4	8.5, 9.0 (a)	1	99
Oil and grease (mg/L)	*N*	12	12	12	12	12	NR	12	12			
	Min.	< 1.3	< 1.4	1.7	< 1.4	< 1.4	NR	< 1.4	< 1.4	NA		
	Max.	5.1	4.6	5.6	4.7	5.3	NR	5	3.8	15	0	100
Copper (mg/L)	*N*	NR	NR	4	NR	NR	NR	NR	3			
	Min.	NR	NR	<0.003 (T)	NR	NR	NR	NR	< 0.003 (D)	NA		
	Max.	NR	NR	0.004	NR	NR	NR	NR	0.008 (D)	1.0	0	100
Aluminum (mg/L)	*N*	4	NR	NR	NR	NR	NR	4	4			
	Min.	< 0.07 (T)	NR	NR	NR	NR	NR	< 0.07 (D)	< 0.07 (D)	NA		
	Max	0.07	NR	NR	NR	NR	NR	1.4 (D)	0.2 (D)	2.0	0	100
Lead, Dissolved (mg/L)	*N*	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	< 0.0005	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.001	0.05	0	100
Vanadium, Dissolved (mg/L)	*N*	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	< 0.001	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.006	NPL	NA	NA
Chloroform (mg/L)	*N*	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	0.3	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	1.3	NR	NR	NR	NR	NR	NR	NR	7	0	100
Bromodichloromethane (mg/L)	*N*	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	0.4	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	1.6	NR	NR	NR	NR	NR	NR	NR	5	0	100
1,1,1-trichloroethane (mg/L)	*N*	4	NR	NR	NR	NR	NR	12	NR			
	Min.	< 1.0	NR	NR	NR	NR	NR	< 1.0	NR	NA		
	Max.	< 1.0	NR	NR	NR	NR	NR	< 1.0	NR	5	0	100

(continued on next page)

Table 3-4. Analytical Results for Wastewater Discharges to Outfalls 002, 005 - 008, and 010 *(concluded).*

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
1,1-dicloroethylene (µg/L)	*N*	NR	NR	NR	NR	NR	NR	12	NR			
	Min.	NR	NR	NR	NR	NR	NR	< 1.0	NR	NA		
	Max.	NR	NR	NR	NR	NR	NR	< 1.0	NR	5	0	100
Hydroxyethylidene-diphosphonic acid (mg/L)	*N*	4	4	4	4	4	NR	NR	NR			
	Min.	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	NR	NR	NR	NA		
	Max.	< 0.05	< 0.05	< 0.05	< 0.05	0.3	NR	NR	NR	0.5	0	100
Tolyltriazole (mg/L)	*N*	4	4	4	4	4	NR	NR	NR			
	Min.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NR	NR	NR	NA		
	Max.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NR	NR	NR	0.2	0	100

Notes:
See Chapter 5, Figure 5-6, for location of outfalls.
There are no monitoring requirements for Outfalls 009, 011, and 012.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
CR = Continuous Recorder
D = Dissolved
MGD = Million Gallons per Day
Max. = Maximum value
Min. = Minimum value
N = Number of samples
NA = Not Applicable
NPL = No permit limit, monitoring only
NR = Analysis Not Required
SU = Standard Unit
T = Total Recoverable
(a) pH limit is 8.5 for Outfalls 005, 008, and 010 and pH limit is 9.0 for Outfalls 002, 002B, 006A, 006B, and 007. There was a single pH excursion at Outfall 002B in August 2008.

with activated carbon or air stripping to remove volatile organic compounds (VOCs). At the point of consumption, drinking water complied with all NYSDWS during 2008. Chapter 7 provides additional data on environmental surveillance tests performed on potable wells. This additional testing goes beyond the minimum SDWA testing requirements.

Several events occurred in 2008 that impacted BNL's potable water system. Review of several years of monitoring data showed that organic contaminant levels in Wells 10, 11, and 12 had dropped to levels far below the NYS DWS and in most instances have been non-detectable. In 2007, BNL petitioned SCDHS to remove the activated carbon adsorption vessels from service at these three wells. The request was approved in 2007 and by September 2008 all carbon vessels were emptied and the vessels by-passed. On October 13, 2008, potable well 12 became inoperable due to a propane explosion that destroyed the structure housing the well drive and controls. A leak of propane from the auxiliary drive for the well supplied the fuel for the explosion. The cause of the leak was determined to be the propane solenoid valve that accidentally became energized during a maintenance procedure. There were no personnel present during the explosion, which occurred at 2135 hours; consequently, there were no injuries. Environmental impacts from the explosion were negligible.

To ensure that BNL drinking-water consumers are informed about the quality of Laboratory-produced potable water, BNL annually publishes a Consumer Confidence Report (CCR) by the end of May, a deadline required by the SDWA. This report provides information regarding BNL's source water, supply system, the analytical tests conducted, and the detected contaminants as compared to federal drinking water standards. The CCR also describes the measures the Laboratory takes to protect its water source and limit consumer exposure to contaminants. The CCR is distributed as a special edition of the Laboratory's weekly newsletter to all BNL employees and on-site residents, and it is also available electronically at http://www.bnl.gov/bnlweb/pubaf/water/reports.htm and http://www.bnl.gov/bnlweb/pubaf/bulletin.asp.

Table 3-5. Potable Water Wells and Potable Distribution System: Analytical Results (Maximum Concentration, Minimum pH Value).

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Water Quality Indicators								
Ammonia (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	SNS
Chlorides (mg/L)	33.1	15.2	28.7	34	48.1	30.2	31.7	250
Color (units)	< 5	< 5	< 5	< 5	< 5	< 5	< 5	15
Conductivity (μmhos/cm)	191	125	153	186	232	182	226	SNS
Cyanide (μg/L)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	SNS
MBAS (mg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	SNS
Nitrates (mg/L)	0.3	< 0.10	0.28	0.59	0.72	0.64	0.27	10
Nitrites (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1.0
Odor (units)	0	0	0	0	0	0	0	3
pH (Standard Units)	5.6	5.6	5.7	5.7	5.6	5.7	6.2	SNS
Sulfates (mg/L)	9.1	9.1	11	7.6	11.2	13.6	10.5	250
Total coliform	ND	ND	ND	ND	ND	ND	1***	Negative
Metals								
Antimony (μg/L)	< 5.90	< 5.90	< 5.90	< 5.90	< 5.90	< 5.90	< 5.90	6.0
Arsenic (μg/L)	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00	< 3.00	50
Barium (mg/L)	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2.0
Beryllium (μg/L)	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	4.0
Cadmium (μg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5.0
Chromium (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.1
Fluoride (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	2.2
Iron (mg/L)	1.2*	2.7*	2.3*	0.029	0.018	0.086	0.17	0.3
Lead (μg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
Manganese (mg/L)	0.22	0.17	0.07	< 0.010	< 0.010	< 0.010	0.04	0.3
Mercury (μg/L)	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	2.0
Nickel (mg/L)	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040	SNS
Selenium (μg/L)	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	50.0
Sodium (mg/L)	19.3	10.1	17.8	17	25.5	18.7	18.8	SNS
Silver (μg/L)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	100
Thallium (μg/L)	< 1.90	< 1.90	< 1.90	< 1.90	< 1.90	< 1.90	< 1.90	2.0
Zinc (mg/L)	< 0.020	0.035	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	5.0
Radioactivity								
Gross alpha activity (pCi/L)	< 1.88	< 1.86	< 1.95	< 1.96	1.95 ± 1.44	< 1.96	NR	15.0
Gross beta activity (pCi/L)	< 2.18	< 2.25	< 2.09	< 2.62	< 2.12	2.85 ± 0.85	NR	(a)
Radium-228 (pCi/L)	< 0.83	1.78	1.75	1.24	0.99	0.92	NR	5.0
Strontium-90 (pCi/L)	< 0.71	< 0.81	< 0.78	< 0.50	< 0.89	< 0.73	NR	8.0
Tritium (pCi/L)	< 310	< 310	< 310	< 310	< 310	< 320	NR	20,000

(continued on next page)

Table 3-5. Potable Water Wells and Potable Distribution System: Analytical Results (Maximum Concentration, Minimum pH Value) *(concluded).*

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Other								
Alkalinity (mg/L)	11.8	8.9	14	23.3	18.8	19.2	28.1	SNS
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	NR	< 0.20	7
Calcium (mg/L)	6.3	4	5.4	9.3	7	7.6	10.4	SNS
HAA5 (mg/L)	NR	NR	NR	NR	NR	NR	0.003	0.06**
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	NR	0.6	4.0
TTHM (mg/L)	NR	NR	NR	NR	NR	NR	0.02	0.08**

Notes:
See Figure 7-3 for well locations.
HAA5 = Five Haloacetic Acids
MBAS = Methylene Blue Active Substances
MRDL = Maximum Residual Disinfectant Level
ND = Not Detected
NR = Analysis Not Required
NYS DWS = New York State Drinking Water Standard
SNS = Drinking Water Standard Not Specified
TTHM = Total Trihalomethanes

* Water from these wells is treated at the Water Treatment Plant for color and iron reduction prior to site distribution.
** Limit imposed on distribution samples only.
*** A single sample tested positive for coliform. Upon retesting, all samples were negative.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in late 2003. Gross beta activity does not identify specific radionuclides; therefore, a dose equivalent can not be calculated. No specific nuclides were detected; therefore, compliance with the requirement is demonstrated.

3.7.2 Cross-Connection Control

The SDWA requires that public water suppliers implement practices to protect the water supply from sanitary hazards. One of the safety requirements is to rigorously prevent cross-connections between the potable water supply and facility piping systems that may contain hazardous substances. Cross-connection control is the installation of control devices (e.g., double-check valves, reduced pressure zone valves, etc.) at the interface between a facility and the domestic water main. Cross-connection control devices are required at all facilities where hazardous materials are used in a manner that could result in their introduction into the domestic water system, especially under low-pressure conditions. In addition, secondary cross-connection controls at the point of use are recommended to protect users within a specific facility from hazards that may be posed by intra-facility operations.

The Laboratory maintains approximately 200 cross-connection control devices at interfaces to the potable water main, and secondary control devices at the point of use. In 2008, 213 cross-connection control units were tested at BNL, including primary and secondary devices. If a problem with a cross-connection device is encountered during testing, the device is repaired and retested to ensure proper function. Copies of the cross-connection device test reports are filed with SCDHS annually.

3.7.3 Underground Injection Control

Underground Injection Control (UIC) wells are regulated under the SDWA. At the Laboratory, UICs include drywells, cesspools, septic tanks, and leaching pools, all of which are classified by EPA as Class V injection wells. Proper management of UIC devices is vital for protecting underground sources of drinking water. In New York State, the UIC program is implemented through EPA because NYSDEC has not adopted UIC regulatory requirements. (Note: New York State regulates the discharges of pollutants to cesspools under the SPDES program.) Under EPA's UIC program, all Class V injection wells must be included in an inventory maintained with the agency. In 2008, four storm water drywells were proposed for closure: three near Building T-100 and one near Building 423. All drywells were tested and found to meet Suffolk County Action Levels for contaminants in soils. Only the drywell at 423 was permanently closed in 2008. The drywells at T-100 will be closed in early 2009 as part of the site preparation for the construction of the National Synchrotron Light Source II.

Table 3-6. Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, and Micro-Extractables.

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
Dichlorodifluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chloromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Vinyl Chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
Bromomethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Trichlorofluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Methylene Chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
trans-1,2-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1-dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
cis-1,2-dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
2,2-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Bromochloromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,1-trichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Carbon Tetrachloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2-dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Trichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Dibromomethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
trans-1,3-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
cis-1,3-dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,2-trichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,3-dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,1,2-tetrachloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Bromobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,3-trichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
2-chlorotoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
4-chlorotoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,3-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,4-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2-dichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,4-trichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Hexachlorobutadiene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Tetrachloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,1,2,2-Tetrachloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,3-trichlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5

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Table 3-6. Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, and Micro-Extractables *(continued).*

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	μg/L							
Benzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Toluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Ethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
m,p-xylene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
o-xylene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Styrene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Isopropylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
n-propylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,3,5-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
tert-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,4-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
sec-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
4-Isopropyltoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
n-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chloroform	2	2	1.1	0.8	0.6	< 0.5	< 0.5	50
Bromodichloromethane	2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Dibromochloromethane	2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Bromoform	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Methyl tert-butyl ether	< 0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	50
Lindane	NR	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.2
Heptachlor	NR	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.4
Aldrin	NR	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	5
Heptachlor Epoxide	NR	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.2
Dieldrin	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5
Endrin	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.2
Methoxychlor	NR	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	40
Toxaphene	NR	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	3
Chlordane	NR	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
Total PCB's	NR	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.5
2,4,5,-TP (Silvex)	NR	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	10
Dinoseb	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	50
Dalapon	NR	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	50
Picloram	NR	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Dicamba	NR	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	50
Pentachlorophenol	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1
Hexachlorocyclopentadiene	NR	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	5
Bis(2-ethylhexyl)Phthalate	NR	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	50
Bis(2-ethylhexyl)Adipate	NR	< 1	< 1	< 1	< 1	< 1	< 1	50

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Table 3-6. Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, and Micro-Extractables *(concluded).*

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	NYS DWS
	µg/L							
Hexachlorobenzene	NR	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	5
Benzo(A)Pyrene	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Aldicarb Sulfone	NR	< 1	< 1	< 1	< 1	< 1	< 1	SNS
Aldicarb Sulfoxide	NR	< 1	< 1	< 1	< 1	< 1	< 1	SNS
Aldicarb	NR	< 1	< 1	< 1	< 1	< 1	< 1	SNS
Oxamyl	NR	< 1	< 1	< 1	< 1	< 1	< 1	50
3-Hydroxycarbofuran	NR	< 1	< 1	< 1	< 1	< 1	< 1	50
Carbofuran	NR	< 1	< 1	< 1	< 1	< 1	< 1	40
Carbaryl	NR	< 1	< 1	< 1	< 1	< 1	< 1	50
Methomyl	NR	< 1	< 1	< 1	< 1	< 1	< 1	50
Glyphosate	NR	< 10	< 10	< 10	< 10	< 10	< 10	50
Diquat	NR	< 1	< 1	< 1	< 1	< 1	< 1	50
1,2-dibromoethane (EDB)	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.05
1,2-dibromo-3-chloropropane	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
2,4,-D	NR	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	50
Alachlor	NR	< 1	< 1	< 1	< 1	< 1	< 1	2
Simazine	NR	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Atrazine	NR	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3
Metolachlor	NR	< 1	< 1	< 1	< 1	< 1	< 1	50
Metribuzin	NR	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Butachlor	NR	< 1	< 1	< 1	< 1	< 1	< 1	50
Endothall	NR	< 50	< 50	< 50	< 50	< 50	< 50	100
Propachlor	NR	< 1	< 1	< 1	< 1	< 1	< 1	50

Notes:
See Chapter 7, Figure 7-3, for well locations.
For compliance determination with New York State Department of Health standards, potable water samples were analyzed quarterly for Principal Organic Compounds and annually for other organics by H2M Labs Inc., a New York State-certified contractor laboratory.
The minimum detection limits for principal organic compound analytes are 0.5 mg/L. Minimum detection limits for synthetic organic chemicals and micro-extractables are compound-specific, and, in all cases, are less than the New York State Department of Health drinking water standard.

NA = Not available
NR = Analysis Not Required
SNS = Drinking Water Standard Not Specified
NYS DWS = New York State Drinking Water Standard
WTP = Water Treatment Plant

In addition to the UICs maintained for routine Laboratory discharges of sanitary waste and stormwater, UICs also are maintained at several on- and off-site treatment facilities used for groundwater remediation. Contaminated groundwater is treated and then returned to the aquifer via drywells, injection wells, or recharge basins. Discharges to these UICs are "authorized by rule" rather than by permit. Under the "authorized by rule" requirements, a separate inventory is maintained for these treatment facilities and is periodically updated whenever a new device is added or closed.

3.8 PREVENTING AND REPORTING SPILLS

Federal, state, and local regulations are in place to address the management of storage facilities containing chemicals, petroleum, and other hazardous materials. The regulations include specifications for the design of storage facilities, requirements for written plans relating to unplanned releases, and requirements for reporting any releases that do occur. BNL's compliance with these regulations are described further in the subsections of this section.

3.8.1 Preventing Oil Pollution and Spills

As required by the Oil Pollution Act, BNL maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as a condition of its license to store petroleum fuel. The SPCC Plan is part of the Laboratory's emergency preparedness program and outlines mitigating and remedial actions that would be taken in the event of a major petroleum release. The plan also provides information regarding release prevention measures, the design of storage facilities, and maps detailing storage facility locations. The SPCC Plan is filed with NYSDEC, EPA, and DOE, and was updated in October 2007 (Chaloupka 2007). BNL remained in full compliance with SPCC requirements in 2008.

In July 2002, EPA adopted significant changes to the SPCC regulations that extended the requirements to previously unregulated facilities and provided some relief to existing covered facilities. These changes, among others, included extending the plan update deadline from 3 to 5 years, and specifying that containers smaller than 55 gallons need not be counted toward reaching SPCC applicability. In December 2008, the proposed deadline for updating and implementing BNL's SPCC plan was once again extended by EPA, this time to November 2009. Although the Laboratory has recently updated its SPCC Plan ahead of schedule, the plan will be reviewed again prior to the November 2009 deadline to ensure it complies with all SPCC requirements.

BNL also maintains a Facility Response Plan (FRP) (Lee 2006) that outlines emergency response procedures to be implemented in the event of a worst-case discharge of oil. In October 2005, EPA reviewed the Laboratory's FRP and responded with numerous comments. The revised FRP was approved by EPA in September 2006. Updates to the plan were published in 2007 to ensure all telephone notification lists remained current. In March 2008, EPA conducted an unannounced government-initiated oil spill response exercise and a field inspection at BNL. The objective of the unannounced exercise was to test notification procedures, equipment deployment, and other actions associated with a response to an oil spill scenario identified within BNL's FRP. The exercise revealed that the Laboratory's response procedures were effective and satisfactorily addressed the requirements of the FRP regulation (40 CFR Part 112). BNL fully met the objectives of the government-initiated unannounced exercise and field inspection.

3.8.2 Emergency Reporting Requirements

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of the Superfund Amendments and Reauthorization Act (SARA) require that facilities report inventories (i.e., Tier II Report) and releases (i.e., Tier III Report) of certain chemicals that exceed specific release thresholds. These reports are submitted to the local emergency planning committee and the state emergency response commission. Community Right-to-Know requirements are codified under 40 CFR Parts 355, 370, and 372. Table 3-1 summarizes the applicability of the regulations to BNL. The Laboratory complied with these requirements in 2008 through the submittal of reports under EPCRA Sections 302, 303, 311, and 312. In 2008, through the Tier III report, BNL reported releases of lead (~21,075 pounds), mercury (~118 pounds), PCBs (~5 pounds),

Applicability of EPCRA to BNL				
EPCRA 302–303	**Planning Notification**	**YES [X]**	**NO [ ]**	**NOT REQUIRED [ ]**
EPCRA 304	**EHS Release Notification**	**YES [ ]**	**NO [ ]**	**NOT REQUIRED [X]**
EPCRA 311–312	**MSDS/Chemical Inventory**	**YES [X]**	**NO [ ]**	**NOT REQUIRED [ ]**
EPCRA 313	**TRI Reporting**	**YES [X]**	**NO [ ]**	**NOT REQUIRED [ ]**

benzo(g,h,i)perylene (<1 pound), and polycyclic aromatic compounds (<1 pound). Releases of lead, PCBs, and mercury were predominantly in the form of shipments of waste for off-site recycling or disposal. Releases of benzo(g,h,i)perylene and polycyclic aromatic compounds were as byproducts of the combustion of fuel oils. In 2008, there were no releases of "extremely hazardous substances" reportable under Part 304.

3.8.3 Spills and Releases

When a spill of hazardous material occurs, Laboratory and contractor personnel are required to immediately notify the on-site Fire Rescue Group, whose members are trained to respond to such releases. Fire Rescue's initial response is to contain and control any release and to notify additional response personnel (i.e., BNL environmental professionals, industrial hygienists, etc.). Environmental professionals reporting to the scene assess the spill for environmental impact and determine if it is reportable to regulatory agencies. Any release of petroleum products to soil must be reported to both NYSDEC and SCDHS, and any release affecting surface water is also reported to the EPA National Response Center. In addition, a release of more than 5 gallons of petroleum product to impermeable surfaces or containment areas must be reported to NYSDEC and SCDHS. Spills of chemicals in quantities greater than the CERCLA-reportable limits must be reported to the EPA National Response Center, NYSDEC, and SCDHS. Remediation of the spill is conducted, as necessary, to prevent impacts to the environment, minimize human health exposures, and restore the site.

During 2008, there were 22 spills, nine of which met regulatory agency reporting criteria. The remaining 13 spills were small-volume releases either to containment areas or to other impermeable surfaces that did not exceed a reportable quantity. Table 3-7 summarizes each of the nine reportable events, including a description of the cause and corrective actions taken. Each of the events was unique. There were no long-term effects from these releases and no significant impact on the environment. Five of the events were 5 gallons or less in volume, three ranged from 10 to 15 gallons, and one was the release of 70 gallons of heat transfer fluid that was contained within the facility. In all instances, any recoverable material was pumped out of the secondary containment, then spill absorbents were used to remove residual product. All contaminated absorbents and impacted soils were containerized for off-site disposal. Three of the events were also reportable through the DOE Occurrence Reporting and Processing System (ORPS), a system for identifying, categorizing, notifying, investigating, analyzing, and reporting to DOE events or conditions discovered on site. In addition, there were three other incidents reportable through ORPS in 2008 that were environmental in nature. These included the mischaracterization of wastes shipped to the Waste Management Facility, the issuance of a Notice of Violation for deficiencies identified during the 2008 NYSDEC annual waste inspection, and the finding of loose radioactive material (Naturally Occurring Uranium Oxide) in a sink in Building 490A. A description of each event is provided in Table 3-8.

3.8.4 Major Petroleum Facility License

The storage and transfer of 2.3 million gallons of fuel oil (principally No. 6 oil) subjects the Laboratory to MPF licensing by NYSDEC. The fuel is used at the CSF to produce high-pressure steam to heat and cool BNL facilities and is stored in six tanks with capacities ranging from 300,000 to 600,000 gallons. During 2008, BNL remained in full compliance with the MPF license requirements, which include monitoring groundwater in the vicinity of six active aboveground storage tanks. The license also requires BNL to inspect the storage facilities monthly and test the tank leak detection systems, high-level monitoring, and secondary containment. Tank integrity is also checked periodically. Groundwater monitoring consists of monthly checks for the presence of floating products and twice-yearly analyses for VOCs and semi-volatile organic compounds (SVOCs). In 2008, no VOCs, SVOCs, or floating products attributable to MPF activities were detected. See SER Volume II, Groundwater Status Report, for

Table 3-7. Summary of Chemical and Oil Spill Reports.

Spill No. and Date	Material and Quantity	ORPS Report	Source/Cause and Corrective Actions
08-01 01/16/08	Gasoline 1 quart	No	An abandoned pump inside a plastic tray was found in a remote area of the site. There was evidence of spillage to the soil around the tray. Approximately 50 pounds of soil was removed from the area and containerized for off-site disposal.
08-02 01/28/08	Heat Transfer Oil 70 gallons	No	A helium compressor failed in Building 902C, resulting in spillage of heat exchange fluid to the containment area under the compressor and building floor. All spilled oil was contained within the building. Free liquids were recovered using pumps and absorbents. The remaining oil was recovered using speedy dry. All waste materials were containerized for off-site disposal.
08-04 04/28/08	Power Steering Fluid 1 quart	No	While performing work at the composting area, the power steering unit in a backhoe started to leak. A containment tray was placed beneath the unit immediately upon discovery; however, some fluid was spilled onto the soil. The impacted soil was removed for off-site disposal.
08-06 06/11/08	Hydraulic Fluid 13 gallons	Yes	A street sweeper developed a hydraulic leak while sweeping Upton Road. Upon discovery, the unit was secured to prevent further leakage. The release impacted approximately 200 feet of road surface. Speedy dry was used to absorb the oil. The sweeper was transferred to the repair shop and impacted soils and speedy dry were collected and containerized for off-site disposal.
08-13 09/12/08	Motor Oil 5 gallons	No	A BNL vehicle was being pushed to the gasoline refueling station after running out of gas. While turning to enter the driveway to the station, an unsecured 5-gallon container of motor oil fell out of the vehicle from behind the driver's seat. The container ruptured upon impact with the road. The container belonged to a BNL employee who was transporting it to the on-site service station for disposal. Impacted soils were cleaned up and speedy dry was used to absorb residual oil from the pavement. The impacted soil was containerized for off-site disposal.
08-14 10/06/08	Motor Oil/Hydraulic Oil Mixture 10 gallons	Yes	While mowing the lawn near Building 703, the lawn mower tipped on its side due to the angle of the hill being mowed. Motor oil and hydraulic oil leaked from the vehicle as it lied on its side. All oil was contained on asphalt, but was reportable due to the volume released. The spilled oil was absorbed with speedy dry and containerized for off-site disposal. There were no injuries resulting from this event.
08-15 10/13/08	Ethylene Glycol 1 gallon	No	The radiator hose on a dump truck failed, resulting in the release of 1 gallon of coolant to soil and asphalt. Spill absorbents were used to remove residual liquid. All impacted soils and spill absorbents were collected and containerized for off-site disposal.
08-16 10/13/08	Sodium Hydroxide 1 - 2 gallons	Yes	During the late evening of October 13, 2008 a propane explosion occurred resulting in the demolition of Building 637, Potable Well House 12. The falling debris caused extensive damage to the sodium hydroxide storage tank. Initial inspection of the tank revealed that the site gauge, which was constructed of Tygon tubing, broke away from the tank and complete loss of all product was suspected. Once the debris field was cleared, inspection of the tank showed that the site gauge pinched back on itself, restricting loss of hydroxide to a couple of gallons or less. All spilled product was contained by the tank's secondary containment, and there was no environmental release.
08-21 12/09/08	Hydraulic Oil 15 gallons	No	Hydraulic oil leaked from the elevator casing at Building 750. Upon inspection, the rubber hydraulic seal and fiber gasket were found to be faulty and were replaced. Approximately 15 gallons of oil were recovered from the elevator pit. Residual oil was cleaned using absorbents. All oil and absorbents were containerized for off-site disposal.

Note:
* Release is reportable to DOE under the requirements of DOE Order 231.1A, Occurrence Reporting and Processing.

additional information on groundwater monitoring results.

In January 2008, NYSDEC approved engineering plans for a complete upgrade of the secondary containment basin for tanks 5 and 6. Construction was completed in June 2008 and a Certification Report was prepared by Dvirka & Bartillucci and submitted to NYSDEC in September 2008, documenting all of the corrective actions taken to reconstruct the containment basis for tanks 5 and 6. Based on a review of the report, NYSDEC determined that the secondary

Table 3-8. Summary of Other Environmental Occurrence Reports.

ORPS* ID: SC-BHSO-BNL-BNL-2008-0002 A 0.25 microcurie cesium-137 source was found packaged in a container of waste scintillation vials and fluid containing tritium. This was a violation of requirements to separate sources from other waste types. The researcher responsible for the incident has been retrained, and all future wastes generated reviewed for compliance with hazardous and radioactive waste requirements.	**Date:** 01/03/08 **Status:** Closed. All corrective actions have been completed.
ORPS ID: SC-BHSO-BNL-PE-2008-0001 While performing routine street sweeping, a 1999 Tenant Street Sweeper ruptured a hydraulic control line resulting in the release of 13 gallons of hydraulic fluid to the street. The release was immediately cleaned up and the sweeper was repaired.	**Date:** 06/11/08 **Status:** Closed. All corrective actions have been completed.
ORPS* ID: SC-BHSO-BNL-BNL-2008-0012 While mowing a small hillside near Building 911, a mower slowly rolled onto its side due to the steepness of the incline. There were no injuries. Oils (motor and hydraulic) leaked from the mower onto the pavement. The release was cleaned up to the satisfaction of the regulatory agency.	**Date:** 10/26/08 **Status:** Closed. All corrective actions have been completed.
ORPS* ID: SC-BHSO-BNL-BNL-2008-0013 On October 13, a propane explosion occurred at BNL resulting in the demolition of Building 637, Potable Well House 12. Investigation of the incident found that a propane solenoid valve was accidentally energized during maintenance at the end of the work day. Propane accumulated in the building until explosive levels accumulated within a motor control center. The propane was ignited by a relay or other electrical component within that control center. A small quantity of sodium hydroxide was released during the event. Environmental impacts of this event were negligible and there were no injuries.	**Date:** 10/13/08 **Status:** Open. Investigation into the extent of cause is on-going.
ORPS* ID: SC-BHSO-BNL-BNL-2008-0015 The New York State Department of Environmental Conservation issued a Notice of Violation (NOV) for inadequate labeling of three waste containers discovered during the 2008 annual Resource Conservation and Recovery Act compliance inspection. All violations were immediately corrected and the NOV acknowledged that all violations had been addressed to their satisfaction subsequent to the inspection.	**Date:** 11/13/08 **Status:** Closed. All corrective actions have been completed.
ORPS ID: SC-BHSO-BNL-BNL-2008-0016 During a routine radiological survey of Lab 12-110 in Building 490A, loose contamination was discovered in one of the laboratory sinks. The incident was investigated, and it was determined that the material was naturally occurring uranium oxide used in experiments by students during the summer. Evaluation of down- stream manholes showed no impact by this material, indicating that it was contained to the sink and sink trap.	**Date:** 11/19/08 **Status:** Closed. All corrective actions have been completed.

Notes:
* Reportable under the Occurrence Reporting and Processing System (ORPS), established by the requirements of DOE Order 231.1A.

containment system met the regulatory requirements of 6NYCRR Part 613.2(c)(6) and Special Conditions 3(d) and (e) of BNL's Major Oil Storage Facility License and that it could be placed back in service.

In November, NYSDEC conducted its annual inspection of the Major Oil Storage Facility. Three conditions that required corrective action were identified: repair of a malfunctioning alarm system associated with the #2 fuel oil pipeline secondary containment leak detection system, inspection and repair of a product pipe stanchion that had settled and was not providing the necessary structural support, and evaluation of the Cathodic Protection System servicing tanks 3, 5, and 6 to ensure that it is adequately protecting the tanks. In addition, an inspection of the Laboratory's underground storage facilities and other smaller satellite fuel storage tanks identified three conditions that required corrective action. They included reapplication of the proper color coding for an underground storage tank containing gasoline, addressing deficiencies associated with a satellite #2 fuel oil tank servicing Building 630, and modifying the generic BNL tank identification label to include both the design and working capacities of each tank. Most conditions were corrected in accordance with NYSDEC directives prior to the end of calendar year 2008. With NYSDEC approval, the remaining conditions will be addressed in 2009.

3.8.5 Chemical Bulk Storage

Title 6 of the Official Compilation of the Codes, Rules and Regulations of the State of New York (NYCRR), Part 597, requires that all aboveground tanks larger than 185 gallons and all underground tanks that store specific chemicals be registered with NYSDEC. The Laboratory holds a Hazardous Substance Bulk Storage Registration Certificate for six tanks that store treatment chemicals for potable water (sodium hydroxide and sodium hypochlorite). The tanks range in capacity from 200 to 1,000 gallons. These tanks are also regulated under Suffolk County Sanitary Code (SCSC) Article 12 (SCDHS 1993) and are managed in accordance with BNL procedures designed to conform to Suffolk County requirements.

In November 2008, BNL modified its Chemical Bulk Storage Registration to account for two tank closures. A 750 gallon gallium trichloride tank formerly required in physics experiments was successfully pumped out and removed from the site. In addition, due to an incident in Well House #12 (see Section 3.7.1 for details), the 1,200 gallon sodium hydroxide tank was emptied and will be permanently removed.

NYSDEC also conducted an inspection of the Chemical Bulk Storage (CBS) facilities in November 2008. During this inspection, one issue was identified that required corrective action: modifying the generic BNL tank identification label to include both the design and working capacities of each tank registered under the CBS program. This issue was corrected in accordance with the NYSDEC directive.

3.8.6 County Storage Requirements

Article 12 of the Suffolk County Sanitary Code regulates the storage and handling of toxic and hazardous materials in aboveground or underground storage tanks, drum storage facilities, piping systems, and transfer areas. Article 12 specifies design criteria to prevent environmental impacts resulting from spills or leaks and specifies administrative requirements such as identification, registration, and spill reporting procedures. In 1987, the Laboratory entered into a voluntary Memorandum of Agreement with SCDHS, in which DOE and BNL agreed to conform to the environmental requirements of Article 12.

Currently, there are 351 active storage facilities at BNL for wastewater, chemicals, and fuel (some fuel facilities are regulated under the MPF license), as well as storage facilities used to support BNL research. An additional 32 storage facilities are temporarily out of service. The Laboratory has one active storage facility associated with environmental restoration activities conducted under the CERCLA program; this is not regulated under Article 12.

BNL has an ongoing program to upgrade or replace existing storage facilities, to ensure that the information provided to SCDHS for all registered storage facilities is accurate, and to ensure that new or modified storage facilities are designed and reviewed for full conformance with Article 12 regulations. In 2008, the Laboratory continued to provide SCDHS with updated information regarding several registered tanks, and coordinated several field inspections that resulted in BNL receiving “Permits to Operate” for five existing registered storage facilities. In addition, the design plans and specifications for two new diesel generator tank systems at Buildings 515 and 912A were approved and construction was completed. Both systems were designed and constructed to fully conform to SCSC Article 12 requirements for aboveground storage.

In April 2008, the last single-walled underground storage tank (UST) was removed from the ground and sent off site for recycling. The tank, a 3,000-gallon diesel fuel oil tank, was in good condition and never leaked; however, it did not meet the stringent codes for underground storage in Suffolk County. The Laboratory has been upgrading tanks for more than three decades and has removed approximately 65 USTs and spent well over $30 million to bring storage tanks into conformance with the Suffolk County Article 12 standard. Currently, BNL maintains 55 petroleum product storage tanks subject to the requirements, which call for secondary containment, leak detection, and other safety systems to protect the environment.

3.9 RCRA REQUIREMENTS

The Resource Conservation and Recovery Act regulates hazardous wastes that, if mismanaged, could present risks to human health or the environment. The regulations are designed to ensure that hazardous wastes are managed from the point of generation to final disposal. In New York State, EPA delegates the RCRA program to NYSDEC, with EPA retaining an oversight role. Because the Laboratory may generate greater than 1,000 Kg (2,200 pounds) of hazardous waste in a month, it is considered a large-quantity generator and has a RCRA permit to store hazardous wastes for up to one year before shipping the wastes off site to licensed treatment and disposal facilities. As noted in Chapter 2, BNL also has a number of satellite accumulation and 90-day waste storage areas.

Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. The Federal Facilities Compliance Act (1992) requires that DOE work with local regulators to develop a site treatment plan to manage mixed waste. Development of the plan has two purposes: to identify available treatment technologies and disposal facilities (federal or commercial) that are able to manage mixed waste produced at federal facilities, and to develop a schedule for treating and disposing of these waste streams.

BNL's Site Treatment Plan is updated annually and submitted to NYSDEC for review. The updated plan documents the current mixed waste inventory and describes efforts undertaken to seek new commercial treatment and disposal outlets for various waste streams. Treatment options for all of the mixed waste now in storage have been identified. One item was identified in the 2008 plan which required storage beyond the one-year storage limitation due to treatment facility availability. This item has been approved for shipment to DOE's Toxic Substance and Control Act (TSCA) Incinerator in Oak Ridge, Tennessee and will be treated in April 2009. The Laboratory anticipates that it will continue to manage future mixed wastes within the permitted one-year storage limitation and will continue to maintain and update its Site Treatment Plan as a reporting mechanism, should waste types or treatment facility availability change in the future.

3.10 POLYCHLORINATED BIPHENYLS

The storage, handling, and use of polychlorinated biphenyls (PCBs) are regulated under the Toxic Substance and Control Act. Capacitors manufactured before 1970 that are believed to be oil filled are handled as if they contain PCBs, even when that cannot be verified from the manufacturer's records. All equipment containing PCBs must be inventoried, except for capacitors containing less than 3 pounds of dielectric fluid and items with a concentration of PCB source material of less than 50 parts per million. Certain PCB-containing articles or PCB containers must be labeled. The inventory is updated by July 1 of each year. The Laboratory responds to any PCB spill in accordance with standard emergency response procedures. BNL was in compliance with the regulatory requirements in 2008.

The Laboratory has aggressively approached reductions in its PCB inventory. By replacing and disposing of the last large capacitor and over 300 small capacitors from the Collider-Accelerator Department in 2008, the inventory was reduced an additional 9 percent. Since 2003, BNL has reduced its PCB inventory by more than 99 percent.

3.11 PESTICIDES

The storage and application of pesticides (insecticides, rodenticides, herbicides, and algicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act. Pesticides are used at the Laboratory to control undesirable insects, mice, and rats; bacteria in cooling towers; and to maintain certain areas free of vegetation (e.g., around fire hydrants and inside secondary containment berms). Insecticides are also applied to agricultural research fields and in greenhouses on site. Herbicide use is minimized wherever possible (e.g., through spot treatment of weeds). All pesticides are applied by BNL-employed, New York State–certified applicators. By February 1, each applicator files an annual report with NYSDEC detailing insecticide, rodenticide, algicide, and herbicide use for the previous year. The Laboratory was in full compliance with the legislated requirements in 2008.

3.12 WETLANDS AND RIVER PERMITS

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

Activities that could require review under the BNL Natural and Cultural Resource Management Programs are identified during the NEPA process (see Section 3.3). 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 affect 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, the Laboratory must comply with the permit conditions.

In 2008, two projects remained permitted under this program. These projects included the installation of air conditioning for instrument houses at multiple locations at the Relativistic Heavy Ion Collider (RHIC), and the construction of a block house at the 4 o'clock area at RHIC. Installation of the air conditioning units was substantially complete at the end of 2008; consequently, close-out documentation for this project will be completed and submitted during the first half of 2009. Work to install the block house will continue through 2009.

3.13 PROTECTION OF WILDLIFE

3.13.1 Endangered Species Act

In 2006, the Laboratory updated its list of endangered, threatened, and species of special concern (see Table 6-1 in Chapter 6). Although the tiger salamander is no longer the only state endangered species found at BNL, it is the most notable and best-studied species on site. Tiger salamanders are listed as endangered in New York State because populations have declined due to habitat loss through development, road mortality during breeding migration, introduction of predatory fish into breeding sites, historical collection for the bait and pet trade, water level fluctuations, pollution, and general disturbance of breeding sites. The Laboratory adopted and implemented the BNL Natural Resource Management Plan (NRMP) in December 2003. One component of the plan formalizes the strategy and actions needed to protect 26 confirmed tiger salamander breeding locations on site. The strategy includes identifying and mapping habitats, monitoring breeding conditions, improving breeding sites, and controlling activities that could negatively affect breeding. A multi-year study of three ponds was begun in 2004 to gain a better understanding of salamander habitat requirements and migration patterns.

The banded sunfish and swamp darter are found in the Peconic River drainage areas at BNL. Both species are listed as threatened within New York State, with eastern Long Island having the only known remaining populations of these fish in New York. Measures taken or being taken by the Laboratory to protect the banded sunfish and swamp darter and their habitats include: eliminating, reducing, or controlling pollutant discharges; reducing nitrogen loading in the Peconic River; monitoring populations and water quality to ensure that habitat remains viable; maintaining adequate flow to the river to enable the fish to survive drought; and minimizing disturbances to the river and adjacent banks.

Three butterfly species that are endangered, threatened, or of special concern have been historically documented at the Laboratory; these include the frosted elfin, persius duskywing, and the mottled duskywing. None have been documented in recent surveys. Habitat for the frosted elfin and persius duskywing exists on Laboratory property and mottled duskywing is likely to exist on site; therefore, management of habitat and surveys for the three butterflies has been added to the NRMP.

Surveys for damselflies and dragonflies conducted annually during the summer months confirmed the presence of one of the three threatened species of damselflies expected to be found on site. In June 2005, the pine-barrens bluet (*Enallagma recurvatum*), a threatened species, was documented at one of the many coastal plain ponds located at BNL.

The Laboratory is also home to 14 species that are listed as species of special concern. Such species have no protection under the state endangered species laws, but may be protected under other state and federal laws (e.g., Migratory Bird Treaty Act). New York State monitors species of special concern and manages their populations and habitats, where practical, to ensure that they do not become threatened or endangered. Species of special concern found at BNL include the mottled duskywing butterfly, marbled salamander, eastern spadefoot toad, spotted turtle, eastern box turtle, eastern hognose snake, worm snake, horned lark, whip-poor-will, vesper sparrow, grasshopper sparrow, and Cooper's hawk. The management efforts for the tiger salamander also benefit the marbled salamander. At present, no additional protective measures are planned for the eastern box turtle or spotted turtle, as little activity occurs within their known habitat at the Laboratory. BNL continues to evaluate bird populations as part of the management strategy outlined in the NRMP. In addition to the bird species mentioned above, 18 other bird species listed as species of special concern and two federally threatened species have been observed during spring and fall migrations.

The Laboratory has 20 plant species that are protected under state law. One is an endangered plant, the crested fringed orchid; two are threatened plants, the stiff goldenrod and stargrass; and two are rare plants, the narrow-leafed bush clover and long-beaked bald-rush. The other 15 species are considered to be "exploitably vulnerable," meaning that they may become threatened or endangered if factors that result in population declines continue. These plants are currently sheltered at BNL due to the large areas of undeveloped pine-barren habitat on site. As outlined in the NMRP, locations of these rare plants must be determined, populations estimated, and management requirements established. In an effort to locate and document rare plants, BNL is working with a botanist to assess the flora found on site. See Chapter 6 for further details.

3.13.2 Migratory Bird Treaty Act

As mentioned in Chapter 1, the Laboratory has identified over 185 species of migratory birds since 1948; of those, approximately 85 species nest on site. Migratory birds are protected under the Migratory Bird Treaty Act. This protection includes protection from take, harassment, and destruction or disturbance of nests without permits issued by the U.S. Fish and Wildlife Service. In the past, migratory birds have caused health and safety issues, especially through the deposition of fecal matter and the bird's assertive protection of nesting sites. When this occurs, proper procedures are followed to allow the birds to nest, and then preventive measures are taken to ensure that they do not cause problems in the future. Canada geese (*Branta Canadensis*) are managed under an annual permit from the U.S. Fish and Wildlife Services goose nest management program. See Chapter 6 for more information on migratory birds.

3.13.3 Bald and Golden Eagle Protection Act

While BNL does not have Bald or Golden eagles nesting on site, they do occasionally visit the area during migration. At times, immature golden eagles have spent several weeks in the area of the Laboratory. Bald eagles are known to spend long periods of time on the north and south shores of Long Island. In general, the Laboratory has no concerns with eagles and has no specific management needs concerning them.

3.14 EXTERNAL AUDITS AND OVERSIGHT

3.14.1 Regulatory Agency Oversight

A number of federal, state, and local agencies oversee BNL activities. In addition to external audits and oversight, the Laboratory has a comprehensive self-assessment program, as described in Chapter 2. In 2008, BNL was inspected by federal, state, or local regulators on 11 occasions and SCDHS continued to maintain an on-site office for an inspector who provided periodic oversight of BNL activities. These inspections included:

- *Air Compliance*. While NYSDEC did not conduct a formal inspection of the Laboratory's air compliance program, the agency was present during the annual Relative

Accuracy Test Audit (RATA). During the RATA, the monitoring equipment at the CSF is evaluated by a contracted testing firm to ensure the equipment is operating as required to document compliance with permit-required monitoring requirements. During the audit, NYSDEC found all conditions satisfactory and all equipment tested satisfactorily.

- *Potable Water*. In July, SCDHS collected samples and conducted its annual inspection of the BNL potable water system. No issues were identified.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the Laboratory's STP, to evaluate operations and sample the effluent. In 2008, no performance or operational issues were identified. In November, NYSDEC also inspected the STP and other SPDES regulated outfalls; no issues were identified.
- *Recharge Basins.* SCDHS inspected several of the SPDES-regulated outfalls and collected samples. No issues were identified.
- *Major Petroleum Facility.* The annual NYSDEC inspection of the MPF was conducted in November. See Section 3.8.4 for a discussion of the issues identified.
- *Chemical Bulk Storage Facilities.* The CBS facilities are inspected periodically by NYSDEC. The inspection was conducted in November (see Section 3.8.5).
- *Hazardous Waste.* NYSDEC performed its annual inspection of the BNL Hazardous Waste Program in September 2008. During this inspection, three instances of waste labeling were identified that did not fully comply with hazardous waste storage requirements. These included two bottles of waste that were not labeled as "Hazardous Waste" and one container of mercury switches that did not have the accumulation start date noted on the label. All items were corrected immediately upon their identification and documented in e-mail correspondence to NYSDEC on September 29, 2008. On November 13, 2008 NYSDEC issued a Notice of Violation for the three items identified above. In the letter, NYSDEC acknowledged that all violations were corrected subsequent to the inspection. For a point of reference, during the inspection approximately eighteen 90-day and 135 satellite accumulation areas, including the Treatment, Storage, and Disposal Facility storage area, were inspected and contained approximately 600 containers of waste.

3.14.2 DOE Assessments/Inspections

In 2008, the Laboratory underwent several reviews by DOE, most notably an assessment of BNL's implementation of its emergency management program by the Office of Emergency Management. That evaluation noted significant improvement in the Laboratory's emergency management program, compared with an audit conducted in 2004. Several areas for improvement were identified and a corrective action plan was prepared to continue improvements in the program.

In April 2008, the DOE Brookhaven Site Office (BHSO), in coordination with the DOE Chicago Support Center, conducted a mercury assessment of the site. This assessment focused on efforts to minimize mercury in effluents and emissions and to reduce the on-site inventory of mercury-bearing devices and chemicals. Overall, the assessment found mercury management to be satisfactory, with two recommendations for improvement: reduction of mercury in a lab in Building 815 and frequent monitoring and reporting of pH in the sludge digester at the STP. Both recommendations were addressed immediately after the assessment.

From October 2007 through March 2008, BHSO conducted an assessment of the management of the radiological inventory at the Waste Management Facility. There were two findings identified during this assessment and three noteworthy practices. Corrective actions have been implemented to address accuracy in the waste inventory and modification to personnel protective equipment for performing radiological work. All corrective actions are complete.

In August 2008, BHSO coordinated with the Chicago Operations Support Center to perform a review of long-term monitoring and surveillance activities established for the Peconic

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

Number Agreements	Title	Parties	Effective Date	Status
No Number	Suffolk County Agreement	SCDHS, DOE, and BNL	Originally signed on 09/23/87	This Agreement was developed to ensure that the storage and handling of toxic and hazardous materials at BNL conform to the environmental and technical requirements of Suffolk County codes.
No Number	Federal Facilities Compliance Agreement on Mixed Wastes	NYSDEC and DOE	1992 (updated annually)	The Federal Facilities Compliance Act (FFCA) requires that a site treatment plan to manage mixed wastes be written and updated annually. BNL is in compliance with this requirement.
II-CERCLA-FFA-00201	Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section 120 (also known as the Interagency Agreement or "IAG" of the Environmental Restoration Program)	EPA, DOE, and NYSDEC	05/26/92	Provides the framework, including schedules, for assessing the extent of contamination and conducting the BNL cleanup. Work is performed either as an Operable Unit or a Removal Action. The IAG integrates the requirements of CERCLA, Resource Conservation and Recovery Act (RCRA), and the National Environmental Policy Act (NEPA). While all clean-up actions were completed in 2005, BNL continues to perform surveillance and maintenance of operating remediation systems. All systems operated as required in 2008.
Notices of Violation/Enforcement Actions				
None	NYSDEC Notice of Violation – RCRA Annual Inspection	NYSDEC	11/13/2008	During the NYSDEC annual RCRA compliance inspection, three instances of waste labeling were identified that did not fully comply with hazardous waste storage requirements. These included two bottles of waste that were not labeled as "Hazardous Waste" and one container of mercury switches that did not have the accumulation start date noted on the label. All items were corrected immediately upon their identification and documented in e-mail correspondence on 09/29/08. On 11/13/08, NYSDEC issued a Notice of Violation for the three items identified above. In the letter, the NYSDEC acknowledged that all violations were corrected subsequent to the inspection.

Notes:
EPA = Environmental Protection Agency
NYSDEC = New York State Department of Environmental Conservation
SCDHS = Suffolk County Department of Health Services

River. This assessment found the long-term stewardship to be effective and recommended two improvements: interpret data presented in the annual report, and evaluate the need to maintain or remove the sediment trap installed at the site boundary. Both recommendations are being addressed through routine discussions with the regulators and through modifications to routine reports.

3.14.2.1 Environmental Multi-Topic Assessment

In 2008, BNL conducted a programmatic self-assessment on several aspects of the environmental management program. Determination of topics for this assessment was based on institutional risk, DOE and regulatory agency expectations, and to ensure that key environmental requirements are being implemented as designed. The self-assessment focused on requirements related to properly maintaining institutional and engineered controls for known or potentially contaminated areas of the site, accurately collecting and analyzing groundwater surveillance samples, and maintaining and retrieving environmental surveillance data.

During the self-assessment, no nonconformance or noncompliance issues were identified. The assessment did identify a total of six observations, seven noteworthy practices, and 15 opportunities for improvement. The six observations included:

- Formal procedures for properly maintaining the Land Use Institutional Controls web site had not been established.
- Documentation of contaminated purge water treatment during some groundwater sampling activities was inconsistent.
- A formal tracking system for the comple-

tion of semiannual cap inspections at the Brookhaven Linac Isotope Producer is needed.

- The Collider-Accelerator Department's cap maintenance verification process needs to be modified to ensure that identified repairs/maintenance items are completed in a timely manner.
- The Environmental Management Information System Data Management Description needs to be updated to reflect current operations.
- A standard operating procedure for the Environmental Information Management System's ingest process is needed.

Corrective actions for the observations are being tracked to closure using BNL's Institutional Assessment Tracking System. The completion of the Opportunities for Improvement will be tracked using BNL's Facility Assessment Tracking System.

3.14.2.2 Nevada Test Site Inspection

BNL continues to be a certified Nevada Test Site (NTS) waste generator. As part of the NTS waste certification process, random unannounced inspections are conducted by the NTS Maintenance and Operations Contractor. There were no NTS inspections in 2008.

3.15 ENFORCEMENT ACTIONS AND AGREEMENTS

A Notice of Violation was issued by NYSDEC for deficiencies identified during the 2008 annual hazardous waste inspection. The Notice of Violation has been added to the list of agreements and enforcement actions listed in Table 3-9. There were no fines or other penalties issued as a result of this Notice of Violation, since all corrective actions were completed immediately upon identification.

REFERENCES AND BIBLIOGRAPHY

BNL. 1997. *BNL Site Treatment Plan.* Brookhaven National Laboratory, Upton, NY.

BNL. 2003. *Natural Resource Management Plan for Brookhaven National Laboratory.* Brookhaven National Laboratory, Upton, NY.

Chaloupka, W. 2007. *Brookhaven National Laboratory Spill Prevention Control and Countermeasure Plan.* Brookhaven National Laboratory, Upton, NY.

Chaloupka, W. 2008. *Brookhaven National Laboratory 2008 Annual Potable Water Sampling Plan.* Brookhaven National Laboratory, Upton, NY.

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

DOE Policy 450.4. 1996. *Safety Management System Policy.* U.S. Department of Energy, Washington, DC. 10-15-96.

EPA. 2000. *Federal Facilities Agreement under CERCLA 120.* Administrative Docket Number II-CERCLA-FFA-00201.

Lee, R. 2006. *Brookhaven National Laboratory, Facility Response Plan.* Brookhaven National Laboratory, Upton, NY.

Dorsch, W.R., *Brookhaven National Laboratory, Programmatic Self-Assessment Report for 2008, Multi-Topic Environmental Assessment,* September 2008, Brookhaven National Laboratory, Upton, NY.

SCDHS. 1993. *Suffolk County Sanitary Code Article 12: Toxic and Hazardous Material Storage and Handling Controls.* Suffolk County Department of Health Services, NY.

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4 Air Quality

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

During 2008, BNL facilities released a total of 2,650 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted 99 percent of the site's radiological air emissions.

Since natural gas prices were comparatively lower than residual fuel prices from January through October of 2008, the Central Steam Facility used natural gas to meet most of the heating and cooling needs of the Laboratory's major facilities during this period. As a result, annual facility emissions of particulate matter and sulfur dioxide were considerably lower in 2008 than in the years 1996 and 2003 to 2005, when residual fuel satisfied more than 90 percent of BNL's major facility heating and cooling needs.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and DOE regulations that govern the release of airborne radioactive material include 40 CFR 61 Subpart H: National Emission Standards for Hazardous Air Pollutants (NESHAPs)—part of the Clean Air Act (CAA), and DOE Order 5400.5, Radiation Protection of the Public and the Environment. Under NESHAPs Subpart H, facilities that have the potential to deliver an annual radiation dose of greater than 0.1 mrem (1 µSv) to a member of the public must be continuously monitored for emissions. Facilities capable of delivering radiation doses below that limit require periodic, confirmatory monitoring. Although not required, BNL has one facility that is continuously monitored, the Brookhaven Linac Isotope Producer (BLIP). Periodic monitoring is conducted at one active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Figure 4-1 indicates the locations of these monitored facilities, and Table 4-1 presents the airborne release data from each of these facilities during 2008. Annual emissions from monitored facilities are discussed in the following sections of this chapter. Also discussed is a fourth inactive facility, the Evaporator Facility, which was periodically monitored in past years. The associated radiation dose estimates are presented in Chapter 8, Table 8-4.

4.1.1 Brookhaven Medical Research Reactor

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

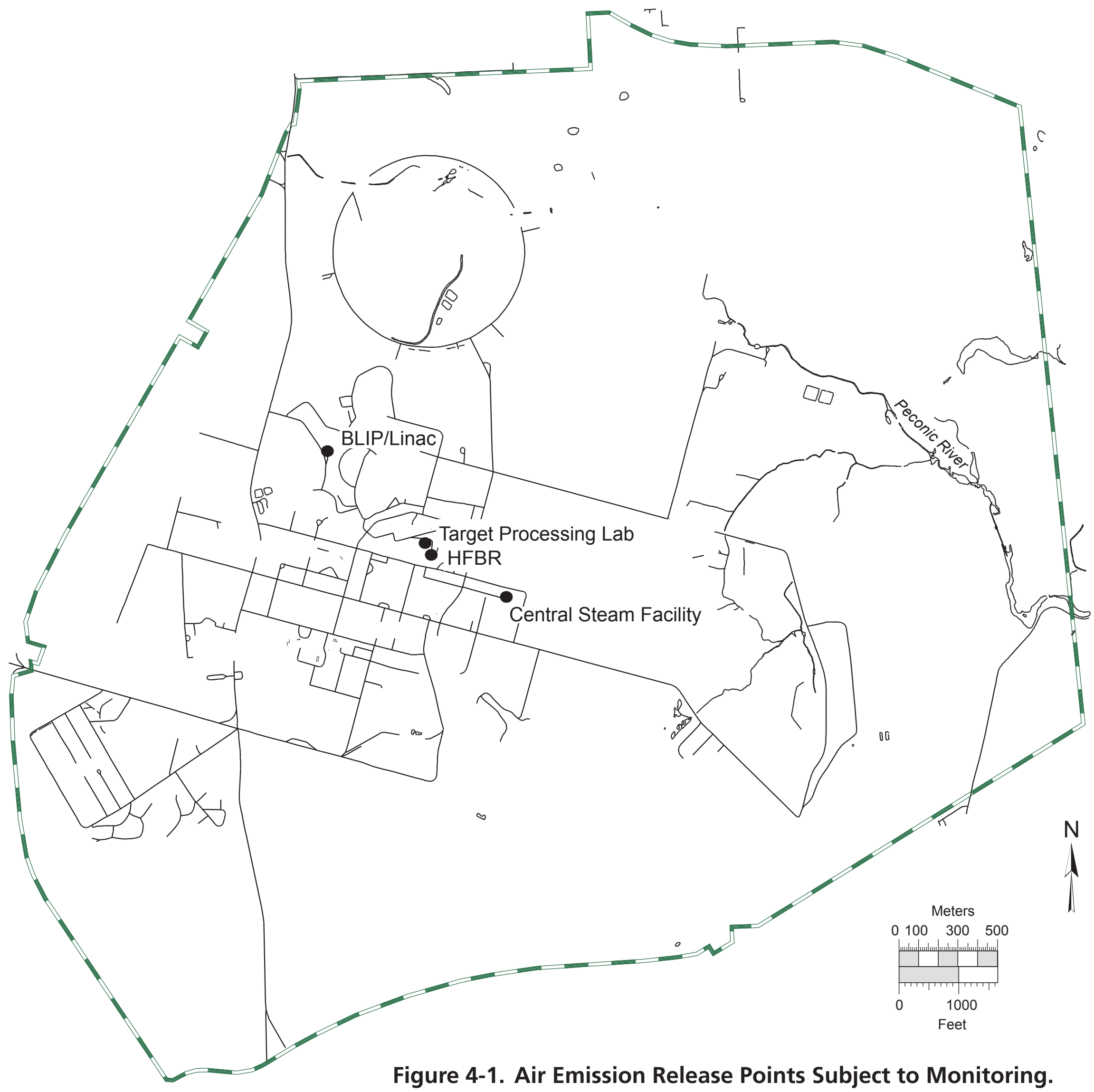

Figure 4-1. Air Emission Release Points Subject to Monitoring.

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

After the BMRR stopped operating, continuous Ar-41 monitoring was reduced to periodic, semi-annual monitoring to confirm that radionuclide concentrations remained below detection limits. In January 2003, the remaining fuel was removed from the BMRR reactor vessel, eliminating the last significant source for radionuclide emissions. The sole remaining BMRR emission source was evaporation of the cooling water, which contained the radioactive isotope tritium (H-3, half-life 12.3 years), produced by neutron activation when the BMRR operated. In January 2005, EPA approved BNL's petition to discontinue emissions monitoring at the BMRR. As a result, sample collection was stopped in 2006 and all removable radioactive materials were shipped off site to a disposal facility.

In 2008, the BMRR remained in a "cold" shutdown mode as a radiological facility. During regular periodic inspections of the facility, tritium samples were collected to quantify the tritium content in the humid air enclosed within the facility. Tritium concentrations inside the building were very low and do not pose any dose risk.

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

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	2.01E+1
BLIP	Carbon-11	20.4 minutes	8.56E+2
	Oxygen-15	122 seconds	1.77E+3
	Tritium	12.3 years	4.57E-2
TPL - Bldg. 801	Germanium-68	270.8 days	1.16E-8
	Selenium-75	119.8 days	1.36E-8
Total			**2.65E+3**

Notes:
Ci = 3.7E+10 Bq
BLIP = Brookhaven Linac Isotope Producer
HFBR = High Flux Beam Reactor (operations were terminated in November 1999)
TPL = Target Processing Laboratory

4.1.2 High Flux Beam Reactor

When the HFBR operated, "heavy" water was used as a neutron moderator and fuel coolant. Heavy water, or D_2O, is water composed of a nonradioactive isotope of hydrogen known as deuterium. When exposed to neutron fields generated inside a reactor vessel, deuterium becomes activated and produces radioactive tritium. As a result of the transfer of fuel elements from the reactor, the spent fuel storage pool contained tritiated heavy water (HTO) from the HFBR system. In 1997, a plume of tritiated groundwater was traced back to a leak in the pool. Consequently, the HFBR was put in standby mode, the pool was pumped out, and the HTO from the pool was properly disposed of as radioactive waste. The pool was replaced with a double lined in accordance with Suffolk County Article 12 regulations (SCDHS 1993) and remained empty while the facility was in a standby mode.

The HFBR continued in standby mode until November 1999, when DOE declared that it was to be permanently shut down. Residual tritium in water in the reactor vessel and piping systems continues to diffuse into the building's air through valve seals and other system penetrations, though emission rates are much lower than during the years of operation (Figure 4-2).

As shown in Figure 4-2, the increase in emissions in 2003 was attributed to evaporative losses when HTO remaining in the reactor core was pumped out for approved disposal. In 2004, the downward trend in emissions resumed: the

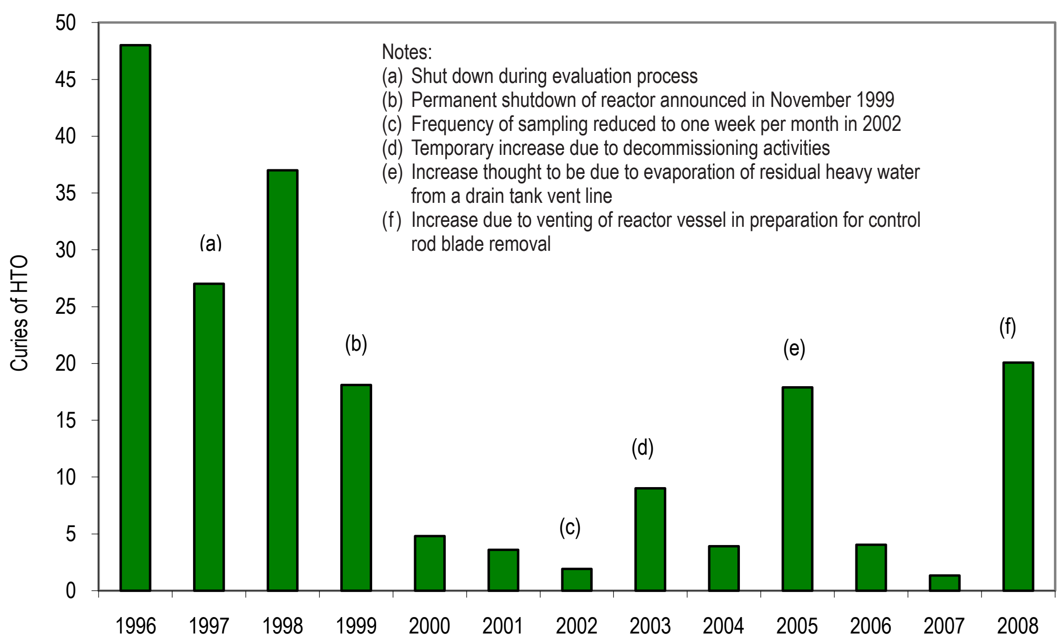

Figure 4-2. High Flux Beam Reactor Tritium Emissions, (1996–2008).

level dropped from 9.0 Ci (the 2003 value) to 3.94 Ci. In 2005, tritium emissions climbed to 17.9 Ci, apparently due to evaporation of residual heavy water through an open drain-tank vent line. In 2006, tritium emissions dropped to 4.03 Ci, a level consistent with 2004 emissions. In 2007, the downward trend continued, as tritium emissions fell to 1.33 Ci. The rise in tritium emissions in 2008 to 20.06 Ci was due to periodic venting of the reactor vessel when domestic water was added to the reactor vessel in preparation for the removal of the HFBR control rod blades. Air emissions from the HFBR facility have been monitored since 2002 via air sampling of the building at a frequency of one week per month. During the periodic venting of the reactor vessel, air sampling of the building was performed weekly.

4.1.3 Brookhaven Linac Isotope Producer

Protons from the Linear Accelerator (Linac) are sent via an underground beam tunnel to the BLIP, where they strike various metal targets to produce new radionuclides for medical diagnostics. The activated metal targets are transferred to the TPL in Building 801 for separation and shipment to various radiopharmaceutical research laboratories. During irradiation, the targets become hot and are cooled by a continuously recirculating water system. The cooling water also becomes activated during the process, producing secondary radionuclides. The most significant of these radionuclides are oxygen-15 (O-15, half-life 122 seconds) and carbon-11 (C-11, half-life 20.4 minutes). Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-foot stack. Emissions of these radionuclides are dependent on the current and energy of the proton beam used to manufacture the radioisotopes.

In 2008, BLIP operated over a period of 23 weeks, during which 856 Ci of C-11 and 1,774 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 4.57 E-2 Ci. Combined emissions of C-11 and O-15 were approximately 4 percent higher than 2007 levels, primarily due to increased hours of operation in 2008.

4.1.4 Evaporator Facility

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

No aqueous waste has been processed at the WCF since 2001. As a result, the Evaporator Facility has not been used and has produced no emissions of tritiated water vapor. Because generation rates of aqueous wastes containing residual radioactivity are expected to remain low, it is no longer cost effective to process the waste in the same manner. Wastes are now solidified and sent to an approved off-site disposal facility. As a result, planning is underway to decommission the Evaporator Facility. Subject to funding availability, the plans also call for demolishing the Building 802B stack and decontaminating the WCF.

4.1.5 Target Processing Laboratory

As mentioned in Section 4.1.3, metal targets irradiated at the BLIP are transported to the TPL in Building 801, where isotopes are chemically extracted for radiopharmaceutical production. Airborne radionuclides released during the extraction process are drawn through multistage HEPA and charcoal filters and then vented to the

HFBR stack. The types of radionuclides that are released depend on the isotopes chemically extracted from the irradiated metal targets, which may change from year to year. Annual radionuclide quantities released from this facility are very small, typically in the µCi to mCi range. In 2008, the total release from the TPL was 0.025 µCi. See Table 4-1 for details of the radionuclides released in 2008.

4.1.6 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves small quantities of radioactive materials (in the µCi to mCi range). The work typically involves labeling chemical compounds and transferring material between containers using pipettes. Due to the use of HEPA filters and activated charcoal filters, the nature of the work conducted, and the small quantities involved, these operations have a very low potential for atmospheric releases of any significant quantities of radioactive materials. Compliance with NESHAPs Subpart H is demonstrated through the use of an inventory system that allows an upper estimate of potential releases to be calculated. Facilities that demonstrate compliance in this way include Buildings 463, 490, 490A, 510, 535, 555, 725, 801, and 830, where research is conducted in the fields of biology, medicine, high energy physics, chemistry, applied and materials science, advanced technology, and environmental sciences. See Table 8-4 in Chapter 8 for the calculated dose from these facility emissions.

4.1.7 Nonpoint Radiological Emission Sources

Nonpoint radiological emissions from a variety of diffuse sources were evaluated in 2008 for compliance with NESHAPs Subpart H. Diffuse sources evaluated included planned research, environmental restoration, and waste management activities. The EPA-approved CAP88-PC dose modeling computer program was used to calculate the possible dose to members of the public from each of the planned activities. The evaluations determined whether NESHAPs permitting and continuous monitoring requirements were applicable, or whether periodic confirmatory sampling was needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of the research, environmental restoration, and waste management activities that occurred in 2008.

4.2 FACILITY MONITORING

In the past, potential sources of radioactive emissions have been monitored at the BMRR, HFBR, Evaporator Facility, TPL, and BLIP. Because the BMRR and HFBR are permanently shut down and the Evaporator Facility has not processed any aqueous wastes since 2001, no particulate sampling was conducted at these facilities in 2008.

The samplers in the TPL exhaust duct and the exhaust stack for BLIP are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-3 for locations). The filters are collected and analyzed weekly for gross alpha and beta activity. Particulate filter analytical results for gross alpha and beta activity in 2008 are reported in Table 4-2. The average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were 0.1101 and 1.3934 pCi/m^3, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0026 and 0.0313 pCi/m^3, respectively.

4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, air monitoring stations are in place around the perimeter of the BNL site (see Figure 4-3 for locations). Samples are collected using equipment at six blockhouse stations and three pole-mounted, battery-powered silica-gel samplers. The blockhouses are fenced to control access and protect costly sampling equipment. In 2003, the number of pole-mounted samplers used for airborne tritium monitoring was reduced from 16 to three because historical air surveillance data revealed that tritium concentrations at most sampling stations were below minimum detection limits (MDLs).

At each blockhouse, vacuum pumps draw air through columns where particulate matter is captured on a glass-fiber filter. Particulate filters

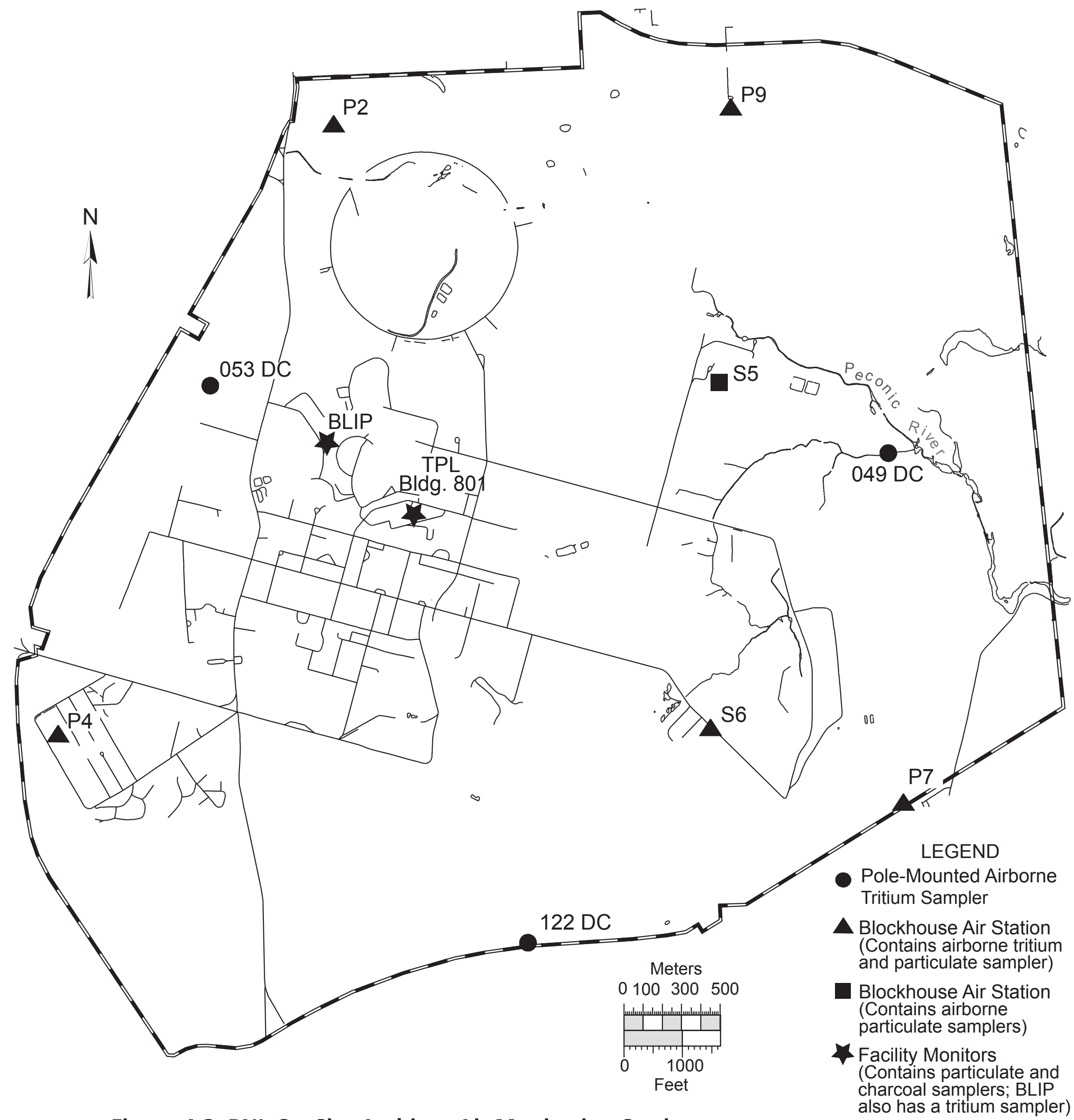

Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.

are collected weekly and are analyzed for gross alpha and beta activity using a gas-flow proportional counter. Also, water vapor for tritium analysis is collected on silica-gel absorbent material for processing by liquid scintillation analysis. In 2008, silica-gel samples were collected every two weeks.

4.3.1 Gross Alpha and Beta Airborne Activity

Particulate filter analytical results for gross alpha and beta airborne activity are reported in Table 4-3. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., sample air volumes were not acceptable). The annual average gross alpha and beta airborne activity levels for the six monitoring stations were 0.0123 and 0.0149 pCi/m^3, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-4. The results for this location are typical for the site. The trend shows seasonal variation in activity within a range that is representative of natural background levels. The New York State Department of Health (NYSDOH) received duplicate filter samples that were collected at Station P7 using a sampler they provided. These samples were

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

Facility Monitor		Gross Alpha (pCi/m³)	Gross Beta (pCi/m³)
BLIP	N	39	39
	Max.	0.3270 ± 0.2180	8.3800 ± 0.5070
	Avg.	0.1101 ± 0.1102	1.3934 ± 0.2447
	MDL	0.1640*	0.2332*
TPL - Bldg. 801	N	51	51
	Max.	0.0079 ± 0.0027	0.2890 ± 0.0113
	Avg.	0.0026 ± 0.0018	0.0313 ± 0.0040
	MDL	0.0023*	0.0032*

Notes:
See Figure 4-3 for sample station locations.
All values shown with a 95% confidence interval.
BLIP = Brookhaven Linac Isotope Producer
MDL = Minimum Detection Limit
N = Number of validated samples collected
TPL = Target Processing Laboratory
*Average MDL for all samples taken at this location

collected weekly and analyzed by the NYSDOH laboratory for gross beta activity only. The analytical results found were comparable to the Station P7 samples analyzed by General Engineering Lab, an analytical laboratory contracted by BNL. New York State's analytical results for gross beta activity at the Laboratory were between 0.0013 and 0.0190 pCi/m^3, with an average concentration of 0.0094 pCi/m^3. BNL results ranged from 0.0038 to 0.0262pCi/m^3, with an average concentration of 0.0106 pCi/m^3. As part of a statewide monitoring program, NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions. In 2008, NYSDOH reported that airborne gross beta activity at that location varied between 0.0050 and 0.0300 pCi/m^3, and the average concentration was 0.0124 pCi/m^3. Sample results measured at the Laboratory generally fell within this range, demonstrating that on-site radiological air quality was consistent with that observed at locations in New York State not located near radiological facilities.

4.3.2 Airborne Tritium

Airborne tritium in the form of HTO is monitored throughout the BNL site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors used for tritium sampling are located at or near the Labortory's property boundary (see Figure 4-3 for locations). On average, observed concentrations of tritium at the sampling stations in 2008 were slightly higher than concentrations observed in 2007. Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concentration. Validated samples are those not rejected due to equipment malfunction or other

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

Sample Station		Gross Alpha (pCi/m³)	Gross Beta (pCi/m³)
P2	N	49	49
	Max	0.0036 ± 0.0010	0.0241 ± 0.0018
	Avg.	0.0018 ± 0.0007	0.0152 ± 0.0014
	MDL	0.0005*	0.0007*
P4	N	44	44
	Max	0.0036 ± 0.0010	0.0297 ± 0.0020
	Avg.	0.0016 ± 0.0006	0.0140 ± 0.0013
	MDL	0.0005*	0.0007*
P7	N	48	48
	Max	0.0032 ± 0.0009	0.0262 ± 0.0019
	Avg.	0.0011 ± 0.0005	0.0106 ± 0.0011
	MDL	0.0005*	0.0006*
P9	N	47	47
	Max	0.0056 ± 0.0013	0.0253 ± 0.0021
	Avg.	0.0016 ± 0.0006	0.0160 ± 0.0015
	MDL	0.0005*	0.0009*
S5	N	31	31
	Max	2.8400 ± 1.0800	0.1550 ± 0.0169
	Avg.	0.0938 ± 0.0358	0.0208 ± 0.0020
	MDL	0.0286*	0.0012*
S6	N	48	48
	Max	0.0043 ± 0.0016	0.0325 ± 0.0030
	Avg.	0.0017 ± 0.0007	0.0147 ± 0.0014
	MDL	0.0006*	0.0009*
Grand Average		**0.0123 ± 0.0208**	**0.0149 ± 0.0012**

Notes:
See Figure 4-3 for sample station locations.
All values shown with a 95% confidence interval.
MDL = Minimum Detection Limit
N = Number of validated samples collected
*Average MDL for all samples taken at this location

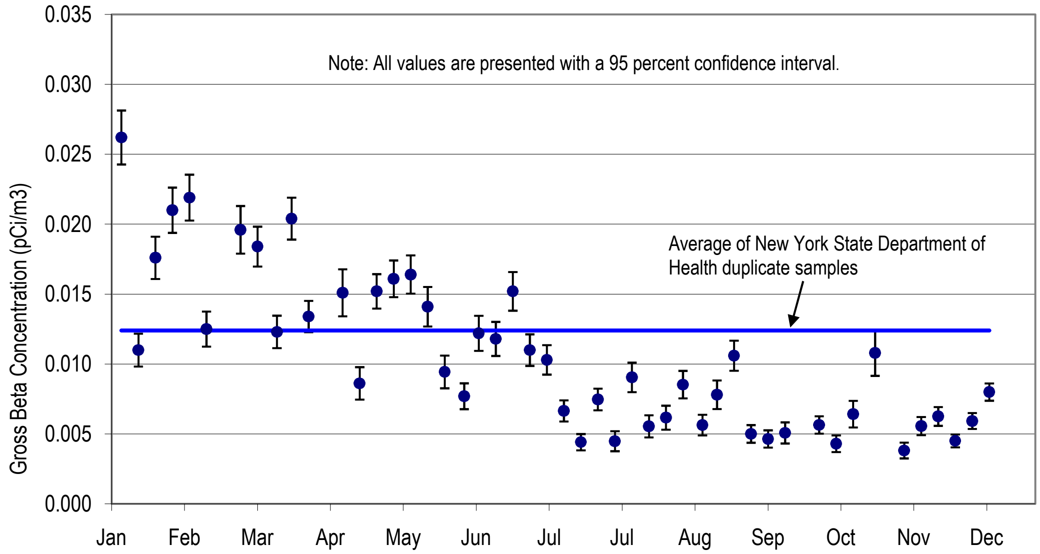

Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.

factors (e.g., a battery failure in the sampler, frozen or supersaturated silica gel, insufficient sample volumes, or the loss of sample during preparation at the contract analytical laboratory). Airborne tritium samples were collected every two weeks from each sampling station during 2008; however, the contract laboratory rejected numerous samples because moisture captured on silica gel was insufficient for analysis. The average tritium concentrations at all of the sampling locations, with the exception of sampling Station P2, were less than the typical MDL, which ranged from 4.0 to 13.0 pCi/m^3. The relative increase in average tritium concentrations at sampling stations appears to have been influenced by the periodic venting of the HFBR reactor vessel that commenced in June 2008 in preparation for the removal of control rod blades.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emission monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that requires monitoring for nonradiological emissions. The Laboratory has several other emission sources subject to state and federal regulatory requirements that do not require emission monitoring (see Chapter 3 for more details). The CSF supplies steam for heating and cooling to major BNL facilities through an underground steam distribution and condensate grid. The location of the CSF is shown in Figure 4-1. The combustion units at the CSF are designated as Boilers 1A, 5, 6, and 7. Boiler 1A, which was installed in 1962, has a heat input of 16.4 MW (56.7 million British thermal units [MMBtu] per hour). Boiler 5, installed in 1965,

Table 4-4. Ambient Airborne Tritium Measurements in 2008.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
049	E	8	13.3 ± 9.5	4.3 ± 5.9
053	NW	19	72.5 ± 8.0	6.1 ± 3.7
122	SSE	2	8.3 ± 11.5	4.2 ± 7.1
P2	NNW	6	69.2 ± 13.0	18.3 ± 8.5
P4	WSW	12	73.7 ± 6.8	12.2 ± 2.8
P7	ESE	20	54.9 ± 6.4	5.1 ± 3.3
P9	NE	21	24.9 ± 3.0	4.3 ± 2.9
S6	SE	22	81.4 ± 8.7	10.5 ± 3.2
Grand Average				**7.6 ± 2.4**

Notes:
See Figure 4-3 for station locations.
Wind sector is the downwind direction of the sample station from the HFBR stack.
All values reported with a 95% confidence interval.
Typical minimum detection limit for tritium is between 1.0 and 10.0 pCi/m^3.
DOE Order 5400.5, Air Derived Concentration Guide, is 100,000 pCi/m^3.

has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers 6 and 7, were installed in 1984 and 1996, and each has a heat input of 42.6 MW (147 MMBtu/hr). For perspective, National Grid's Northport, New York power station has four utility-sized turbine/generator boilers, each with a maximum rated heat input of 1,082 MW (3,695 MMBtu/hr).

Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are subject to Title 6 of the New York Code, Rules, and Regulations (NYCRR) Part 227-2, and the Federal New Source Performance Standard (40 CFR 60 Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Boilers). These boilers are equipped with continuous emission monitors to measure nitrogen oxides (NO_x) and Boiler 7 is equipped with a continuous opacity monitor to comply with Subpart Db opacity monitoring requirements. After a new continuous opacity monitor for Boiler 6 was voluntarily brought online in 2004, emissions on both boilers are now continuously monitored for opacity. To measure combustion efficiency, the boilers are also monitored for carbon dioxide (CO_2). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation (NYSDEC).

From May 1 to September 15 (the peak ozone period), compliance with the 0.30 lbs/MMBtu (129 ng/J) NO_x emission standard for No. 6 oil and the 0.20 lbs/MMBtu (86 ng/J) NO_x emission standard for No. 2 oil and natural gas is demonstrated by calculating the 24-hour average emission rate from continuous emission monitoring system readings and comparing the value to the emission standard. During the remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Boiler 6 and 7 opacity levels are recorded as 6-minute averages. Measured opacity levels cannot exceed 20 percent opacity, except for one 6-minute period per hour of not more

Table 4-5. Central Steam Facility Fuel Use and Emissions (1996 – 2008).

	Annual Fuel Use and Fuel Heating Values						Emissions			
Year	No. 6 Oil (10^3 gals)	Heating Value (MMBtu)	No. 2 Oil (10^3 gals)	Heating Value (MMBtu)	Natural Gas (106 ft^3)	Heating Value (MMBtu)	TSP (tons)	NO_x (tons)	SO_2 (tons)	VOCs (tons)
1996	4,782.55	703,991	52.77	7,388	0.00	0	14.0	104.9	109.0	0.7
1997	3,303.43	484,613	10.23	1,432	190.65	194,463	13.7	83.5	75.1	1.0
1998	354.28	52,283	9.44	1,322	596.17	608,093	2.7	75.1	8.9	1.7
1999	682.76	78,335	2.77	388	614.98	627,280	5.1	53.5	16.7	1.8
2000	2,097.32	309,317	0.82	115	342.40	349,248	9.5	81.6	45.0	1.2
2001	3,645.10	538,847	3.40	476	103.96	106,039	17.5	80.4	77.8	0.8
2002	2,785.04	407,518	0.29	41	220.62	225,030	15.4	62.4	53.8	1.0
2003	4,290.94	628,765	402.06	56,288	0.98	1,000	22.8	75.3	107.1	0.6
2004	4,288.76	628,063	2.45	343	0.11	109	16.4	81.9	104.7	2.4
2005	4,206.12	618,590	0.87	122	0.00	0	15.2	80.4	93.1	2.4
2006	2,933.00	432,430	0.22	30	191.35	195,177	11.8	66.9	66.3	2.2
2007	2,542.85	374,432	0.00	0	263.04	268,301	9.7	77.3	59.3	2.2
2008	1,007.49	148,939	0.10	736	496.48	506,406	5.7	46.7	23.0	1.9
Permit Limit (in tons)							**113.3**	**159.0**	**445.0**	**39.7**

Notes:
NO_x = Oxides of Nitrogen
SO_2 = Sulfur Dioxide
TSP = Total Suspended Particulates
VOCs = Volatile Organic Compounds

than 27 percent opacity. In 2008, there were no measured exceedances of the NO_x emission standards for either boiler. In addition, there were no 6-minute periods when Boiler 6 or Boiler 7 opacity measurements exceeded the opacity limit during soot blowing intervals. Changes in the sequence of the soot blowing cycle for Boiler 6 that were made in August 2005 have proven effective in eliminating most opacity exceedances due to soot blowing. Similar changes made to the soot blowing cycle on Boiler 7 after the installation of a new soot blowing controller in March 2006 have also been successful in eliminating soot blowing opacity exceedances from this boiler. While there are no regulatory requirements to continuously monitor opacity for Boilers 1A and 5, surveillance monitoring of visible stack emissions is a condition of BNL's Title V operating permit. Daily observations of stack gases recorded by CSF personnel throughout the year showed no visible emissions, with opacity levels lower than the regulatory limits established for these boilers.

To satisfy continuous emissions monitoring system quality assurance requirements of the Laboratory's Title V operating permit, a relative accuracy test audit (RATA) of the Boilers 6 and 7 continuous emissions monitoring systems for NO_x and CO_2 was conducted in November 2008. The results of the RATA demonstrated that Boiler 6 and 7 NO_x and CO_2 continuous emissions monitoring systems met RATA acceptance criteria, which are defined in 40 CFR 60 Appendix B Specifications 2 and 3.

In 2008, residual fuel prices from January through October exceeded those of natural gas. As a result, natural gas was used to supply 95 percent of the heating and cooling needs of BNL's major facilities during these months. Natural gas supplied approximately 77 percent of major facility heating and cooling needs for the year. By comparison, in 2004 and 2005, residual fuel satisfied more than 99.9 percent of the major facility heating and cooling needs. Consequently, 2008 emissions of particulates, NO_x, and sulfur dioxide (SO_2) were 9.5, 33.7, and 70.1 tons less than the respective totals for 2005. All emissions were well below the respective permit limits of 113.3, 159, and 445 tons. Table 4-5 shows fuel use and emissions since 1996.

REFERENCES AND BIBLIOGRAPHY

40 CFR 60 Subpart Db. *Standards of Performance for Industrial-Commercial-Institutional Steam Boilers.* 52 FR 47842, Dec. 16, 1987, as amended 72 FR 32742, June 13, 2007.

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

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

NYCRR Part 227-2. Title 6. *Reasonably Available Control Technology for Oxides of Nitrogen.* New York State Department of Environmental Conservation, Albany, NY. Amended 1-28-04.

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

SCDHS. 1993. *Suffolk County Sanitary Code Article 12: Toxic and Hazardous Material Storage and Handling Controls.* Suffolk County Department of Health Services, New York.

USC Title 42, Chapter 85. *Air Pollution Prevention and Control (Clean Air Act)*, 1990.

Water Quality

5

Wastewater generated from Brookhaven National Laboratory (BNL) operations is discharged to surface waters via the Sewage Treatment Plant (STP) and to groundwater via recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and vigilant operation of treatment facilities ensure that these discharges comply with all applicable requirements and that the public, employees, and environment are protected.

Analytical data for 2008 show that the average gross alpha and beta activity levels in the STP discharge were within the typical range of historical levels and were well below drinking water standards. During 2008, tritium was detected in the STP effluent only once at a concentration just above the minimum detectable activity (280 pCi/L vs. 250 pCi/L). The average concentration was slightly lower than in 2007, resulting in a decrease in releases to the Peconic River. The maximum concentration of tritium released was less than 2 percent of the drinking water standard. Tritium was also detected once in the influent, but again at levels barely above the minimum detectable activity. Analysis of the STP effluent continued to show no detection of cesium-137, strontium-90, or other gamma-emitting nuclides attributable to BNL operations. Similarly, there were no radionuclides detected along the Peconic River in 2008 that were attributable to BNL operations.

Nonradiological monitoring of the STP effluent showed that all discharges complied with State Pollutant Discharge Elimination System effluent limitations or other applicable standards. Inorganic data from Peconic River samples collected upstream, downstream, and at control locations demonstrated that elevated amounts of aluminum, iron, and vanadium detected in the river are associated with natural sources.

Examination of analytical data for discharges to recharge basins shows that the average concentrations of gross alpha and beta activity were within typical ranges and that neither tritium nor gamma-emitting radionuclides were detected in 2008. Review of organic data shows that disinfection byproducts are detected in discharges to recharge basins due to the use of chlorine and bromine for the control of algae and bacteria in potable and cooling water systems. Inorganics (i.e., metals) are also detected in these discharges, primarily from sediment run-off in storm water discharges.

5.1 SURFACE WATER MONITORING PROGRAM

Treated wastewater from the BNL STP is discharged into the headwaters of the Peconic River. This discharge is permitted under the New York State Department of Environmental Conservation (NYSDEC) State Pollutant Discharge Elimination System (SPDES) Program. Effluent limits are based on the water quality standards established by NYSDEC, as well as historical operational data. To assess the impact of wastewater discharge on the quality of the river, surface water is monitored at several locations upstream and downstream of the discharge point. Monitoring Station HY (see Figure 5-8), on site but upstream of all Laboratory operations, provides information on the background water quality of the Peconic River. The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by operations at BNL or within the Peconic River watershed.

On the Laboratory site, the Peconic River is an intermittent stream. Off-site flow occurs only during periods of sustained precipitation, typically in the spring. Off-site flow in 2008 was only persistent through early June, due to a dry spring. When flow ceased, standing water was continuous throughout the year in several of the deeper sections of the river. The following sections describe BNL's surface water monitoring and surveillance program.

5.2 SANITARY SYSTEM EFFLUENTS

The STP effluent (Outfall 001) is a discharge point authorized under a SPDES permit issued by NYSDEC. Figure 5-1 shows a schematic of the STP and its sampling locations. The Laboratory's STP treatment process includes four principal steps: 1) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 2) secondary clarification, 3) sand filtration for final solids removal, and 4) ultraviolet disinfection for bacterial control prior to discharge to the Peconic River. Tertiary treatment for nitrogen removal is also provided by controlling the oxygen levels in the aeration tanks. During the aeration process (Step 1), the oxygen levels are allowed to drop to the point where microorganisms use nitrate-bound oxygen for respiration; this liberates nitrogen gas and consequently reduces the concentration of nitrogen in the STP discharge.

Nitrogen is an essential nutrient in biological systems that, in high concentrations, can cause excessive aquatic vegetation growth. During the night (when photosynthesis does not occur), aquatic plants use oxygen in the water. Too much oxygen uptake by aquatic vegetation deprives a water system of oxygen needed by fish and other aquatic organisms for survival. Limit-

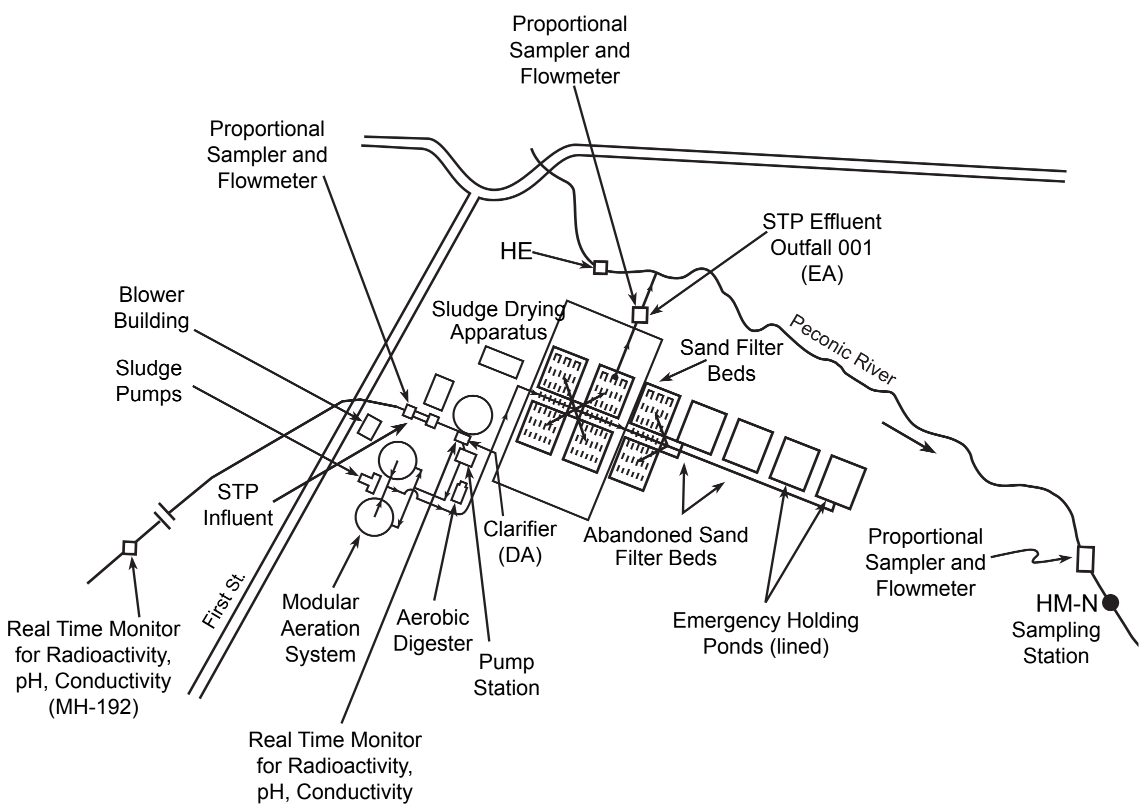

Figure 5-1. Schematic of BNL's Sewage Treatment Plant (STP).

ing the concentration of nitrogen in the STP discharge helps keep plant growth in the Peconic River in balance with the nutrients provided by natural sources.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity takes place at two locations. The first site (MH-192, see Figure 5-1) is approximately 1.1 miles upstream of the STP, providing at least 30 minutes' warning to the STP operators if wastewater is en route that may exceed SPDES limits or BNL effluent release criteria (which are more stringent than DOE-specified levels). The second site is at the point where the STP influent enters the treatment process, as shown in Figure 5-1.

Based on the data collected by the real-time monitoring systems, any influent to the STP that may not meet SPDES limits or BNL effluent release criteria (whichever is more stringent) is diverted to two double-lined holding ponds. The total combined capacity of the two holding ponds exceeds 6 million gallons, or approximately 18 days of flow. Diversion continues until the effluent's water quality meets the permit limits or release criteria. If wastewater is diverted to the holding ponds, it is tested and evaluated against the requirements for release. If necessary, the wastewater is treated and then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits for non-radiological parameters or BNL effluent release criteria for radiological parameters. In 2008, there were no instances that required diversion of the waste water to the hold-up ponds. Waste water contained in the ponds from a diversion of chilled water in 2007, was processed through the addition of coagulants and discharged back through the head of the treatment plant for re-processing. Solids separated during this activity were collected for off-site disposal.

Solids separated in the clarifier are pumped to aerobic digesters for continued biological solids reduction and sludge thickening. Until 2007, the thickened sludge was periodically emptied into solar/heat lamp-powered drying beds, where it was dried to a solid cake. The dried sludge historically contained very low levels (less than 0.5 pCi/g) of radioactivity, such as residual levels of cobalt-60 (Co-60: half-life 5.2 years) from sewage releases. Consequently, the dried sludge was dispositioned as low-level radioactive waste. In an effort to reduce a high inventory of sludge stored in the aerobic digesters, in 2007 BNL retained the services of Mineral Processing Services to process the sludge for drying and eventual off-site disposal. The sludge was processed in late 2007 and placed into Geotubes (large filter bags) and left to dry throughout 2008. Disposal is being planned for the summer of 2009. The dried sludge will be mixed with sand from the sand filter beds and dispositioned off site at a landfill authorized by NYSDEC. With the clean-out of the digesters, newly generated sludge was analyzed and found to be free of radiological contamination. In 2008, authorization was received from the local County authority to transfer waste sludge directly from the aerobic digester to the County-operated sewage treatment facility. In May 2008, approximately 50,000 gallons of sludge were released to the County sewage works.

5.2.1 Sanitary System Effluent–Radiological Analyses

Wastewater at the STP is sampled at the inlet to the treatment process, Station DA (see Figure 5-1) and at the Peconic River Outfall (Station EA). At each location, samples are collected on a flow-proportional basis; that is, for every 1,000 gallons of water treated, approximately 4 fluid ounces of sample are collected and composited into a 5-gallon collection container. These samples are analyzed for gross alpha and gross beta activity and for tritium concentrations. In 2008, samples were collected three times weekly. Samples collected from these locations are also composited and analyzed monthly for gamma-emitting radionuclides and strontium-90 (Sr-90: half-life 29 years).

Although the Peconic River is not used as a direct source of potable water, the Laboratory applies the stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of DOE wastewater criteria. Under the SDWA, water standards are based on a 4 mrem (40 µSv) dose limit. The SDWA specifies that no individual

Table 5-1. Tritium and Gross Activity in Water at the BNL Sewage Treatment Plant (STP).

		Flow (a) (Liters)	Tritium (pCi/L)		Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
			max.	avg.	max.	avg.	max.	avg.
January	*influent*	3.19E+7	< 350	-24.6 ± 68.9	1.2 ± 0.8	0.1 ± 0.2	5.6 ± 1.1	4.8 ± 0.5
	effluent	2.48E+7	< 360	2.6 ± 53.4	< 1.4	0.4 ± 0.1	7.4 ± 1.4	4.8 ± 1.0
February	*influent*	3.75E+7	< 360	48.3 ± 81.8	< 1.6	0.4 ± 0.2	5.5 ± 1.2	4.3 ± 0.5
	effluent	2.85E+7	< 280	-29.2 ± 77.4	< 1.9	0.2 ± 0.2	6.2 ± 1.3	4.4 ± 0.7
March	*influent*	3.80E+7	< 370	-7.2 ± 62.5	< 2.2	0.7 ± 0.3	5.4 ± 1.3	4.0 ± 0.5
	effluent	3.88E+7	< 340	2.2 ± 75.9	4.6 ± 1.5	0.8 ± 0.7	9.4 ± 1.5	4.8 ± 1.0
April	*influent*	4.22E+7	< 350	80.8 ± 40.8	< 1.5	0.2 ± 0.2	6.0 ± 1.3	4.4 ± 0.5
	effluent	4.00E+7	< 350	31.5 ± 38	1.4 ± 0.9	0.5 ± 0.3	6.4 ± 1.3	4.9 ± 0.6
May	*influent*	3.29E+7	< 300	-0.8 ± 53.1	1.3 ± 1.0	0.3 ± 0.3	6.2 ± 1.2	4.8 ± 0.7
	effluent	2.70E+7	< 300	-29.2 ± 53.9	1.7 ± 1.1	0.2 ± 0.4	6.4 ± 1.3	5.2 ± 0.5
June	*influent*	5.40E+7	< 380	-43.8 ± 55	< 1.7	0.2 ± 0.4	7.4 ± 1.4	5.3 ± 0.8
	effluent	3.73E+7	< 360	-56.9 ± 59.1	2.3 ± 1.5	0.6 ± 0.4	8.2 ± 1.7	5.2 ± 0.9
July	*influent*	6.54E+7	< 310	120.7 ± 39	< 1.2	0.4 ± 0.2	7.7 ± 2.7	4.9 ± 0.6
	effluent	3.81E+7	280 ± 170	100.8 ± 62.1	2.4 ± 2.4	0.8 ± 0.5	11.7 ± 2.8	5.0 ± 1.3
August	*influent*	5.85E+7	< 290	94.6 ± 34.4	1.5 ± 1.1	0.5 ± 0.2	6.7 ± 1.3	5.1 ± 0.5
	effluent	2.49E+7	< 290	90 ± 43.3	< 1.4	0.3 ± 0.3	7.4 ± 1.4	4.7 ± 0.8
September	*influent*	5.26E+7	< 290	68.8 ± 45.4	< 1.8	0.4 ± 0.2	6.2 ± 1.5	4.3 ± 0.5
	effluent	2.46E+7	< 280	66.2 ± 28.5	2.2 ± 1.7	0.9 ± 0.3	6.4 ± 1.5	4.8 ± 0.6
October	*influent*	4.88E+7	< 280	70 ± 47.4	1.1 ± 1.1	0.4 ± 0.2	6.9 ± 1.3	4.8 ± 0.6
	effluent	2.74E+7	< 300	20.6 ± 28.3	< 1.5	0.4 ± 0.2	7.3 ± 1.4	5.2 ± 0.7
November	*influent*	5.04E+7	< 300	115.5 ± 32.7	< 0.8	0.2 ± 0.1	6.0 ± 1.3	4.9 ± 0.4
	effluent	2.62E+7	< 300	77.3 ± 25.8	1.2 ± 0.9	0.4 ± 0.3	6.9 ± 1.3	4.6 ± 0.8
December	*influent*	3.76E+7	290 ± 170	-3.1 ± 79.9	3.5 ± 1.5	0.7 ± 0.5	5.1 ± 1.2	3.4 ± 0.5
	effluent	2.60E+7	< 250	-6.9 ± 73.8	1.9 ± 1.0	0.7 ± 0.3	6.5 ± 1.3	4.3 ± 0.8
Annual Avg.	*influent*	4.58E+7		21.5 ± 17		0.5 ± 0.1		4.8 ± 0.2
	effluent	3.03E+7		42 ± 17.8		0.4 ± 0.1		4.6 ± 0.2
Total Release		5.50E+8		11.8 mCi		0.27 mCi		3.3 mCi
Average MDL (pCi/L)				322.4		1.5		1.3
SDWA Limit (pCi/L)				20,000		15		(b)

Notes:
All values are reported with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
To convert values from pCi to Bq, divide by 27.03.
MDL = Minimum Detection Limit
SDWA = Safe Drinking Water Act
(a) Effluent values greater than influent values occur when water that had been diverted to the holding ponds is tested, treated (if necessary), and released.
(b) The drinking water standards were changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

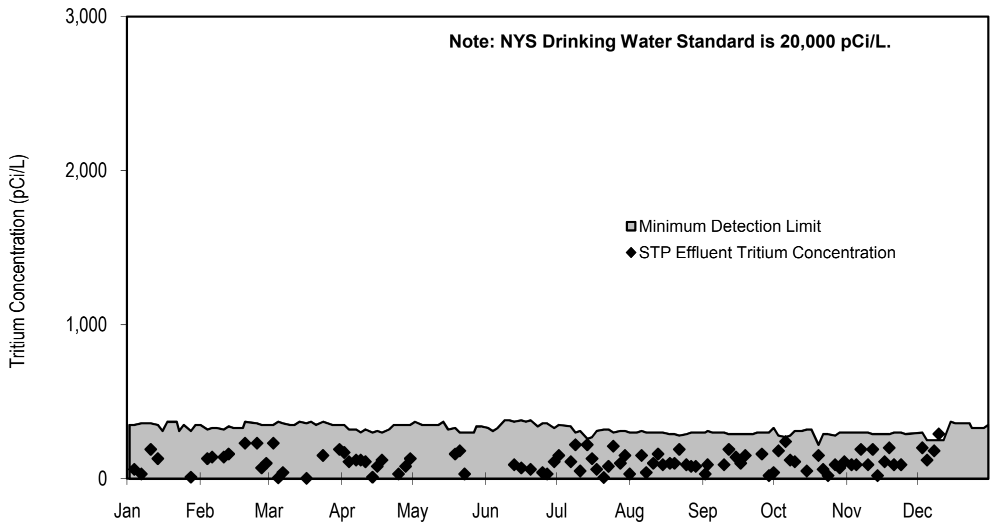

Figure 5-2. Tritium Concentrations in Effluent from the BNL Sewage Treatment Plant (2008).

may receive an annual dose greater than 4 mrem from radionuclides that are beta or photon emitters, which includes up to 168 individual radioisotopes. The Laboratory performs radionuclide-specific gamma analysis to ensure compliance with this standard. The SDWA annual average gross alpha activity limit is 15 pCi/L, including radium-226 (Ra-226: half-life 1,600 years), but excluding radon and uranium. Other SDWA-specified drinking water limits are 20,000 pCi/L for tritium (H-3: half-life 12.3 years), 8 pCi/L for Sr-90, 5 pCi/L for Ra-226 and radium-228 (Ra-228: half-life 5.75 years), and 30 µg/L for uranium. Gross activity (alpha and beta) measurements are used as a screening tool for detecting the presence of radioactivity. Table 5-1 shows the monthly gross alpha and beta activity data and tritium concentrations for the STP influent and effluent during 2008. Annual average gross alpha and beta activity levels in the STP effluent were 0.4 ± 0.1 pCi/L and 4.6 ± 0.2 pCi/L, respectively. These concentrations remain essentially unchanged from year to year. Control location data (Carmans River Station HH; see Figure 5-8) show average gross alpha and beta levels of 0.87 ± 0.64 pCi/L and 3.34 ± 4.02 pCi/L, respectively (see Table 5-7). The average concentrations of gross alpha and beta activity in Peconic River water samples collected upstream of BNL were 0.68 ± 0.21 pCi/L and 1.23 ± 1.09 pCi/L, respectively.

Tritium detected at the STP originates from either High Flux Beam Reactor (HFBR) sanitary system releases, or from small, infrequent batch releases that meet BNL discharge criteria from other facilities. Although the HFBR is no longer operating, tritium continues to be released from the facility at very low concentrations due to off-gassing. When the HFBR was operating, air within the reactor building contained higher levels of tritium in the form of water vapor. The water was absorbed by many porous surfaces and materials, which slowly liberate the tritiated moisture as it is replaced by untritiated water. Once tritium is in the air stream, it condenses as a component of water vapor in the air conditioning or air compressor units and is discharged in these wastewater streams. To minimize the quantity of tritium released to the STP, efforts have been made to capture most of the air compressor condensate collected in the equipment areas of the structure. A plot of the 2008 tritium concentrations recorded in STP effluent is presented in Figure 5-2. A 15-year trend plot of annual average tritium concentrations measured in the STP discharge is shown in Figure 5-3. The annual average concentration trend has been declining since 1995.

In 2008, with the exception of a single low-level reported value, tritium was not detected in the discharge of the STP (EA, Outfall 001) for

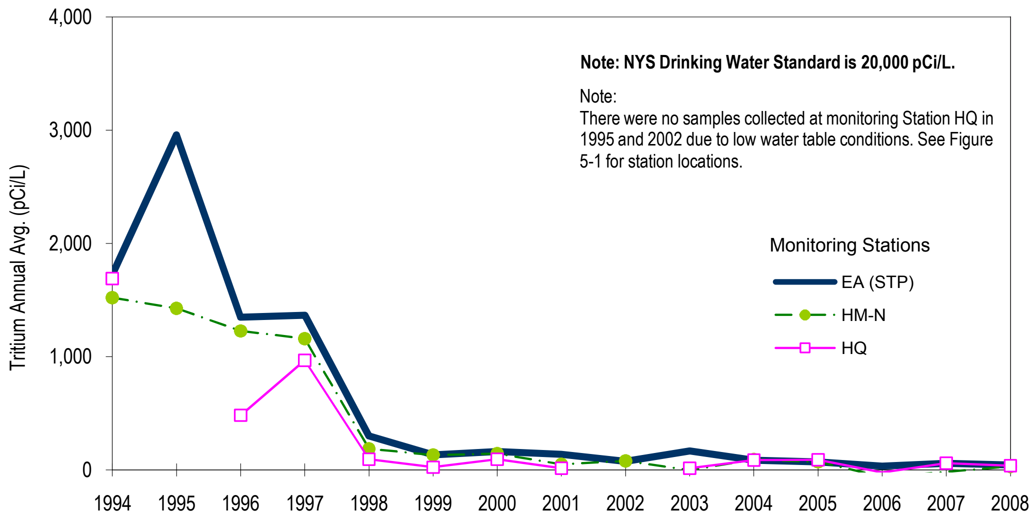

Figure 5-3. Sewage Treatment Plant/Peconic River Annual Average Tritium Concentrations (1994–2008).

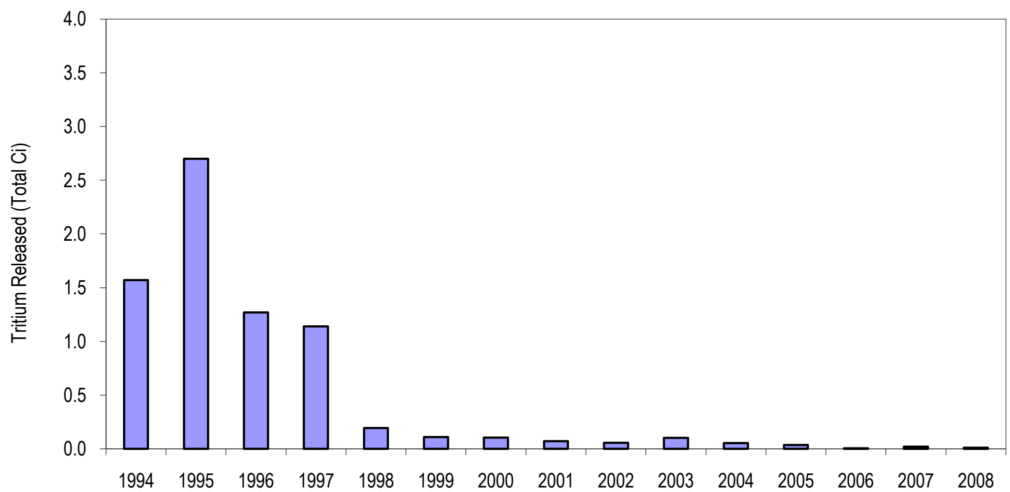

Figure 5-4. Tritum Released to the Peconic River, 15-Year Trend (1994–2008).

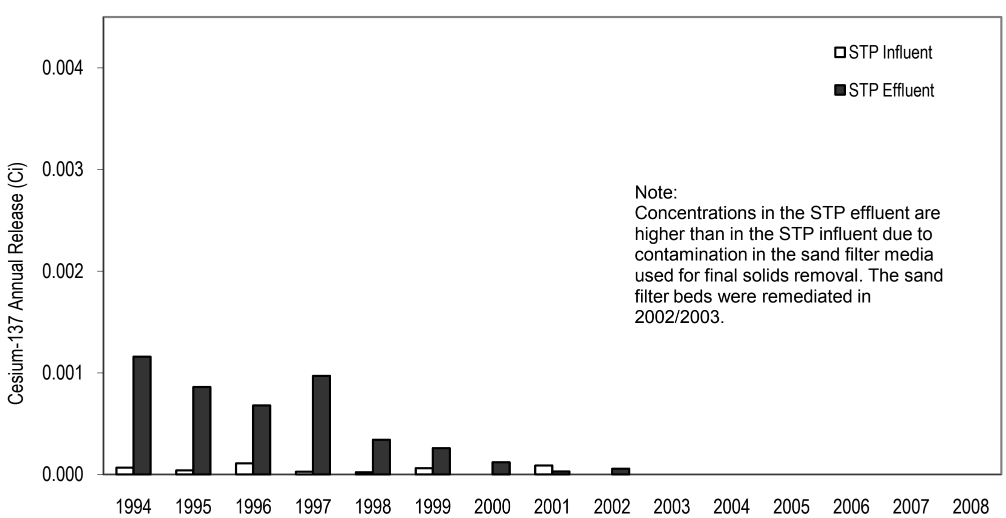

Figure 5-5. Cesium-137 in the BNL Sewage Treatment Plant Influent and Effluent (1994–2008).

the entire year. The concentration measured in the single sample of the STP discharge (see Figure 5-2) was 290 ± 170 pCi/L (December 12). Due to the low level of detection and the high uncertainty, this concentration is indistinguishable from the minimum detection limit (MDL). The annual average tritium concentration, as measured in the STP effluent, was 42 ± 17.8 pCi/L, which is only 13 percent of the average MDL, 322 pCi/L. Since both the maximum and average values were so low and were reported with high uncertainty, all releases should be considered near or below background values. Using the annual average concentration and the flow recorded for the year, a total of 0.012 Ci (11.8 mCi) of tritium was released during the year (see Figure 5-4). Total tritium released for 2008 was 40 percent less than that recorded for 2007. Tritium was also detected in a single sample of STP influent at a similar low-concentration (280 ± 170 pCi/L), in July. Again, this concentration is indistinguishable from the MDL due to the low level of detection and the uncertainty. Both positive detections were reported as estimates by the contract analytical laboratory.

Table 5-2 presents the gamma spectroscopy data for anthropogenic radionuclides historically detected in the monthly STP wastewater composite samples. In 2008, there were no gamma-emitting nuclides detected in the STP effluent, which is consistent with data reported for 2003–2007 (see Figure 5-5). Similarly there was no Sr-90 detected in 2008.

5.2.2 Sanitary System Effluent – Nonradiological Analyses

In addition to the compliance monitoring discussed in Chapter 3, effluent from the STP is also monitored for nonradiological contaminants under the BNL Environmental Surveillance Program. Data are collected for field-measured parameters such as temperature, specific conductivity, pH, and dissolved oxygen, as well as inorganic parameters such as chlorides, nitrates, sulfates, and metals. Composite samples of the STP effluent are collected using a flow-proportional refrigerated sampling device (ISCO Model 3700RF) and are then analyzed by contract analytical laboratories. Samples are analyzed for 23 inorganic elements and for anions, semivolatile organic compounds (SVOCs), pesticides, and herbicides. In addition, grab samples are collected monthly from the STP effluent and analyzed for 38 different volatile organic compounds (VOCs). Daily influent and effluent logs are maintained by the STP operators for flow, pH, temperature, and settleable solids, as part of routine monitoring of STP operations.

Table 5-3 summarizes the water quality and inorganic analytical results for the STP samples. Comparing the effluent data to the SPDES effluent limits (or New York State Ambient Water Quality Standards [NYS AWQS], as appropriate) shows that most of the analytical parameters were within SPDES effluent permit limits (see also the compliance data in Chapter 3). Only total aluminum and zinc were detected in the effluent at concentrations exceeding the SPDES permit limits or ambient water quality standards. Unlike the data reported in Chapter 3, there were no exceedances for nitrogen reported for the environmental surveillance program, which supports the fact that the concentrations reported under the compliance program were isolated incidents. Aluminum was detected in a single sample in February at a concentration greater than 100 ppb. All other concentrations were less than 50 ppb. Due to very high concentrations of aluminum in native soils, the February data is likely skewed due to the presence of sediment in the sample. Aluminum is also regulated in the ionic (i.e., dissolved) form. All data reported in Table 5-3 are for “total recoverable,” which includes suspended and dissolved fractions; consequently, the data are conservative (err on the side of caution). Zinc concentrations in February and December were also higher than the permit limit of 100 µg/L, with concentrations of 120 and 122 µg/L, respectively. These data are consistent with the compliance data reported in Chapter 3. The SPDES permit limit is represented as 0.1 mg/L; thus, with standard rounding, these values do not constitute violations of the limit.

In 2008, five VOCs were detected in the STP effluent, but at very low concentrations. Methyl chloride, chloroform, and toluene were detected on several occasions, at concentra-

Table 5-2. Gamma-Emitting Radionuclides and Strontim-90 in Water at the BNL Sewage Treatment Plant.

		Flow (Liters)	Co-60	Cs-137	Be-7 (pCi/L)	Na-22	Sr-90
January	*influent*	3.19E+7	ND	ND	ND	ND	ND
	effluent	2.48E+7	ND	ND	ND	ND	ND
February	*influent*	3.75E+7	ND	ND	ND	ND	ND
	effluent	2.85E+7	ND	ND	ND	ND	ND
March	*influent*	3.80E+7	ND	ND	ND	ND	ND
	effluent	3.88E+7	ND	ND	ND	ND	ND
April	*influent*	4.22E+7	ND	ND	ND	ND	ND
	effluent	4.00E+7	ND	ND	ND	ND	ND
May	*influent*	3.29E+7	ND	ND	ND	ND	ND
	effluent	2.70E+7	ND	ND	ND	ND	ND
June	*influent*	5.40E+7	ND	ND	ND	ND	ND
	effluent	3.73E+7	ND	ND	ND	ND	ND
July	*influent*	6.54E+7	ND	ND	ND	ND	ND
	effluent	3.81E+7	ND	ND	ND	ND	ND
August	*influent*	5.85E+7	ND	ND	ND	ND	ND
	effluent	2.49E+7	ND	ND	ND	ND	ND
September	*influent*	5.26E+7	ND	ND	ND	ND	ND
	effluent	2.46E+7	ND	ND	ND	ND	ND
October	*influent*	4.88E+7	ND	ND	ND	ND	ND
	effluent	2.74E+7	ND	ND	ND	ND	ND
November	*influent*	5.04E+7	ND	ND	ND	ND	ND
	effluent	2.62E+7	ND	ND	ND	ND	ND
December	*influent*	3.76E+7	ND	ND	ND	ND	ND
	effluent	2.60E+7	ND	ND	ND	ND	ND
Total Release to the Peconic River (mCi)			0	0	0	0	0
DOE Order 5400.5 DCG (pCi/L)			5,000	3,000	50,000	10,000	1,000
Dose limit of 4 mrem EDE (pCi/L)			100	200	6,000	400	8

Notes:
No BNL-derived radionuclides were detected in the effluent to the Peconic River for 2008.
To convert values from pCi to Bq, divide by 27.03.
DCG = Derived Concentration Guide
EDE = Effective Dose Equivalent
ND = Not Detected

tions estimated at less than 1 µg/L and much less than the NYS AWQS of 5 µg/L. Acetone and methylene chloride were also detected, at concentrations ranging from less than 1 µg/L to a maximum of 5.8 µg/L. Acetone and methylene chloride are common solvents used in the contract analytical laboratory and are routinely detected due to cross-contamination within the laboratory.

5.3 PROCESS-SPECIFIC WASTEWATER

Wastewater that may contain constituents above SPDES permit limits or ambient water quality discharge standards must be held by

Table 5-3. BNL Sewage Treatment Plant (STP) Water Quality and Metals Analytical Results.

		STP Influent				STP Effluent				SPDES Limit or AWQS (1)	Comment or Qualifier
ANALYTE	Units	N	Min.	Max.	Avg.	N	Min.	Max.	Avg.		
pH	SU	CM	6.5	8	NA	CM	6	7.6	NA	5.8 - 9.0	
Conductivity	µS/cm	CM	NR	NR	NR	174(a)	175	630	349.6	SNS	
Temperature	°C	CM	NR	NR	NR	174(a)	4.2	26.5	15	SNS	
Dissolved Oxygen	mg/L	NM	NM	NM	NM	174(a)	6.4	13.3	9.6	SNS	
Chlorides	mg/L	12	40.2	92.3	62.6	12.0	48.3	76.4	57.1	SNS	
Nitrate (as N)	mg/L	12	0.1	2.1	1.0	12.0	2.8	8.2	5.0	10	Total N
Sulfates	mg/L	12	13.0	20.7	17.5	12.0	13.9	21.4	18.3	250	GA
Aluminum	µg/L	12	47.0	831.0	216.3	12.0	15.8	113.0	33.7	100	Ionic
Antimony	µg/L	12	0.4	< 5	< 5	12.0	0.3	< 5	< 5	3	GA
Arsenic	µg/L	12	2.6	< 5	< 5	12.0	< 5	< 5	< 5	150	Dissolved
Barium	µg/L	12	28.8	182.0	56.6	12.0	15.8	24.6	18.9	1000	GA
Beryllium	µg/L	12	< 2	< 10	< 10	12.0	< 2	< 10	< 10	11	Acid Soluble
Cadmium	µg/L	12	0.2	1.8	0.6	12.0	0.2	0.6	0.4	1.1	Dissolved
Calcium	mg/L	12	10.4	15.6	12.8	12.0	10.2	14.7	12.9	SNS	
Chromium	µg/L	12	2.2	< 10	< 10	12.0	2.8	< 10	< 10	34.4	Dissolved
Cobalt	µg/L	12	0.5	3.1	1.1	12.0	0.4	< 5	< 5	5	Acid Soluble
Copper	µg/L	12	49.1	424.0	125.3	12.0	31.6	55.5	41.9	150	SPDES
Iron	mg/L	12	0.5	2.7	1.1	12.0	0.1	0.3	0.1	0.37	SPDES
Lead	µg/L	12	2.3	29.7	9.5	12.0	0.7	4.2	1.5	19	SPDES
Magnesium	mg/L	12	3.0	5.0	3.7	12.0	3.1	4.3	3.6	SNS	
Manganese	µg/L	12	29.1	90.2	53.3	12.0	1.7	16.1	4.3	300	GA
Mercury	µg/L	12	0.1	0.6	< 0.2	12.0	0.1	< 0.2	< 0.2	0.8	SPDES
Nickel	µg/L	12	3.3	34.1	10.3	12.0	5.6	10.9	8.0	110	SPDES
Potassium	mg/L	12	4.9	7.2	6.1	12.0	4.0	5.5	5.0	SNS	
Selenium	µg/L	12	0.5	< 5	< 5	12.0	0.5	< 5	< 5	4.6	Dissolved
Silver	µg/L	12	0.4	2.1	< 2	12.0	0.7	4.4	1.7	15	SPDES
Sodium	mg/L	12	32.2	63.3	43.2	12.0	32.5	60.0	39.2	SNS	
Thallium	µg/L	12	0.2	< 5	< 5	12.0	0.2	< 5	< 5	8	Acid Soluble
Vanadium	µg/L	12	2.1	15.4	< 5	12.0	2.1	6.3	< 5	14	Acid Soluble
Zinc	µg/L	12	39.5	375.0	117.2	12.0	39.0	122.0	65.5	100	SPDES

Notes:
See Figure 5-1 for locations of the STP influent and effluent monitoring locations.
All analytical results were generated using total recoverable analytical techniques.
For Class C Ambient Water Quality Standards (AWQS), the solubility state for the metal is provided.
(1) Unless otherwise provided, the reference standard is NYSDEC Class C Surface Water Ambient Water Quality Standards (AWQS).
(a) The conductivity, temperature, and dissolved oxygen values reported are based on analyses of daily grab samples.
AWQS = Ambient Water Qualty Standards
CM = Continuously monitored
GA = Class GA (groundwater) AWQS
N = Number of samples
NA = Not Applicable
NM = Not Monitored
NR = Not Recorded
NYSDEC = New York State Department of Environmental Conservation
SNS = Standard Not Specified
SPDES = State Pollutant Discharge Elimination System
SU = Standard Units

the generating facility and be characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate discharge limit, and the wastewater is released to the sanitary system only if the volume and concentration of contaminants in the discharge would not jeopardize the quality of the STP effluent and, subsequently, the Peconic River.

The Laboratory's SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from printed-circuit-board fabrication operations conducted in Building 535B, metal cleaning operations in Building 498, and cooling tower discharges from Building 902. These operations are monitored for contaminants such as metals, cyanide, VOCs, and SVOCs. In 2008, analyses of these waste streams showed that, although several operations contributed contaminants (principally metals) to the STP influent in concentrations exceeding SPDES-permitted levels, these discharges did not affect the quality of the STP effluent.

Process wastewaters that were not expected to be of consistent quality because they were not routinely generated were held for characterization before release to the site sewer system. The process wastewaters typically included purge water from groundwater sampling, wastewater from cleaning of heat exchangers, wastewater generated as a result of restoration activities, and other industrial wastewaters. To determine the appropriate disposal method, samples were analyzed for contaminants specific to the process. The analyses were then reviewed and the concentrations were compared to the SPDES effluent limits and BNL's effluent release criteria. If the concentrations were within limits, authorization for sewer system discharge was granted; if not, alternate means of disposal were used. Any waste that contained elevated levels of hazardous or radiological contaminants in concentrations that exceeded Laboratory effluent release criteria was sent to the BNL Waste Management Facility for proper management and off-site disposal.

BNL maintains a Central Chilled Water Facility that provides recirculated, refrigerated water for cooling processes, such as heat exchangers used at research facilities, chillers for computer equipment, and comfort cooling in buildings. To provide cost-effective cooling, the facility stores 3.2 million gallons of cold water. The cold water is generated during overnight hours when electricity rates are lower. In April 2007, the chilled water system underwent maintenance to remove accumulated sediment and provide access for inspection. The water was drained to the sanitary sewer. Due to high iron levels, the sewer was diverted and the water was collected in hold-up ponds for treatment and release. In 2008, the wastewater was processed by adding reagents to precipitate and coagulate the very fine iron particles into larger clumps of particles (called floc) for easier and quicker separation. The treated water was discharged to the sanitary sewer for further treatment and discharge, and the retained solids were concentrated and collected for off-site disposal.

5.4 RECHARGE BASINS

Recharge basins are used for the discharge of "clean" wastewater streams, including once-through cooling water, stormwater runoff, and cooling tower blowdown. With the exception of elevated temperature and increased natural sediment content, these wastewaters are suitable for direct replenishment of the groundwater aquifer. Figure 5-6 shows the locations of the Laboratory's discharges to recharge basins (also called "outfalls" under BNL's SPDES permit). Figure 5-7 presents an overall schematic of potable water use at the Laboratory. Eleven recharge basins are used for managing once-through cooling water, cooling tower blowdown, and stormwater runoff:

- Basins HN, HT-W, and HT-E receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS) and Relativistic Heavy Ion Collider (RHIC), as well as cooling tower blowdown and stormwater runoff.
- Basin HS receives predominantly stormwater runoff, once-through cooling water from Building 555 (Chemistry Department), and minimal cooling tower blowdown from the National Synchrotron Light Source (NSLS).
- Basin HX receives Water Treatment Plant filter backwash water.
- Basin HO receives cooling water discharges from the AGS and stormwater runoff from the area surrounding the HFBR.

- Several other recharge areas are used exclusively for discharging stormwater runoff. These areas include Basin HW in the former warehouse area, Basin CSF at the Central Steam Facility (CSF), Basin HW-M at the former Hazardous Waste Management Facility (HWMF), and Basin HZ near Building 902.

Each of the recharge basins is a permitted point-source discharge under the Laboratory's SPDES permit. Where required by the permit, the discharge to the basin is equipped with a flow monitoring station; weekly recordings of flow are collected, along with measurements of pH. The specifics of the SPDES compliance monitoring program are provided in Chapter 3. To supplement that monitoring program, samples are also routinely collected and analyzed under BNL's Environmental Surveillance Program for radioactivity, VOCs, metals, and anions. During 2008, water samples were collected from all basins listed above except recharge basin HX at the Water Treatment Plant (exempted by NYSDEC from sampling due to documented non-impact to groundwater) and the recharge basin at the former HWMF, as there are no longer any operations that could lead to the contamination of runoff.

Figure 5-6. BNL Recharge Basin/Outfall Locations.

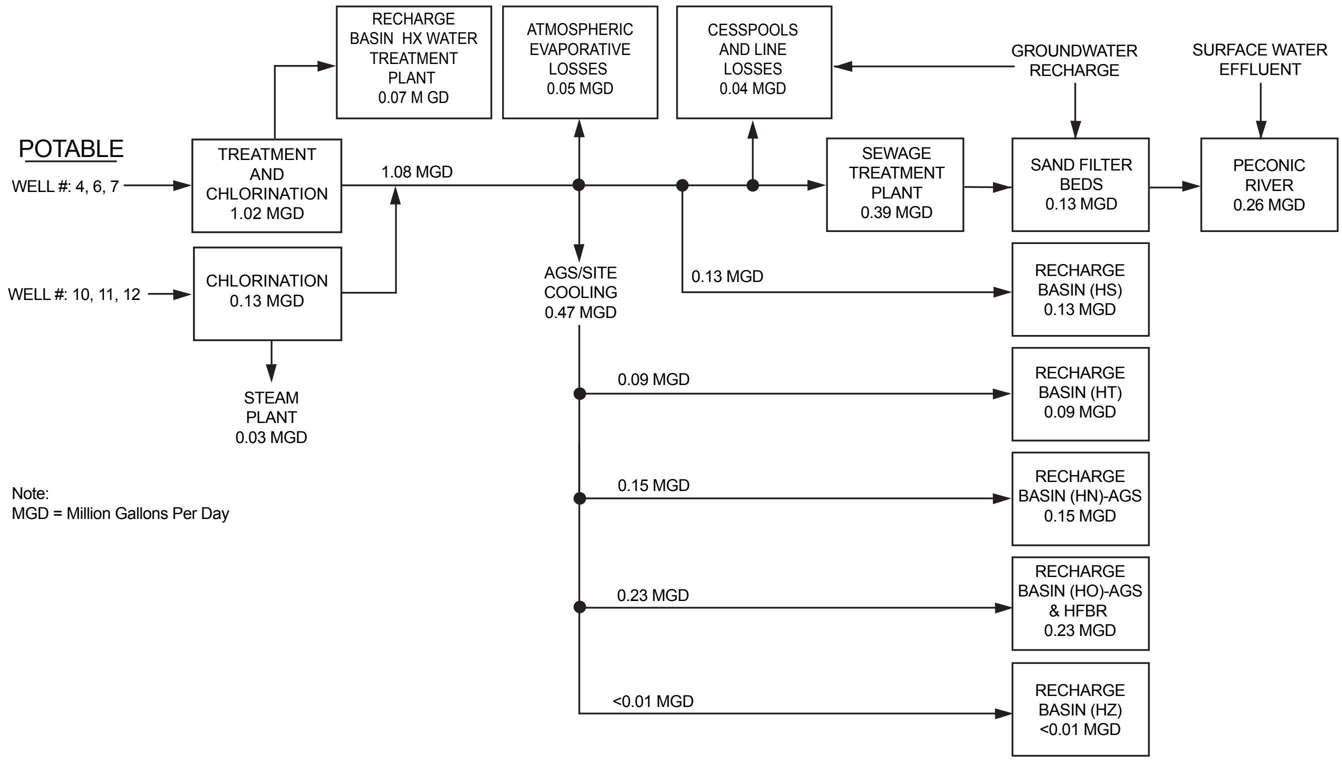

Figure 5-7. Schematic of Potable Water Use and Flow at BNL.

5.4.1 Recharge Basins – Radiological Analyses

Discharges to the recharge basins were sampled throughout the year for subsequent analyses for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. These results are presented in Table 5-4 and show that low levels of alpha and beta activity were detected in most of the basins. Activities ranged from nondetectable to 2.7 ± 1.2 pCi/L for gross alpha activity, and from nondetectable to 4.8 ± 1.0 pCi/L for gross beta activity. Low-level detections of gross alpha and beta activity are attributable to very low levels of naturally occurring radionuclides, such as potassium-40 (K-40: half-life 1.3E+09 years). The contract analytical laboratory reported no gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins in 2008. Tritium was also not detected in samples collected at the basins in 2008.

5.4.2 Recharge Basins – Nonradiological Analyses

To determine the overall impact on the environment of discharges to the recharge basins, the nonradiological analytical results were compared to groundwater discharge standards promulgated under Title 6 of the New York Codes, Rules, and Regulations (NYCRR), Part 703.6. Samples were collected quarterly for water quality parameters, metals, and VOCs, and were analyzed by a contract analytical laboratory. Field-measured parameters (pH, conductivity, and temperature) were routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 5-5 and 5-6, respectively.

Low concentrations of disinfection byproducts were periodically detected in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, lead to the formation of VOCs, including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. All concentrations were less than 10 µg/L. Acetone was the only other analyte detected above the MDL for most recharge basins. The concentration of acetone ranged from nondetectable to a maximum of 39.0 µg/L. In most instances, acetone was also found as a contaminant in the contract analytical laboratory, as evidenced by detections in blank samples.

The analytical data in Tables 5-5 show that for 2008, the concentrations of all analytes were within effluent standards. A mild winter with little snow and ice resulted in less discharge of sodium and chlorides due to road salting. The data in Table 5-6 show that all parameters, except for aluminum, iron, cobalt, and lead, complied with the respective water quality or groundwater discharge standards (GDS). Due to the prevalence of metals in soils, the presence of these elements is likely due to suspended soil in the samples at the time of collection. Acidification of the samples (part of the analytical process) results in the dissolution of the element and its detection during analysis. This is supported by the observation that the concentrations of metals in all filtered samples were significantly less, and well below the discharge standard or NYS AWQS. As these metals are in particulate form in the discharge water, they pose no threat to groundwater quality because the recharge basin acts as a natural filter, trapping particles before they reach the groundwater.

Table 5-4. Radiological Analysis of Samples from On-Site Recharge Basins at BNL.

Basin		Gross Alpha	Gross Beta	Tritium
		(pCi/L)		
	*No. of samples**	4	4	4
HN	*max.*	< 0.94	2.3 ± 1.1	< 300
	avg.	0.32 ± 0.28	1.55 ± 0.57	47.5 ± 172.06
HO	*max.*	2.8 ± 1.1	1.73 ± 0.81	< 280
	avg.	1.18 ± 1.3	0.95 ± 0.57	-12.5 ± 100.38
HS	*max.*	1.01 ± 0.71	3.9 ± 1.2	< 300
	avg.	0.58 ± 0.36	2.31 ± 1.19	115 ± 70.44
HT-E	*max.*	0.88 ± 0.64	2.8 ± 1.1	< 300
	avg.	0.62 ± 0.29	2.18 ± 0.59	50 ± 93.66
HT-W	*max.*	< 1.1	< 1.6	< 300
	avg.	0.24 ± 0.38	1.02 ± 0.42	119.9 ± 96.51
HW	*max.*	2.7 ± 1.2	4.8 ± 1	< 320
	avg.	1.91 ± 0.87	3.83 ± 1.15	-40 ± 68.37
HZ	*max.*	2.04 ± 0.9	< 1	< 250
	avg.	1.34 ± 0.71	0.46 ± 0.3	37.5 ± 120.12
SDWA Limit		15	(a)	20,000

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
All values reported with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
To convert values from pCi to Bq, divide by 27.03.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific adionuclides, a dose equivalent of this value cannot be calculated.
MDL = Minimum Detection Limit
SDWA = Safe Drinking Water Act
* Samples typically collected 4 times per year. HW only sampled 3 times in 2008.

5.4.3 Stormwater Assessment

All recharge basins receive stormwater runoff. Stormwater at BNL is managed by collecting runoff from paved surfaces, roofs, and other impermeable surfaces and directing it to recharge basins via underground piping and abovegrade vegetated swales. Recharge basin HS receives most of the stormwater runoff from the central, developed portion of the Laboratory site. Basins HN, HZ, HT-W, and HT-E receive runoff from the Collider–Accelerator complex. Basin HO receives runoff from the Brookhaven Graphite Research Reactor (BGRR) and High Flux Beam Reactor (HFBR) areas. Basin CSF receives runoff from the CSF area and along Cornell Avenue east of Railroad Avenue on site. Basin HW receives runoff from the former warehouse area, and HW-M receives runoff from the fenced area at the former HWMF.

Stormwater runoff at the Laboratory typically has elevated levels of inorganics and low pH. The inorganics are attributable to high sediment content in stormwater (inorganics occur naturally in native soil). In an effort to further improve the quality of stormwater runoff, BNL has finalized formal procedures for managing and maintaining outdoor work and storage areas. The requirements include covering areas to prevent contact with stormwater, conducting an aggressive maintenance and inspection program, implementing erosion control measures during soil disturbance activities, and restoring these areas when operations cease. Soil samples are also routinely collected from the recharge basins to ensure these discharges are not compromising the quality of the basins. These data are reported in Chapter 6.

Table 5-5. Water Quality Data for BNL On-Site Recharge Basin Samples.

ANALYTE		HN (RHIC)	HO (AGS)	HS (s)	HT-W (Linac)	HT-E (AGS)	HW (s)	CSF (s)	HZ (s)	NYSDEC Effluent Standard	Typical MDL
		Recharge Basin									
No. of samples		4	4	4	4	4	4	4	4		
pH (SU)	*min.*	7.2	7.2	7.1	7.4	7.5	7	7	7.1	6.5 - 8.5	NA
	max.	7.5	7.6	7.7	7.8	7.9	8.4	8.4	7.9		
Conductivity (µS/cm)	*min.*	59	103	60	101	63	38	20	54	SNS	NA
	max.	295	170	244	200	152	81	70	224		
	avg.	141	128	134	160	113	54	49	163		
Temperature (ºC)	*min.*	5.2	11.5	3.8	4.7	4.0	1.9	2.4	8.3	SNS	NA
	max.	10.5	27.8	17.2	11.4	11.2	24.1	23.5	24.1		
	avg.	7.0	18.6	7.4	7.3	7.6	12.2	13.7	14.0		
Dissolved oxygen (mg/L)	*min.*	10.3	7.7	8.9	8.6	9.3	8.2	8.1	8.1	SNS	NA
	max.	11.3	10.7	14.3	14.2	14.3	15.3	15.0	12.3		
	avg.	10.8	9.6	11.1	11.8	11.2	10.8	11.0	10.7		
Chlorides (mg/L)	*min.*	5.4	12.2	3.3	24.2	3.6	0.8	0.9	5.1	500	4
	max.	39.1	34.7	43.1	32.3	24.5	9.5	14.9	36.8		
	avg.	19.8	24.2	26.6	28.2	12.0	4.0	5.2	26.4		
Sulfates (mg/L)	*min.*	3.1	7.5	3.7	9.2	2.8	1.1	0.6	4.4	500	4
	max.	11.2	10.5	14.0	10.9	6.4	6.7	4.3	10.5		
	avg.	6.7	9.0	8.8	9.8	4.3	3.6	2.2	8.9		
Nitrate as nitrogen (mg/L)	*min.*	0.3	0.3	0.0	0.3	0.2	0.1	0.1	0.1	10	1
	max.	0.4	0.9	0.8	0.4	0.5	0.5	0.3	0.5		
	avg.	0.4	0.6	0.3	0.3	0.4	0.2	0.2	0.3		

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
(s) = stormwater
AGS/HFBR = Alternating Gradient Synchrotron/High Flux Beam Reactor
CSF = Central Steam Facility
Linac = Linear Accelerator
MDL = Minimum Detection Limit
NA = Not Applicable
NYSDEC = New York State Department of Environmental Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified

5.5 PECONIC RIVER SURVEILLANCE

Several locations are monitored along the Peconic River to assess the overall water quality of the river and assess any impact from BNL discharges. Sampling points along the Peconic River are identified in Figure 5-8. In total, 10 stations (three upstream and seven downstream of the STP) were regularly sampled in 2008. A sampling station along the Carmans River (HH) was also monitored as a geographic control location, not affected by Laboratory operations or within the Peconic River watershed. All locations were routinely monitored for radiological and nonradiological parameters. The sampling stations are located as follows:

Upstream sampling stations

- HY, on site immediately east of the William Floyd Parkway
- HV, on site just east of the 10:00 o'clock Experimental Hall in the RHIC Ring
- HE, on site approximately 20 feet upstream of the STP outfall (EA)

Downstream sampling stations

- HM-N, on site 0.5 mile downstream of the STP outfall

Table 5-6. Metals Analysis of Water Samples from BNL On-Site Recharge Basins.

METAL		Recharge Basin: HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
	Total (T) or Filtered (F)	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
	No. of samples	4	3	4	2	4	3	4	3	4	3	4	2	4	3	4	3		
Ag Silver (µg/L)	*min.*	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	50	2.0
	max.	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0		
	avg.	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0		
Al Aluminum (µg/L)	*min.*	<50.0	<50.0	<50.0	<50.0	143.0	<50.0	56.6	<50.0	<50.0	<50.0	122.0	70.3	109.0	<50.0	<50.0	<50.0	2000	50
	max.	194.0	<50.0	70.3	< 50.0	249.0	< 50.0	165.0	<50.0	57.1	< 50.0	12700.0	74.0	3710.0	66.8	< 50.0	< 50.0		
	avg.	92.4	<50.0	< 50.0	< 50.0	193.5	< 50.0	124.9	<50.0	<50.0	< 50.0	3682.4	72.2	1637.8	<50.0	< 50.0	< 50.0		
As Arsenic (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	50	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	2000	20
	max.	26.3	<20.0	24.4	24.2	32.2	29.9	<20.0	<20.0	24.4	21.9	129.0	<20.0	<20.0	<20.0	25.3	23.6		
	avg.	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	22.2	<20.0	33.8	<20.0	<20.0	<20.0	<20.0	<20.0		
Be Beryllium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	SNS	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Cd Cadmium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	10	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	2.4	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co Cobalt (µg/L)	*min.*	0.3	0.7	< 5.0	0.3	< 5.0	0.5	2.3	0.6	0.8	0.6	0.8	3.5	0.9	2.0	< 5.0	0.5	5	0.1
	max.	< 5.0	1.9	< 5.0	2.2	< 5.0	1.9	< 5.0	2.1	< 5.0	2.4	7.4	< 5.0	3.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	1.1	< 5.0	1.2	< 5.0	1.1	< 5.0	1.2	< 5.0	1.2	< 5.0	< 5.0	1.7	< 5.0	< 5.0	< 5.0		
Cr Chromium (µg/L)	min.	<5.0	<5.0	<5.0	<5.0	<5.0	7.4	<5.0	<5.0	<5.0	6.7	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	100	5.0
	max.	< 10.0	7.7	< 10.0	< 10.0	16.0	16.2	< 10.0	< 10.0	< 10.0	< 10.0	24.5	< 10.0	7.4	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	<5.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	9.2	< 10.0	5.1	< 10.0	< 10.0	< 10.0		

(continued on next page)

Table 5-6. Metals Analysis of Water Samples from BNL On-Site Recharge Basins *(continued)*.

METAL		Recharge Basin: HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
	Total (T) or Filtered (F)	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
	No. of samples	4	3	4	2	4	3	4	3	4	3	4	2	4	3	4	3		
Cu Copper (µg/L)	*min.*	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	11.5	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	1000	10.0
	max.	19.3	14.7	25.6	22.0	<10.0	<10.0	15.2	<10.0	36.8	13.9	54.6	<10.0	16.0	<10.0	65.0	61.2		
	avg.	16.4	11.4	11.2	10.0	<10.0	<10.0	13.8	<10.0	22.2	<10.0	17.3	<10.0	10.1	<10.0	27.7	25.5		
Fe Iron (mg/L)	*min.*	0.2	<0.05	<0.05	<0.05	0.2	<0.05	0.2	0.1	0.1	<0.05	0.1	0.1	0.1	<0.05	<0.05	<0.05	0.6	0.05
	max.	0.4	0.1	0.2	0.1	0.6	0.2	0.4	0.1	0.1	< 0.05	15.4	0.1	3.9	0.1	0.1	0.1		
	avg.	0.3	0.1	0.1	< 0.05	0.3	0.1	0.3	0.1	0.1	< 0.05	4.3	0.1	1.8	0.1	0.1	<0.05		
Hg Mercury (µg/L)	*min.*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	<0.2	1.4	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	11.3	5.9	<5.0	<5.0	9.5	<5.0	10.0	9.4	15.8	5.8	<5.0	12.8	6.3	<5.0	<5.0	<5.0	600	5.0
	max.	40.6	13.6	19.6	20.2	19.8	6.4	463.0	31.1	168.0	17.7	265.0	17.3	56.7	10.5	12.8	11.9		
	avg.	22.1	9.0	13.6	11.1	12.7	5.0	131.6	18.2	55.3	10.3	73.1	15.1	33.0	7.6	8.5	7.7		
Na Sodium (mg/L)	*min.*	4.3	3.9	8.7	9.8	2.8	2.5	3.3	4.2	14.7	15.0	0.9	2.0	1.3	1.2	3.1	3.1	SNS	0.25
	max.	31.3	17.5	31.2	29.9	27.6	28.4	17.3	11.3	29.7	26.0	7.1	3.4	10.8	3.3	21.2	20.9		
	avg.	16.9	10.3	17.1	17.6	16.7	15.8	10.9	8.9	19.5	20.0	3.0	2.7	3.5	2.2	16.1	15.8		
Ni Nickel (µg/L)	*min.*	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	200	10
	max.	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	13.7	<10.0	<10.0	<10.0	19.8	<10.0	<10.0	<10.0	<10.0	<10.0		
	avg.	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0		
Pb Lead (µg/L)	*min.*	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	< 3.0	< 3.0	<3.0	< 3.0	<3.0	< 3.0	< 3.0	50	3.0
	max.	4.1	< 3.0	< 3.0	< 3.0	<3.0	< 3.0	<3.0	< 3.0	7.1	< 3.0	129.0	<3.0	26.0	< 3.0	42.7	38.6		
	avg.	<3.0	< 3.0	< 3.0	< 3.0	<3.0	< 3.0	<3.0	< 3.0	< 3.0	< 3.0	33.1	<3.0	13.7	< 3.0	14.7	13.0		
Sb Antimony (µg/L)	*min.*	<5.0	<5.0	<5.0	< 5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	6	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Se Selenium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	20	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		

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Table 5-6. Metals Analysis of Water Samples from BNL On-Site Recharge Basins *(concluded)*.

METAL		Recharge Basin																NYSDEC Effluent Limit or AWQS	Typical MDL
		HN (RHIC)		HO (AGS)		HS (stormwater)		HT-E (AGS)		HT-W (Linac)		HW (stormwater)		CSF (stormwater)		HZ (stormwater)			
	Total (T) or Filtered (F)	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F		
	No. of samples	4	3	4	2	4	3	4	3	4	3	4	2	4	3	4	3		
Tl Thallium (µg/L)	*min.*	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	SNS	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	<5.0	<5.0	<5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	<5.0	<5.0	<5.0	< 5.0	< 5.0		
V Vanadium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5.0
	max.	11.2	< 5.0	10.7	16.9	< 5.0	< 5.0	16.4	< 5.0	16.3	< 5.0	34.0	< 5.0	14.8	10.2	< 5.0	9.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	10.3	< 5.0	9.3	7.6	< 5.0	< 5.0		
Zn Zinc (µg/L)	*min.*	31.6	49.3	<10.0	<10.0	17.9	<10.0	28.3	18.8	15.3	10.3	< 10.0	11.4	<10.0	<10.0	18.4	19.0	5000	10
	max.	60.4	50.1	50.3	47.6	34.2	26.7	52.5	35.6	54.9	42.7	316.0	101.0	55.4	12.4	62.7	61.4		
	avg.	47.9	49.7	22.4	20.8	26.5	18.3	43.0	25.0	33.3	25.4	88.8	56.2	33.3	9.0	39.8	40.1		

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards
CSF = Central Steam Facility
Linac = Linear Accelerator
MDL = Minimum Detection Limit
NYSDEC = New York State Department of Environmental Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified

- HM-S, on site on a typically dry tributary of the Peconic River
- HQ, on site 1.2 miles downstream of the STP outfall at the site boundary
- HA, first station downstream of the BNL boundary, 3.1 miles from the STP outfall
- Donahue's Pond, off site, 4.3 miles downstream of the STP outfall.
- Forge Pond, off site
- Swan Pond, off site, not within the influence of BNL discharges

Control location

- HH, Carmans River

5.5.1 Peconic River – Radiological Analyses

Radionuclide measurements were performed on surface water samples collected from the Peconic River at all 10 locations. Routine samples at Stations HM-N and HQ were collected once per month. All other stations were sampled quarterly unless conditions (such as no water flow) prevented collection. Stations HE, HM-N, and HQ have been equipped with Parshall flumes that allow automated flow-proportional sampling and volume measurements. All other sites were sampled by collecting instantaneous grab samples, as flow allowed.

The radiological data from Peconic River surface water sampling in 2008 are summarized in Table 5-7. Radiological analysis of water samples collected both upstream and downstream of the STP discharge and from background locations had very low concentrations of gross alpha and gross beta activity. The maximum concentration

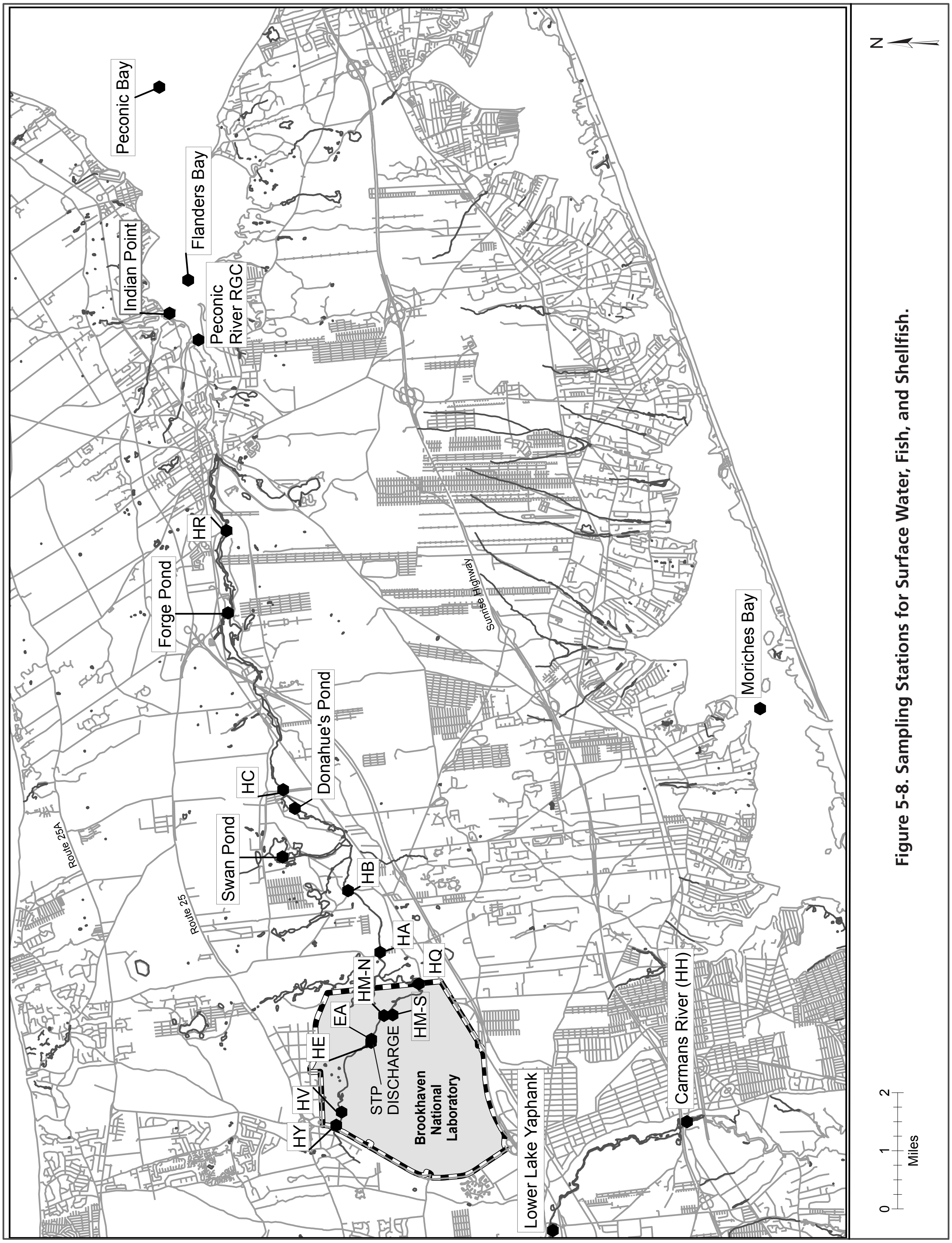

Figure 5-8. Sampling Stations for Surface Water, Fish, and Shellfish.

of gross alpha activity was found in the sections of the Peconic River upstream of the STP and the maximum gross beta was found at the off-site control location (Station HH). The average concentrations were similar at all locations. All detected levels were below the applicable New York State Drinking Water Status (NYS DWS). No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the STP. Tritium was detected in a single water sample collected at Swan Pond, an area of the Peconic not influenced by BNL's discharges, at a concentration of 540 ± 240 pCi/L. Due to the low level of detection and the high uncertainty, the data may be a false positive. Tritium was not detected in the upstream nor downstream sections of the Peconic, which is consistent with the fact that tritium was not detected in the STP discharge for the entire year.

Monitoring for strontium-90 (Sr-90) was performed at all Peconic River and Carmans River stations in 2008. Strontium-90 was detected in one of four samples collected at Stations HQ and at Donahue's Pond, at levels of 0.72 ± 0.38 and 3.87 ± 0.57 pCi/L, respectively. All concentrations detected were much less than the NYS DWS of 8 pCi/L.

5.5.2 Peconic River – Nonradiological Analyses

River water samples collected in 2008 were analyzed for water quality parameters (pH, temperature, conductivity, and dissolved oxygen), anions (chlorides, sulfates, and nitrates), metals, and VOCs. As with other surface water monitoring results, acetone was the only organic contaminant detected at concentrations above the MDL, in samples collected from the Peconic River and Carmans River. The maximum concentration of acetone reported for 2008 was 15 µg/L, which was found at station HE (i.e., upstream of the STP discharge). The inorganic analytical data for the Peconic River and Carmans River samples

Table 5-7. Radiological Results for Surface Water Samples from the Peconic and Carmans Rivers.

Sampling Station		Gross Alpha	Gross Beta	Tritium	Sr-90
		(pCi/L)			
Peconic River					
HY	*N*	4	4	4	4
(headwaters) on site,	*max.*	< 3.3	2.7 ± 1.1	< 290	< 0.41
west of the RHIC ring	*avg.*	0.68 ± 0.21	1.23 ± 1.09	27.5 ± 78.55	-0.12 ± 0.31
HV	*N*	4	4	4	NS
(headwaters) on site,	*max.*	3.5 ± 1.3	2.72 ± 0.83	< 320	
inside the RHIC ring	*avg.*	1.37 ± 1.4	2.2 ± 0.45	7.5 ± 91.36	
HE	*N*	4	4	4	4
upstream of STP	*max.*	0.83 ± 0.58	2.2 ± 1	< 280	< 0.39
outfall	*avg.*	0.6 ± 0.16	1.93 ± 0.36	22.5 ± 110.98	0.28 ± 0.11
HM-N	*N*	12	12	12	4
downstream of STP,	*max.*	3.5 ± 1.2	6.2 ± 1.3	< 320	< 0.34
on site	*avg.*	1.09 ± 0.5	5.25 ± 0.45	30 ± 63.28	-0.06 ± 0.15
HM-S	*N*	2	2	2	2
tributary, on site	*max.*	< 1	1.57 ± 0.71	< 330	< 0.43
	avg.	0.7 ± 0.08	1.2 ± 0.73	60 ± 19.6	0.1 ± 0.07
HQ	*N*	5	5	5	3
downstream of STP,	*max.*	1.08 ± 0.7	6.3 ± 1.3	< 340	0.72 ± 0.38
at BNL site boundary	*avg.*	0.58 ± 0.4	4.14 ± 1.12	36 ± 102.71	0.43 ± 0.3
HA	*N*	4	4	4	4
off site	*max.*	1.12 ± 0.78	1.73 ± 0.8	< 250	< 0.67
	avg.	0.55 ± 0.42	0.94 ± 0.54	44 ± 64.19	0.24 ± 0.15
Donahue's Pond	*N*	4	4	4	4
off site	*max.*	0.98 ± 0.59	1.81 ± 0.98	< 250	3.87 ± 0.57
	avg.	0.46 ± 0.4	1.2 ± 0.42	7.5 ± 92.06	1.09 ± 1.82
Forge Pond	*N*	4	4	4	4
off site	*max.*	< 0.81	3.2 ± 1.1	< 260	< 0.45
	avg.	0.2 ± 0.19	1.97 ± 1	17.5 ± 103.21	-0.02 ± 0.09
Carmans River					
HH	*N*	4	4	4	4
control location,	*max.*	1.76 ± 0.94	9.5 ± 9.7	< 250	< 0.44
off site	*avg.*	0.87 ± 0.64	3.34 ± 4.02	-10 ± 188.17	0.22 ± 0.18
Swan Pond	*N*	4	4	4	4
control location,	*max.*	< 1.1	3.2 ± 1.1	540 ± 240	< 0.49
off site	*avg.*	0.54 ± 0.23	2 ± 1.25	192.5 ± 232.93	0.17 ± 0.15
SDWA Limit (pCi/L)		15	(a)	20,000	8

Notes:
See Figure 5-8 for the locations of sampling stations.
All values reported with a 95% confidence interval.
Negative numbers occur when the measured values are lower than background (see Appendix B).
To convert values from pCi to Bq, divide by 27.03.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.
N = Number of samples analyzed
NS = Not Sampled for this analyte
RHIC = Relativistic Heavy Ion Collider
SDWA = Safe Drinking Water Act
STP = Sewage Treatment Plant

Table 5-8. Water Quality Data for Surface Water Samples Collected along the Peconic and Carmans Rivers.

Analyte		Peconic River Station Locations						Donahue's Pond	Forge Pond	Swan Pond	(Control) HH	NYSDEC Effluent Standard	Typical MDL
		HY	HE	HM-N	HM-S	HQ	HA						
	No. of samples	4	4	12	2	5	4	4	4	4	4	6.5--8.5	NA
pH (SU)	*min.*	3.9	6.7	6	3.8	6.5	6.2	6.3	6.6	6.6	6.5		
	max.	7.2	7.9	7.2	4.6	7.6	6.9	7.2	7.1	6.9	7.2		
Conductivity (µS/cm)	*min.*	50	76	197	55	101	59	36	97	45	151	SNS	NA
	max.	672	126	499	84	266	64	70	132	89	189		
	avg.	215	103	285	70	188	62	58	116	76	173		
Temperature (ºC)	*min.*	3.8	5.2	4	3.0	3.1	3.1	4.1	5.0	2.2	3.9	SNS	NA
	max.	20.3	7.3	22	8.2	14.9	25.2	26.0	27.5	25.4	22.6		
	avg.	11.8	6.1	9.3	5.6	9.0	11.7	12.8	13.6	11.4	11.6		
Dissolved oxygen (mg/L)	*min.*	7.9	8.9	5.7	10.3	6.6	6.0	5.3	7.1	7.0	8.2	>4.0	NA
	max.	10.4	13.8	13	10.5	15.6	12.8	11.9	12.9	13.4	12.9		
	avg.	8.9	10.6	9.2	10.4	11.9	10.1	9.5	9.4	10.4	11.3		
Chlorides (mg/L)	*min.*	3.0	10.8	32.1	4.3	12.8	5.9	9.2	16.2	10.4	28.9	250(a)	4.0
	max.	215.0	15.6	101	6.3	55.2	9.5	10.4	21.0	12.2	31.5		
	avg.	58.0	13.4	52.29	5.3	32.6	7.7	10.0	18.2	11.1	30.4		
Sulfates (mg/L)	*min.*	1.4	4.9	12.8	2.5	6.5	3.7	<4	10.4	5.9	11.8	250(a)	4.0
	max.	7.2	17.9	20.4	7.3	11.8	7.4	7.1	12.2	9.1	13.0		
	avg.	4.1	9.9	15.88	4.9	10.2	5.6	4.8	11.1	7.8	12.3		
Nitrate as nitrogen (mg/L)	*min.*	<1.0	<1.0	0.83	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	10(a)	1.0
	max.	<1.0	<1.0	6.9	<1.0	5.4	<1.0	<1.0	<1.0	<1.0	2.0		
	avg.	<1.0	<1.0	3.54	<1.0	1.5	<1.0	<1.0	<1.0	<1.0	1.6		

Notes:
See Figure 5-6 for the locations of recharge basins/outfalls.
(a) Since there are no NYSDEC Class C surface Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for groundwater is provided, if specified.
Donahue's Pond = Peconic River, off site
Forge Pond = Peconic River, off site
HA = Peconic River, off site
HE = Peconic River, upstream of STP Outfall
HH = Carmans River control location, off site
HM-N = Peconic River on site, downstream of STP
HM-S = Peconic River tributary, on site
HQ = Peconic River, downstream of STP at BNL site boundary
HY = Peconic River headwaters, on site, east of Wm Floyd Pkwy.
MDL = Minimum Detection Limit
NA = Not Applicable
NYSDEC = New York State Department of Environmental Conservation
SNS = Effluent Standard Not Specified

Table 5-9. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers.

METAL		Peconic River Locations: HY		HE		HM-N		HM-S		HQ		HA		DP		Swan Pond		Forge Pond		Control HH		NYSDEC AWQS	Typical MDL
Total or Dissolved		T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D		
No. of samples		4	4	5	3	12	7	2	2	5	4	4	4	4	4	4	4	4	4	4	4		
Ag (I) Silver (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	0.1	2
	max.	< 20.0	< 20.0	< 2.0	< 2.0	11.5	< 2.0	< 2.0	< 2.0	3.1	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 20.0	< 20.0	< 2.0	< 2.0	3.7	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Al (I) Aluminum (µg/L)	*min.*	432.0	127.0	124.0	76.7	216.0	< 50.0	514.0	490.0	284.0	60.7	91.0	< 50.0	52.8	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	13.3	100	50
	max.	729.0	683.0	308.0	218.0	2110.0	116.0	630.0	587.0	1840.0	313.0	107.0	74.7	65.3	50.2	999.0	472.0	57.3	< 50.0	83.9	< 50.0		
	avg.	585.5	356.8	211.2	133.2	616.3	50.2	572.0	538.5	777.2	158.0	101.0	58.5	60.5	< 50.0	337.0	138.2	< 50.0	< 50.0	51.3	< 50.0		
As (D) Arsenic (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	150	5
	max.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	5.1	3.2	17.7	17.4	14.8	12.0	10.6	10.4	9.6	7.4	7.3	6.5	9.1	8.2	7.5	5.8	11.8	10.2	30.8	29.1	SNS	1.8
	max.	32.4	33.3	25.1	26.2	47.2	18.3	12.2	11.8	23.7	9.3	14.7	12.8	20.5	18.3	13.6	9.7	28.1	24.6	39.3	33.0		
	avg.	15.1	13.7	20.4	21.8	24.7	15.1	11.4	11.1	13.6	8.6	10.2	9.2	12.8	11.4	10.4	8.0	18.3	16.6	34.1	31.3		
Be (AS) Beryllium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	11	2
	max.	< 20.0	< 20.0	< 2.0	< 2.0	< 10.0	< 10.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 20.0	< 20.0	< 2.0	< 2.0	< 10.0	< 10.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Cd (D) Cadmium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	0.1	< 2.0	1.1	2
	max.	< 20.0	< 20.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 20.0	< 20.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co (AS) Cobalt (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	5
	max.	< 50.0	< 50.0	< 5.0	< 5.0	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Cr (I) Chromium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	34	5
	max.	< 100.0	< 100.0	< 10.0	< 10.0	< 10.0	< 5.0	< 5.0	5.3	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 100.0	< 100.0	< 10.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Cu (D) Copper (µg/L)	*min.*	2.5	1.9	0.8	0.8	20.8	15.7	1.2	1.3	11.6	6.8	1.3	0.9	0.7	1.0	1.1	0.9	0.7	0.5	0.9	1.5	4	10
	max.	< 100.0	< 100.0	1.3	1.4	118.0	35.6	1.4	1.4	21.8	19.3	1.6	1.3	< 10.0	< 10.0	3.2	1.4	< 10.0	<10.0	< 10.0	< 10.0		
	avg.	< 100.0	< 100.0	1.0	1.1	51.1	25.9	1.3	1.4	17.7	11.1	1.5	1.1	< 10.0	< 10.0	2.1	1.1	< 10.0	< 10.0	< 10.0	< 10.0		
Fe (AS) Iron (mg/L)	*min.*	0.2	0.1	0.6	0.3	0.2	0.04	0.2	0.2	0.2	0.1	0.3	0.2	0.4	0.3	0.1	0.04	0.5	0.2	0.3	0.1	0.3	0.075
	max.	0.7	0.6	3.7	2.3	1.8	< 0.25	0.3	0.3	1.3	0.3	2.0	0.9	3.3	2.1	0.2	0.2	0.9	0.7	0.6	0.3		
	avg.	0.5	0.3	1.8	1.2	0.7	< 0.25	0.2	0.2	0.6	0.2	1.0	0.6	1.5	0.9	0.2	0.1	0.7	0.4	0.4	0.2		
Hg (D) Mercury (µg/L)	*min.*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	1.1	< 0.2	< 0.2	< 0.2	0.4	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	0.3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		

(continued on next page)

Table 5-9. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers *(concluded)*.

METAL		Peconic River Locations: HY		HE		HM-N		HM-S		HQ		HA		DP		Swan Pond		Forge Pond		Control HH		NYSDEC AWQS	Typical MDL
Total or Dissolved		T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D		
No. of samples		4	4	5	3	12	7	2	2	5	4	4	4	4	4	4	4	4	4	4	4		
Mn Manganese (µg/L)	*min.*	8.1	2.7	40.7	49.3	4.0	2.6	33.0	35.0	15.6	11.2	24.3	22.2	30.0	26.6	36.1	14.3	22.9	14.6	55.9	52.5	SNS	2
	max.	59.6	64.1	355.0	361.0	314.0	36.5	54.0	57.4	56.6	37.9	104.0	90.9	305.0	274.0	140.0	76.8	106.0	48.2	118.0	118.0		
	avg.	31.8	32.8	134.5	171.1	52.7	17.0	43.5	46.2	34.0	23.8	46.5	43.2	106.2	97.0	76.2	39.9	57.9	37.0	78.1	73.3		
Na Sodium (mg/L)	*min.*	4.4	4.5	6.7	7.6	21.0	20.7	2.1	2.2	9.5	9.4	4.5	4.4	5.7	5.5	6.2	6.2	9.0	9.0	15.9	15.4	SNS	1
	max.	157.0	152.0	9.0	9.1	72.6	72.2	3.3	3.3	40.3	24.4	6.2	6.5	6.7	6.3	6.8	6.9	11.9	11.4	18.0	18.2		
	avg.	43.2	41.9	7.7	8.3	35.1	36.5	2.7	2.7	22.6	18.3	5.3	5.3	6.1	5.8	6.6	6.5	10.6	10.3	16.6	16.5		
Ni (D) Nickel (µg/L)	*min.*	<1.1	<1.1	<1.1	<1.1	5.0	4.3	<1.1	1.2	3.1	2.9	0.6	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	23	1.1
	max.	< 100.0	< 100.0	1.5	1.9	13.1	7.9	1.3	1.3	6.6	4.4	2.2	<1.1	< 10.0	1.1	2.2	1.1	< 10.0	<1.1	<1.1	<1.1		
	avg.	< 100.0	< 100.0	1.2	1.3	8.2	6.1	1.1	1.3	4.8	3.8	1.1	<1.1	< 10.0	<1.1	1.1	<1.1	< 10.0	<1.1	<1.1	<1.1		
Pb (D) Lead (µg/L)	*min.*	1.5	1.1	0.5	0.5	1.2	0.7	0.8	0.9	1.6	0.7	0.9	0.6	0.9	0.5	0.7	< 3.0	0.6	0.5	0.6	< 3.0	1.4	3
	max.	< 30.0	< 30.0	< 3.0	< 3.0	9.5	< 3.0	1.6	1.5	6.1	1.3	1.6	< 3.0	1.7	< 3.0	2.3	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0		
	avg.	< 30.0	< 30.0	< 3.0	< 3.0	3.3	< 3.0	1.2	1.2	2.7	0.9	1.1	< 3.0	1.2	< 3.0	1.5	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	2.1	SNS	5
	max.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Se (D) Selenium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	4.6	5
	max.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Tl (AS) Thallium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	8	5
	max.	< 50.0	< 50.0	< 5.0	< 5.0	6.2	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 50.0	< 50.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
V (AS) Vanadium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	2.5	2.6	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	14	5
	max.	< 50.0	< 50.0	16.1	16.2	7.3	< 5.0	7.6	12.5	10.4	< 5.0	17.8	15.4	16.8	14.7	15.8	9.8	16.1	15.8	10.2	15.6		
	avg.	< 50.0	< 50.0	< 5.0	5.4	< 5.0	< 5.0	< 5.0	6.3	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Zn (D) Zinc (µg/L)	*min.*	12.6	10.8	< 10.0	11.1	35.0	22.5	11.3	12.2	24.1	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	34	10
	max.	< 100.0	< 100.0	16.8	17.3	133.0	76.7	20.5	18.4	83.0	34.6	11.9	< 10.0	< 10.0	< 10.0	36.4	18.8	< 10.0	< 10.0	< 10.0	10.5		
	avg.	< 100.0	< 100.0	11.2	14.0	62.1	46.3	15.9	15.3	42.5	24.9	< 10.0	< 10.0	< 10.0	< 10.0	17.4	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		

Notes:
See Figure 5-8 for the locations of sampling stations.
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
AS = Acid Soluble
D = Dissolved
DP = Donahue's Pond
SNS = Effluent Standard Not Specified for these elements in Class C Surface Waters
T = Total

are summarized in Tables 5-8 (water quality) and 5-9 (metals).

Peconic River water quality data collected upstream and downstream showed that water quality was consistent throughout the river system. The data were also consistent with water samples collected from the Carmans River control location (HH). Sulfates and nitrates tend to be slightly higher in samples collected immediately downstream of the STP discharge (Stations HM-N and HQ) and were consistent with the concentrations in the STP discharge. Chlorides and sodium were highest at Station HY, which is immediately east of the William Floyd Parkway and likely impacted by road salting operations. There are no NYS AWQS imposed for chloride or sulfates in discharges to surface water; however, NYSDEC imposes a limit of 500 mg/L for discharges to groundwater.

The pH measured at several locations was very low, due to the low pH of precipitation, groundwater, and the formation of humic acids from decaying organic matter. As spring rains mix with decaying matter, these acids decrease the already low pH of precipitation, resulting in a pH as low as 3.8 Standard Units. A discussion of precipitation monitoring is provided in Chapter 6 (see Section 6.7 for more detail).

Ambient water quality standards for metallic elements are based on their solubility state. Certain metals are only biologically available to aquatic organisms if they are in a dissolved or ionic state, whereas other metals are toxic in any form (i.e., dissolved and particulate combined). In 2008, the BNL monitoring program continued to assess water samples for both the dissolved and particulate form. Dissolved concentrations were determined by filtering the samples prior to acid preservation and analysis. Examination of the metals data from locations both upstream and downstream of the STP discharge showed that aluminum, iron, and vanadium were present in concentrations that exceeded NYS AWQS. Aluminum, iron, and vanadium are detected throughout the Peconic and Carmans Rivers at concentrations that exceed the NYS AWQS in both the filtered and unfiltered fractions. Iron and aluminum are found in high concentrations in native Long Island soil and, for iron, at high levels in groundwater. Vanadium also is found in soils. The low pH of groundwater and precipitation contribute to the dissolution of these elements. Copper, lead, silver, and zinc were also found in samples collected immediately downstream of the STP discharge (Station HM-N) at concentrations greater than the NYS AWQS. The concentrations detected were consistent with the concentrations found in the STP discharge and, in most instances, were within the BNL SPDES permit limits. The NYS AWQS limits for copper, lead, and zinc are very restrictive; consequently, the NYS-granted SPDES permit allows higher limits, provided toxicity testing shows no impact to aquatic organisms. Filtration of the samples reduced concentrations of most metals to below the NYS AWQS, indicating that most detections were due to sediment carryover. Mercury was detected in several samples collected downstream of the STP at concentrations greater than the MDL. Since the concentrations in the Peconic River were much higher than the levels detected in the STP discharge (see Table 5-3), the river is a contributor of mercury. Further discussion of mercury in the Peconic River sediment, water, and fish samples is found in Chapter 6.

REFERENCES AND BIBLIOGRAPHY

BNL. 1998. *Operable Unit V: Remedial Investigation and Risk Assessment of the Eastern Area of the Laboratory.* Brookhaven National Laboratory, Upton, NY.

BNL. 2001. *Standards Based Management System Subject Area: Liquid Effluents.* Brookhaven National Laboratory, Upton, NY. May 2001.

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

NYCRR Part 703.6. Title 6. 1999. *Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations.* New York State Department of Environmental Conservation. Albany, NY. Change 8-4-99.

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Natural and Cultural Resources

6

The Brookhaven National Laboratory Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on understanding the site's resources and on maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with staff and the public on ecological issues. BNL focuses on protecting New York State threatened and endangered species on site, as well as continuing the Laboratory's leadership role within the greater Long Island Central Pine Barrens ecosystem.

Monitoring to determine whether current or historical activities are affecting natural resources is also part of this program. In 2008, deer and fish sampling results were consistent with previous years. Vegetables grown in the BNL garden plot and by local farmers continue to support historical analyses that there are no Laboratory-generated radionuclides in produce.

The Foundation for Ecological Research in the Northeast completed the development of Freshwater Wetland Monitoring Protocols for the Long Island Central Pine Barrens. This work is discussed in greater detail in this chapter.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL and DOE historic resources is established and maintained. Additional goals of the program include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of identified resources to on-site personnel and the public for research and interpretation.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The purpose of the Natural Resource Management Program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource management and protection with BNL's scientific mission. To meet this purpose, the Laboratory prepared a Natural Resource Management Plan (NRMP) (BNL 2003a). This plan describes the program strategy, elements, and planned activities for managing the various resources found on site.

6.1.1 Identification and Mapping

An understanding of an environmental baseline is the foundation of natural resource management planning. BNL uses digital global positioning systems (GPS) and geographic information systems (GIS) to clearly relate various "layers" of geographic information (e.g., vegetation types, soil condition, habitat, forest health, etc.). This is done to gain insight into interrelationships between the biotic systems and physical conditions at the Laboratory. In 2005, efforts were initiated to better understand the distribution of deer on site. A model of deer density was developed using the mapping and spatial analysis tools. The model enables resource managers to track changes in deer density over time, detect interactions between components of the ecosystem, and identify locations for management activities.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site.

Table 6-1. New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL.

Common Name	Scientific Name	State Status	BNL Status
Insects			
Frosted elfin	*Callophrys iris*	T	Likely
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Pine Barrens bluet	*Enallagma recurvatum*	T	Confirmed
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Eastern worm snake	*Carphophis amoenus*	SC	Confirmed
Birds (nesting, transient, or potentially present)			
Horned lark	*Eremophila alpestris*	SC	Likely
Whip-poor-will	*Caprimulgus vociferus*	SC	Likely
Vesper sparrow	*Pooecetes gramineus*	SC	Likely
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Northern harrier	*Circus cyaneus*	T	Confirmed
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Sharp-shinned hawk	*Accipiter striatus*	SC	Confirmed
Plants			
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa*	V	Confirmed
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Flowering dogwood	*Cornus florida*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
Ground pine	*Lycopodium obscurum*	V	Confirmed
Bayberry	*Myrica pensylvanica*	V	Confirmed
Cinnamon fern	*Osmunda cinnamomera*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
Stiff goldenrod	*Solidago rigida*	T	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Marsh fern	*Thelypteris palustris*	V	Confirmed
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed

Notes:
* Table information is based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data. No federally listed Threatened or Endangered Species are known to inhabit the BNL site.
E = Endangered
R = Rare
SC = Species of Special Concern
T = Threatened
V = Exploitably Vulnerable

Through implementation of the NRMP, additional endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years. The only New York State endangered species confirmed as now inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Additionally, the New York State endangered Persius duskywing butterfly (*Erynnis p. persius*) and the crested fringed orchid (*Plantathera cristata*) have been identified on the site in the past. Five New York State threatened species have been positively identified on site and two other species are considered likely to be present. The banded sunfish (*Enneacanthus obesus*), the swamp darter fish (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). The northern harrier (*Circus cyaneus*) was seen hunting over open fields in November 2003. In 2005, the Pine Barrens bluet (*Enallagma recurvatum*) damselfly was confirmed at one of the many coastal plain ponds located on site. The frosted elfin butterfly (*Callophrys irus*) has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant (wild lupine). In addition, stargrass (*Aletris farinosa*) was reconfirmed to exist at BNL. A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically (see Table 6-1).

6.1.2 Habitat Protection and Enhancement

BNL has precautions in place to protect onsite habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into Laboratory procedures or into specific program or project plans. Environmental restoration projects remove pollutant sources that could contaminate habitats. Human access to critical habitats is limited. In some cases, habitats are enhanced to improve survival or increase populations. Even routine activities such as road maintenance are not performed until they have been duly evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

To safeguard eastern tiger salamander breeding areas, a map of the locations is reviewed when new projects are proposed. Distribution of the map is limited, to protect the salamander from exploitation by collectors and the pet trade. The map is routinely updated as new information concerning the salamanders is generated through research and monitoring. The most recent update extends the buffer area around tiger salamander habitat from 800 feet to 1,000 feet. Other efforts to protect this state-endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near their habitats are postponed or closely monitored. BNL environmental protection staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been conducted annually since 1999. Biologists conducting egg mass and larval surveys have confirmed 26 on-site ponds that are used by eastern tiger salamanders. The study procedure calls for all ponds that had egg masses during the spring surveys to be surveyed again in June and July to check for the presence of larval salamanders. Egg mass surveys of ponds and additional flooded depressions at the Laboratory were conducted in 2008. A PhD candidate and students working through the intern programs offered by DOE and BNL's Office of Education conducted surveys of tiger salamander ponds, drift fence surveys, and radio telemetry tracking around four ponds. The results of these studies show the extent of egg mass production, the importance of precipitation as a trigger for metamorphic salamanders leaving ponds, and the extent of movements by both adults and metamorphic tiger salamanders. Work toward a comprehensive understanding of eastern tiger salamander movements and habitat requirements began in 2004, with funding provided to SUNY Binghamton by NYSDEC. Continued research adds to the understanding of the needs of this state-endangered species. Information acquired from all research is entered into a database, and portions of the data are linked to a GIS. These data are used to visualize distributions, track reproductive success, and identify areas for focused management or study.

6.1.2.2 Eastern Box Turtle

A radio telemetry study of the eastern box turtle (*Terrapene carolina*) that was initiated in 2006 was continued in 2007 to investigate the amount of territory overlap between individual turtles. The study was initiated after repeatedly finding turtles with ear infections and the discovery of three sick turtles simultaneously in 2005. Two of the three turtles died and were subsequently necropsied, with tissues sent to a contract analytical laboratory for virus isolation. Results confirmed the presence of an iridovirus known to affect turtles and amphibians; this posed a great concern, given the endangered status of some amphibians. As the three turtles were found in a primary breeding pond for tiger salamanders, further study was warranted. The radiotelemetry study confirmed significant amounts of territorial overlap for five turtles outfitted with transmitters. This finding suggests the likelihood for disease transmission among turtles. Additionally, all five turtles spent some time near the pond and may have released the virus to the water, where it may infect other reptiles and amphibians.

Associated with the radiotelemetry study was a study to isolate and identify the iridovirus within eastern box turtles found at BNL. Routine transects of various areas of the Laboratory were established and traversed in order to capture the turtles. When a turtle was found, it was given a unique identification mark, and samples from the mouth and cloaca were taken using cotton swabs. The samples were later tested for iridovirus. Unfortunately, due to difficulties at the contract analytical laboratory, iridovirus could not be isolated in 2006. The study was continued with revisions in 2007 and 2008 in order to assess the potential for turtles to carry iridovirus and infect other reptiles or amphibians. Revisions included improved procedures for obtaining swab samples and alterations of lab procedures to improve the genetic analysis of samples. However, even with improved sampling, only a single turtle tested over the two years and in advanced stages of the disease showed positive results on oral swabs and liver tissue analysis. Cloacal swabs of this animal and both oral and cloacal swabs of all other specimens had negative results, suggesting that swabbing may not be sufficient for early detection of infection (Snyder & Titus, 2007).

6.1.2.3 Other Species

As part of the eastern tiger salamander and herpetological surveys, information is being gathered on other species found on site. Including the tiger salamander (see Section 6.1.2.1), sightings of 26 species of reptiles and amphibians have been recorded over the past several years. The species include the northern red-back salamander (*Plethodon c. cinereus*), marbled salamander (*Ambystoma opacum*), four-toed salamander (*Hemidactylium scutatum*), red-spotted newt (*Notophthalmus viridescens*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), Fowler's toad (*Bufo woodhousei fowleri*), eastern spadefoot toad (*Scaphiopus holbrooki*), snapping turtle (*Chelydra serpentine*), painted turtle (*Chrysemys p. picta)*, musk turtle (*Sternotherus odoratus*), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene c. Carolina*), northern black racer (*Coluber constrictor*), eastern ribbon snake (*Thamnophis s. sauritus*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), northern ring-necked snake (*Diadophis puctatus edwardsi*), brown snake (*Storeria d. dekayi*), northern red-bellied snake (*Storeria occiptiomaculata*), and eastern wormsnake (*Carphophis amoenus*). This list indicates that BNL has one of the most diverse herpetofaunal assemblages on Long Island.

Banded sunfish protection efforts include observing whether adequate flow in the Peconic River is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in their habitat is not disturbed, and evaluating all activities taking place on the river for potential impacts on these habitats. A population estimate of reproductive success of the banded sunfish in a protected pond was conducted in summer 2007 and compared to values obtained in a similar survey in 2005. Conservatively, approximately 3,000 fish remained in the pond after it nearly dried in 2005, based on overall estimates that summer. Hydrologic conditions were maintained throughout 2006 and into 2007. The population survey in 2007 resulted in an estimate of approximately 4,000 fish present. Differences in the two studies may have been responsible for the lower results in 2005. In addition, an increased number of brown bullhead (*Ictalurus nebulosus*) may have had a more significant negative impact on the sunfish population than previously expected.

6.1.2.4 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along six permanent bird survey routes in various habitats on site. In 2008, monthly surveys were conducted starting at the end of March and extending through the end of September. These surveys identified 70 songbird species, compared to 69 species in 2007 and 69 species during 2006. One of the species identified during the 2008 surveys had not been reported previously. A total of 111 songbird species have been identified during surveys in the past 9 years; 45 of these species were present each year. Variations in the number and species identified reflect the time of sampling, variations in weather patterns between years, or actual changes in the environment. The two most diverse transects pass near wetlands by the Biology Fields and the Peconic River. The four transects passing through the various forest types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database that is linked to the Laboratory's GIS.

The eastern bluebird (*Sialia sialis*) has been identified as one of the declining species of migratory birds in North America. This decline is due to loss of habitat and to nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). BNL's NRMP includes habitat enhancement for the eastern bluebird. Since 2000, the Laboratory has installed more than 56 nest boxes around open grassland areas on site to enhance their population.

Migratory birds occasionally cause safety and health concerns. Birds that typically are of concern include Canada geese (*Branta canadensis*) and several species of songbirds that occasionally nest on buildings. Over the past several years, the resident Canada goose population began increasing with the potential to reach large numbers that could result in health and safety issues for the Laboratory. In 2007, under a permit from the U.S. Fish & Wildlife Service (FWS), the Laboratory began managing the resident goose population. In the first year, the goose population was estimated at approximately 120 birds and nests were only managed if they posed a health or safety issue; eggs were treated in ten nests, or the nests were removed. At the end of the 2007 nesting season, the goose population reached an estimated 157 birds. Therefore, in 2008, nest management became more aggressive and eggs in 30 nests that were found were oiled to prevent development. Even with a more aggressive approach to nest management, 15 goslings were hatched and survived. However, with attrition and mortality associated with off site hunting, the resident population was estimated at 148 birds at the end of 2008.

In 2008, the Laboratory continued preparing the area in the central part of the Laboratory for construction of the National Synchrotron Light Source II. This involved demolition of the remaining warehouses and bottled gas facility. As the buildings were prepared for demolition, several barn swallow nests (*Hirundo rustica*) were observed in the rafters of the bottled gas facility. Demolition was halted until nesting was completed and all nestlings had fledged. When it was confirmed that no more active nests were present, the building was released for demolition.

6.1.3 Population Management

The Laboratory also monitors and manages other populations, including species of interest, to ensure that they are sustained and to control invasive species.

6.1.3.1 Wild Turkey

The forested areas of BNL provide good nesting and foraging habitat for wild turkey *(Meleagris gallapavo)*. The on-site population was estimated at 60 to 80 birds in 1999 and had grown to approximately 500 birds in 2004. Since 2004, the population appears to have stabilized at approximately 300 birds. The population across Suffolk County, Long Island, is now sufficiently large for NYSDEC to consider establishing a hunting season to maintain the population at a reasonable number.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. Normally, a population density of 10 to 30 deer per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the BNL property, under normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966). BNL has been conducting population surveys of the white-tailed deer since 2000. In February and March 2004, an aerial infrared survey was conducted of three properties, including Wertheim National Wildlife Refuge (south of BNL), Brookhaven National Laboratory, and Rocky Point Wildlife Area (northwest of BNL). The results indicated a population of 412 deer on site and immediately off site. When a correction for survey accuracy was applied, the on-site population was estimated at 446 animals. This value was much lower than a ground-based estimate of 1,302, made at the same time using the existing methodology. Because there was a large discrepancy between methods, a review of the ground-based methodology was conducted and the method of estimating was refined. The new method uses the Laboratory's vegetation map and estimates the deer population based on the habitat in which deer are sighted during surveys. The result of this revised method indicated that the deer population was approximately 497, which is considered to be reasonably comparable to the aerial survey results. The next step taken was to apply the new population model to historic survey data. Most of the data resulted in much lower yearly estimates, with ranges from approximately 1,000 deer in 2001 to approximately 400 deer in 2005. The current population estimate is 800 deer, based on surveys conducted in November and December 2008. The current estimate reflects a roughly thirty percent increase over the 2007 population estimate of 620 deer. The increase is likely due to the large number of acorns produced in the fall of 2007. The current deer population results in a deer density of 97 deer per square mile.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries—both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (collision damage to autos and browsing damage to ornamental plantings). In 2007, three deer-related collisions occurred on site, compared to 10 accidents in 2006 and 25 accidents documented in 2004. This downward trend in accidents is attributed to a major effort by BNL Safeguards and Security personnel to enforce the 30-mph speed limit on site. Additional emphasis on vehicle–deer safety is also thought to have helped reduce this type of accident. Deer health continues to be affected due to a scarcity of food. While the population increased in 2008 due to abundant food the previous autumn, the overall health of the deer herd in 2008 began to decline through the summer and into the fall. By December 2008, fawns were dying from starvation and exposure. Deer damage to vegetation around buildings continues to be a problem, but varies depending on the severity of the winter and the availability of browse in the lawns. Damage to landscape plants and pine seedlings was taking place in December 2008 due to lack of available food.

Because the high deer population is a regional problem, the Laboratory is working on the issue with other local jurisdictions. As part of this regional approach, an issue and decision paper was prepared for Laboratory management consideration late in 2007. Options for deer management are limited, and most are controversial. While a single regional approach would benefit the community, land managers, and the health of the deer population, individual land managing organizations like the Laboratory must implement a regional approach. In 2008, the BNL Policy Council approved moving forward with deer management planning. Several meetings were held with employees during the spring months, resulting in the development of an employee survey. The survey was sent out to approximately 2,800 individuals; 829 individuals responded. Most respondents believe that deer management is needed, but the survey was unclear on the method of deer management. In the fall months, several informational sessions were held to introduce the various options available in order to begin moving forward with management. The first step is for BNL to prepare an environmental assessment (EA) under the requirements of the National Environmental Policy Act (NEPA). The EA process is scheduled to begin sometime in 2009.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL is key to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory will continue to use NEPA (or NEPA-like) processes under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Environmental Restoration Program when identifying potential environmental impacts associated with site activities—especially with physical alterations. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County

Department of Health Services (SCDHS), BNL's Community Advisory Council, and the Brookhaven Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

On November 9, 2000, then-Secretary of Energy Bill Richardson and Susan MacMahon, Acting Regional Director of Region 5 FWS, dedicated 530 acres of Laboratory property as an ecological research reserve. The property was designated by DOE as the Upton Ecological and Research Reserve (Upton Reserve) and was managed by FWS under an Interagency Agreement (DOE–FWS 2000). The Upton Reserve, on the eastern boundary of BNL, is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from a 1994–1995 biological survey of the Laboratory, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

A transition from FWS management of the Upton Reserve to management by BNL and the Foundation for Ecological Research in the Northeast (FERN) occurred in 2005. During that year, FERN initiated its first pine barrens–wide monitoring program to assess the health of the various forest types within the Pine Barrens, followed by a continuation of the effort in 2006. FERN established 91 permanent plots over the 2-year period of the monitoring program and is currently analyzing the data. One significant finding from the monitoring is the lack of forest regeneration. In virtually every forest type, there is a lack of survival of trees from seedlings through to saplings. This is likely a result of either deer over-abundance or lack of sunlight penetrating to the understory. Further information on the forest health initiative, as well as other activities of FERN, is available on the FERN website at www.fern-li.org. In 2008, FERN finalized protocols for monitoring wetland health throughout the Pine Barrens. These protocols, when implemented, will provide baseline information on the current health of the wetlands found within the Central Pine Barrens. However, this implementation may be delayed indefinitely due to the downturn in the economy.

Research supported by FERN in 2008 included continued investigation into the microbial world of soils located within a number of the Forest Health Plots. Microbial research carried out by a scientist at Dowling College in 2007 identified several new species of fungus and bacteria that had not previously been known. In 2008, the work was expanded to develop a microbial community profile of the Pine Barrens. This work was conducted in conjunction with a Faculty and Student Team from Southern University at New Orleans who have submitted their results for publication. The work is expected to continue in 2009, with genetic analysis of the microbes to further refine the microbial community structure. Additional work funded by FERN includes an aquatic invertebrate survey of the Carmans River and the development of a DVD documenting the various sampling protocols used within the Open Space Stewardship Program sponsored by the Office of Education at BNL. Additional information on these projects is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely monitors flora and fauna to determine the effects of past and present Laboratory activities. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces have now been found in deer and in other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient.

Most radionuclide tables in this chapter list data for both Cs-137 and potassium-40 (K-40), a naturally occurring radioisotope of potassium. Because K-40 is naturally in the environment, it is commonly found in flora and fauna. (In general, K-40 values do not receive significant discussion in the scientific literature because K-40 occurs naturally.) Studies indicate that Cs-137 out-competes K and K-40 when potassium salts are limited in the environment, which is typical on Long Island.

The results of the annual sampling conducted under the flora and fauna monitoring program follow.

6.3.1 Deer Sampling

White-tailed deer in New York State typically are large, with males weighing, on average, about 150 pounds; females typically weigh one-third less, approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer. This fact has implications for calculating the potential radiation dose to consumers of deer meat containing Cs-137, because smaller deer do not provide sufficient amounts of venison to support the necessary calculations.

In 2008, as in recent years, an off-site deer-sampling program was conducted with the NYSDEC Wildlife Branch and FWS. While most off-site samples are from road-killed deer near the Laboratory, NYSDEC provides a few samples from hunters beyond BNL boundaries, yielding control data on deer living 1 mile or more from BNL. In addition, FWS occasionally informs Laboratory staff of deer that have died in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. In all, three deer were obtained on site and 13 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to approximately 5 miles away (Baiting Hollow, New York).

BNL sampling technicians collect the samples and process them for analysis. Samples of meat, liver, and bone are taken from each deer, when possible. The meat and liver are analyzed for Cs-137, and the bone is analyzed for strontium-90 (Sr-90).

6.3.1.1 Cesium-137 in White-Tailed Deer

White-tailed deer sampled at the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), probably because they graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cs-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals.

Removal of contaminated soil areas at BNL has occurred under the Laboratory's Environmental Restoration (ER) Program. All major areas of contaminated soil were remediated by September 2005. In addition, all buildings at the former Hazardous Waste Management Facility (HWMF) were removed in 2003, and the cleanup of the remainder of the facility was completed by fall 2005. Subsequent to the completion of cleanup at the former HWMF, additional minor contamination outside that facility was found and has been characterized and is scheduled for cleanup in 2009.

The number of deer obtained for sampling steadily increased between 1996 and 2004. However, the numbers of deer obtained between 2005 and 2008 are significantly lower. As mentioned above, the number of deer killed on site and available for sampling has decreased, most likely due to increased safety awareness and better enforcement of speed restrictions that results in drivers driving more slowly and paying better attention to their surroundings. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from on site were needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer. The number obtained each year has varied due to the sampling method, which depends on vehicle and deer accidents and people reporting dead deer. The number of deer hit by vehicles varies widely from year to year, depending on the population of deer present near major roadways and the traffic density. Figure 6-1 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2003. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas the concentration on site is near the front gate area and the constructed portions of the Laboratory. This distribution is most likely due to the fact that people on their way to work see and report dead deer. Vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active.

In 2008, Cs-137 concentrations in deer muscle (“meat”) samples taken at BNL ranged from 0.21 to 1.67 pCi/g wet weight. The wet weight concentration is before a sample is dried for analysis, and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The maximum 2008 on-site concentration (1.67 pCi/g wet weight) was seven times higher than the highest level reported in 2007 (0.25 pCi/g wet weight), but continues to be much lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). The arithmetic average concentration in on-site meat samples was 0.89 pCi/g, wet weight (see Table 6-2).

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL (seven samples) and samples taken farther away (six samples) (see Table 6-2). Concentrations in meat samples taken within 1 mile ranged from 0.36 to 8.61 pCi/g wet weight, with an average of 2.32 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from 0.01 to 0.81 pCi/g wet weight, with an average of 0.29 pCi/g wet weight. Because deer on site may routinely travel up to 1 mile off site, the average for deer taken on site and within 1 mile of the Laboratory is also calculated; for 2008, this was 1.89 pCi/g wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2008 from four different location groupings. Although the figure does not show this, 73 percent of all samples taken both on and off site are below 1 pCi/g wet weight (see Table 6-2).

Figure 6-3 presents the 10-year trend of on-site and near-off-site Cs-137 averages in deer meat. While similar in number to the samples taken in 1999, samples from 2008 indicate a much narrower range of error and continue to indicate the effectiveness of cleanup actions across the Laboratory. In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in data from earlier years and occurred again in 2008 (see Table 6-2). During the summer of 2004, a student in the Community College Intern Program reviewed all data from 2000–2003, analyzed the data statistically, and determined that there was a statistical seasonal variation in values for deer both on site as well as far off site (Florendo 2004). This seasonality is likely due to diet and the biological processing of Cs-137. From January through May, deer have a limited food supply—mostly dry vegetation from the previous year’s growth (with a fixed concentration of Cs-137 because plants are dormant). In the summer and fall, deer eat more and the vegetation is constantly growing, taking up nutrients and contaminants from the soil. In summer and fall, deer feeding on vegetation growing in soil containing Cs-137 are more likely to obtain a continuous supply, which is incorporated into their tissues. This increased concentration of Cs-137 in tissues is evidenced by the three highest values seen in deer in 2008 (1.99, 3.11, and 8.61 pCi/g wet weight) from samples taken in October through December. By January or February, the Cs-137 in their tissues has been eliminated through biological processes. The levels of Cs-137 in deer tissue during June through early August are not well known, as there are few vehicle–deer accidents at this time of year.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue. The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed). In liver samples collected on site in 2008, Cs-137 concentrations ranged from 0.07 to 0.35 pCi/g wet weight, with an average of 0.19 pCi/g wet weight. The off-site Cs-137 concentration in liver ranged from non-detectable to 2.03 pCi/g wet weight, with an average for all off-site liver samples of 0.33 pCi/g wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with

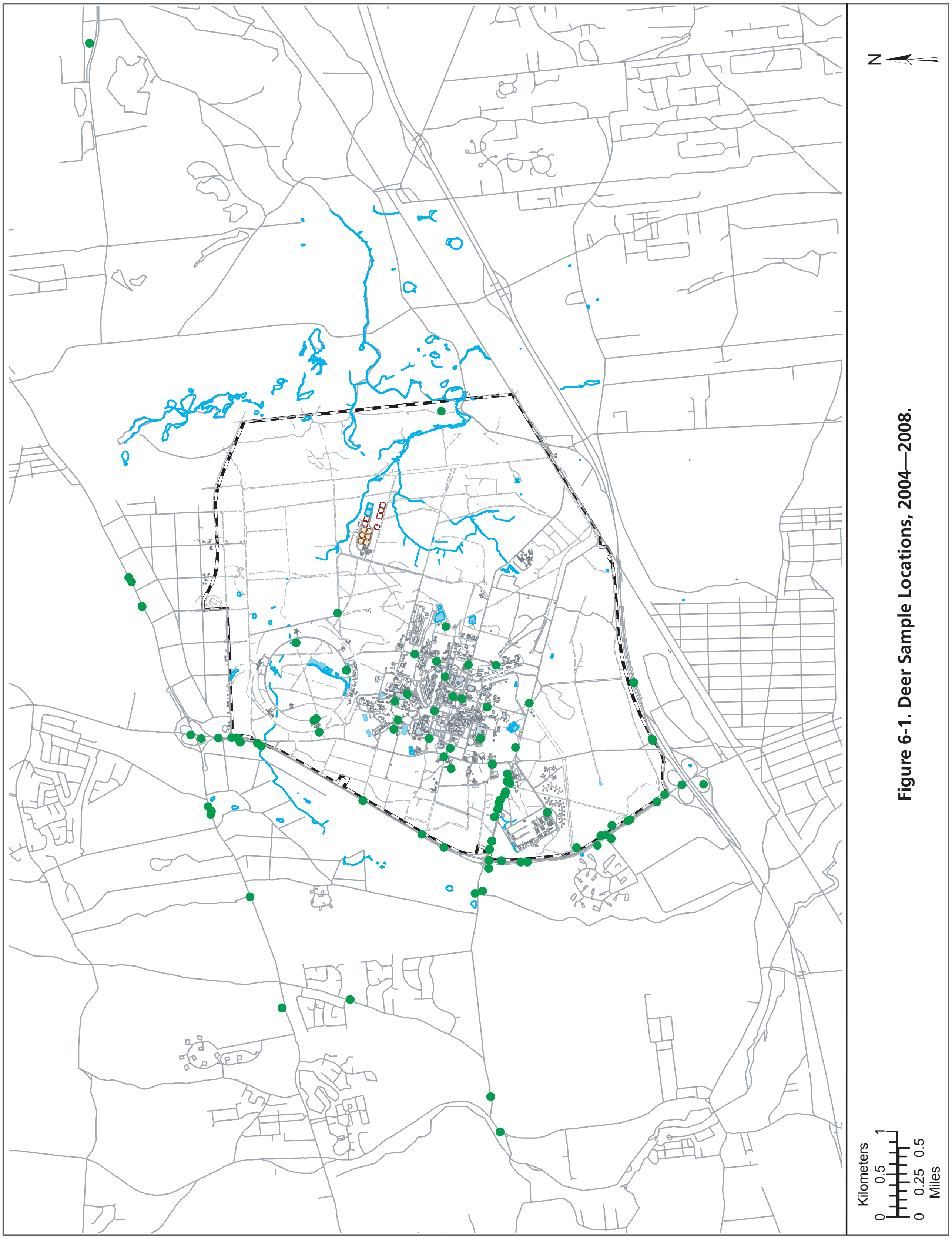


Figure 6-1. Deer Sample Locations, 2004—2008.

Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone).

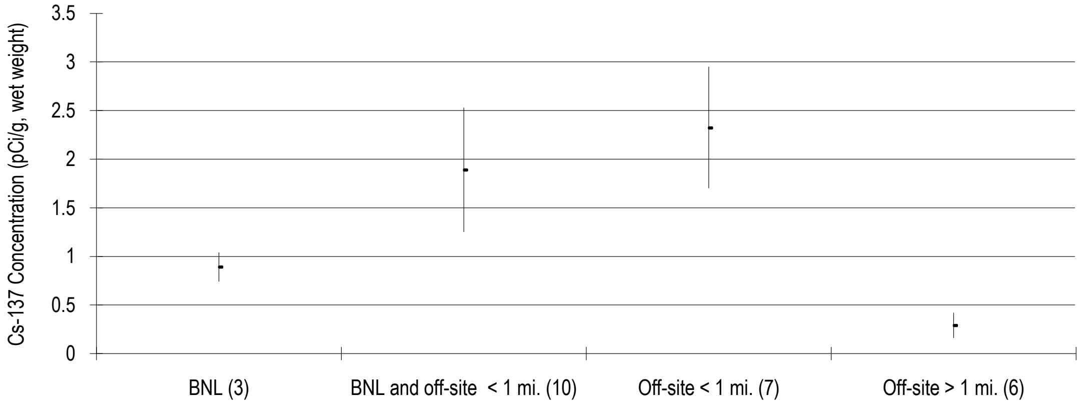
Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
BNL, On Site					
RHIC Ring Road 1008	01/18/08	Hind	3.73 ± 0.65	0.78 ± 0.08	
		Liver	2.53 ± 0.49	0.16 ± 0.04	
		Bone			1.98 ± 0.54
Inbound lane near Motor Pool	11/23/08	Hind	3.45 ± 0.33	1.67 ± 0.13	
		Liver	2.24 ± 0.29	0.35 ± 0.03	
		Bone			2.78 ± 0.36
Behind Fan House C	08/21/08	Hind	3.11 ± 0.37	0.21 ± 0.02	
		Liver*	3.59 ± 0.32	0.07 ± 0.01	
		Bone			1.05 ± 0.39
Offsite < 1 mile					
William Floyd Pkwy., 0.5 miles north of main gate	05/08/08	Hind	3.08 ± 0.50	0.37 ± 0.05	
		Liver	3.16 ± 0.44	0.10 ± 0.03	
		Bone			2.67 ± 0.57
William Floyd Pkwy. and LIE	05/08/08	Hind	2.98 ± 0.64	0.36 ± 0.05	
		Liver	3.39 ± 0.54	0.08 ± 0.02	
		Bone			2.36 ± 0.38
Rt. 25, 1 mile east of William Floyd Pkwy.	06/18/08	Hind	3.25 ± 0.62	0.39 ± 0.06	
		Liver*	2.42 ± 0.63	0.16 ± 0.05	
		Bone			1.41 ± 0.31
William Floyd Pkwy. and LIE	10/29/08	Hind	3.48 ± 0.39	8.61 ± 0.57	
		Liver	2.84 ± 0.32	2.03 ± 0.15	
		Bone			2.12 ± 0.33
Rt.25, 1 mile east of William Floyd Pkwy.	11/21/08	Hind	3.51 ± 0.34	1.41 ± 0.10	
		Liver	2.78 ± 0.35	0.53 ± 0.04	
		Bone			1.55 ± 0.58
William Floyd Pkwy., 0.5 miles north of LIE	12/15/08	Hind	3.80 ± 0.43	1.99 ± 0.13	
		Liver	2.93 ± 0.35	0.29 ± 0.03	
		Bone			4.51 ± 0.46
William Floyd Pkwy., 0.5 miles north of LIE	12/11/08	Hind	2.88 ± 0.34	3.11 ± 0.17	
		Liver	2.29 ± 0.31	0.67 ± 0.05	
		Bone			1.25 ± 0.28
Offsite > 1 mile					
Edwards Ave., Riverhead	02/01/08	Hind	3.22 ± 0.51	0.01 ± 0.02	
		Liver	2.33 ± 0.51	0.00 ± 0.02	
		Bone			1.94 ± 0.36
Rt. 25, 4 miles east of William Floyd Pkwy.	02/06/08	Hind	3.19 ± 0.56	0.36 ± 0.05	
		Liver	2.44 ± 0.49	0.10 ± 0.02	

(continued on next page)

Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone) *(concluded).*

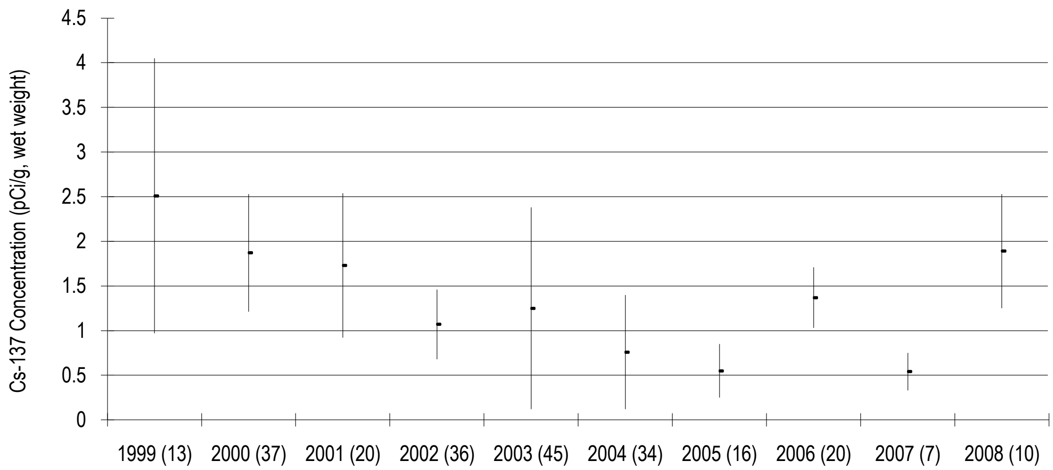
Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
		Bone			0.90 ± 0.27
Rt. 25, Calverton Cemetery	04/15/08	Hind	4.22 ± 0.54	0.81 ± 0.11	
		Liver	2.50 ± 0.55	0.10 ± 0.03	
		Bone			5.55 ± 0.60
Rt. 25, Calverton Cemetery	04/15/08	Hind	3.40 ± 0.59	0.20 ± 0.04	
		Liver	2.56 ± 0.58	0.08 ± 0.03	
		Bone			1.71 ± 0.37
Rt. 25, East of Calverton Cemetery main entrance	05/06/08	Hind	2.76 ± 0.59	0.07 ± 0.02	
		Liver	2.86 ± 0.53	ND	
		Bone			1.51 ± 0.45
Fresh Pond Rd., 1 mile north of Rt. 25	10/24/08	Hind	3.69 ± 0.43	0.28 ± 0.03	
		Liver*	3.02 ± 0.36	0.08 ± 0.02	
		Bone**			0.98 ± 0.25
Averages by Tissue					
Flesh					
Average for all samples (16 samples)			3.36 ± 2.00	1.29 ± 0.65	
BNL on-site average (3 samples)			3.43 ± 0.82	0.89 ± 0.15	
BNL on- and off-site < 1 mile average (10 samples)			3.33 ± 1.51	1.89 ± 0.64	
Off-site average (13 samples)			3.34 ± 1.83	1.38 ± 0.64	
Off-site < 1 mile average (7 samples)			3.28 ± 1.27	2.32 ± 0.62	
Off-site > 1 mile average (6 samples)			3.41 ± 1.32	0.29 ± 0.13	
Liver					
Average for all samples (16 samples)			2.74 ± 1.82	0.30 ± 0.19	
BNL on-site average (3 samples)			2.79 ± 0.65	0.19 ± 0.05	
BNL on- and off-site < 1 mile average (10 samples)			2.82 ± 1.33	0.44 ± 0.18	
Off-site average (13 samples)			2.73 ± 1.70	0.33 ± 0.19	
Off-site < 1 mile average (7 samples)			2.83 ± 1.15	0.55 ± 0.18	
Off-site > 1 mile average (6 samples)			2.62 ± 1.25	0.06 ± 0.06	
Bone					
Average for all samples (16 samples)					2.14 ± 1.68
BNL on-site average (3 samples)					1.94 ± 0.75
BNL on- and off-site < 1 mile average (10 samples)					2.17 ± 1.37
Off-site average (13 samples)					2.19 ± 1.50
Off-site < 1 mile average (7 samples)					2.27 ± 1.14
Off-site > 1 mile average (6 samples)					2.10 ± 0.97

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average.
Confidence limits are 2σ signma (95%) propogated error.
Cs-137 = cesium-137
K-40 = potassium-40
LIE = Long Island Expressway
Sr-90 = strontium-90
* = estimated value for Cs-137
** = estimated value for Sr-90



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, off site but within 1 mile of the boundary, and off site greater than 1 mile from the boundary.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.
Cs-137 = cesium-137

Figure 6-2. Comparison of Cs-137 Average Concentrations in Deer, 2008.



Notes: Averages are shown for samples collected at BNL, and within 1 mile.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.
Cs-137 = cesium-137

Figure 6-3. Ten-Year Trend of Cs-137 Concentrations in Deer Meat at BNL and Within 1 Mile of BNL.

elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999).

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day 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 Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g wet weight, reported in 1996) would carry a total amount of approximately 0.2 µCi. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the threshold evaluated by IAEA. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones for Sr-90 content in 2000. In 2008, Sr-90 content ranged from 1.05 to 2.78 pCi/g dry weight in on-site samples. Sr-90 in off-site samples ranged from 1.41 to 4.51 pCi/g dry weight in samples taken within 1 mile of BNL, and 0.90 to 5.55 pCi/g dry weight in samples taken more than a mile from BNL. This overlap in values between all samples suggests that Sr-90 is present in the environment at background levels, probably as a result of worldwide fallout from nuclear weapons testing. Sr-90 is present at very low levels in the environment, is readily incorporated into bone tissue, and may concentrate over time. BNL will continue to test for Sr-90 in bone to develop baseline information on this radionuclide and its presence in white-tailed deer.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of the Laboratory and the immediate vicinity due to road mortality, they are tested for Cs-137 and Sr-90 content. In 2008, there were no samples taken from geese or turkeys. Data taken over the past several years indicate that both species do not readily uptake radionuclides from their diet.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Routine annual on-site sampling of fish resumed in 2007. Large areas of open water on site resulting from the cleanup of the Peconic River have resulted in sufficient habitat to support larger fish. During sampling activities in 2007, numerous schools of fry of bass and sunfish were noticed. While low dissolved oxygen levels continue to be a problem for fish, the deeper pools provide areas of cooler, more highly oxygenated water for long-term survival. Fish were sampled early in 2008 to take advantage of periods when dissolved oxygen levels are higher, supporting the presence of fish.

As in the past, off-site fish sampling continued in 2008. All samples were analyzed for edible (fillet) content of each of the analytes reported. In 2008, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, Manor Road, and Lower Lake on the Carmans River (see Figure 5-8 for sampling stations). Swan Pond is a semi-control location on the Peconic River system (a tributary of the Peconic not connected to the BNL branch), and Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out in cooperation with NYSDEC and through a contract with the Cold Spring Harbor Fish Hatchery and Museum. Sampling is also separated into samples taken as part of the routine surveillance monitoring program, and those taken as part of the post cleanup monitoring for the Peconic River Cleanup project (primarily for mercury analysis).

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2008 by the Laboratory, NYSDEC, and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), brown trout (*Salmo trutta*), and black crappie (*Pomoxis nigromaculatus*). Gamma spectroscopy analysis was performed on all samples. When fish were not of sufficient mass to conduct all nonradiological and radiological analyses, samples of the same species were composited to gain sufficient volume for radiological analysis. Table 6-3 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations. Information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was detected at low levels in all samples from the Peconic River system, ranging from non-detectable for bluegill and brown bullhead from Forge Pond to 0.29 pCi/g wet weight in a composite sample of largemouth bass taken from Area D on site. In 2008, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) had values

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake.

Location/Species	K-40	Cs-137
	—— pCi/g, wet weight ——	
BNL, On Site		
Area A		
Brown bullhead (composite)	3.52 ± 0.48	0.15 ± 0.03
Brown bullhead (composite)	2.95 ± 0.42	0.14 ± 0.03
Area C		
Brown bullhead (composite)	2.89 ± 0.53	0.25 ± 0.05
Area D		
Largemouth bass/ Bluegill (composite)	3.90 ± 0.52	0.29 ± 0.04
Pumpkinseed (composite)	2.82 ± 0.46	0.15 ± 0.03
Brown bullhead (composite)	2.65 ± 0.58	0.12 ± 0.03
Schultz Road		
Brown bullhead	3.76 ± 0.53	0.10 ± 0.02
Brown bullhead	3.19 ± 0.52	0.13 ± 0.03
Brown bullhead	3.13 ± 0.47	0.08 ± 0.03
Brown bullhead	3.33 ± 0.50	0.08 ± 0.03
Brown bullhead	3.33 ± 0.45	0.10 ± 0.02
Brown bullhead	3.44 ± 0.52	0.09 ± 0.03
Brown bullhead (composite)	3.14 ± 0.50	0.09 ± 0.02
Brown bullhead (composite)	2.98 ± 0.45	0.07 ± 0.02
Brown bullhead (composite)	2.71 ± 0.44	0.11 ± 0.03
Brown bullhead (composite)	3.16 ± 0.47	0.07 ± 0.03
Manor Road		
Chain pickerel	2.98 ± 0.46	0.26 ± 0.04
Pumpkinseed	2.51 ± 0.62	0.06 ± 0.03
Pumpkinseed (composite)	2.58 ± 0.56	0.09 ± 0.03
Pumpkinseed	2.69 ± 0.86	0.03 ± 0.04
Largemouth bass	2.42 ± 0.48	0.16 ± 0.03
Brown bullhead	2.37 ± 0.52	0.13 ± 0.04
Brown bullhead (composite)	1.80 ± 0.46	0.05 ± 0.02

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(continued).*

Location/Species	K-40	Cs-137
	—— pCi/g, wet weight ——	
Brown bullhead (composite)	1.53 ± 0.70	ND
Brown bullhead (composite)	2.78 ± 0.58	0.06 ± 0.04
Swan Pond (Peconic River control location)		
Largemouth bass*	3.22 ± 0.69	0.05 ± 0.03
Black crappie*	2.58 ± 0.67	0.10 ± 0.04
Black crappie	2.42 ± 0.85	ND
Black crappie*	3.16 ± 0.67	0.11 ± 0.04
Brown bullhead	2.48 ± 0.64	ND
Brown bullhead*	3.2 ± 0.69	0.07 ± 0.03
Brown bullhead	2.83 ± 0.78	ND
Brown bullhead	3.28 ± 0.89	ND
Yellow perch	3.34 ± 0.87	ND
Yellow perch*	2.68 ± 0.88	0.11 ± 0.05
Yellow perch*	2.06 ± 0.47	0.05 ± 0.03
Yellow perch*	3.16 ± 0.80	0.07 ± 0.04
Yellow perch	3.27 ± 0.75	ND
Yellow perch*	3.93 ± 0.76	0.09 ± 0.04
Yellow perch (composite)*	3.02 ± 0.95	0.11 ± 0.06
Donahue's Pond		
Chain pickerel	2.83 ± 0.56	0.23 ± 0.04
Brown bullhead	2.62 ± 0.58	0.08 ± 0.03
Brown bullhead	3.1 ± 0.52	0.08 ± 0.04
Brown bullhead	2.72 ± 0.68	0.11 ± 0.04
Brown bullhead	3.01 ± 0.58	0.07 ± 0.03
Brown bullhead	2.51 ± 0.55	0.09 ± 0.03
Brown bullhead	3.21 ± 0.49	0.1 ± 0.03
Brown bullhead	2.89 ± 0.49	0.07 ± 0.03
Brown bullhead	3.48 ± 0.6	0.06 ± 0.03
Largemouth bass	3.37 ± 0.45	0.13 ± 0.03
Largemouth bass	3.18 ± 0.46	0.15 ± 0.03
Largemouth bass	2.81 ± 0.36	0.11 ± 0.02
Largemouth bass	3.09 ± 0.65	0.11 ± 0.04
Largemouth bass	2.77 ± 0.44	0.09 ± 0.02

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmens River, Lower Lake *(concluded).*

Location/Species	K-40	Cs-137
	pCi/g, wet weight	
Pumpkinseed (composite)	2.35 ± 0.59	0.1 ± 0.04
Pumpkinseed (composite)	2.91 ± 0.48	0.06 ± 0.03
Forge Pond		
Largemouth bass*	3.52 ± 0.8	0.09 ± 0.05
Largemouth bass*	2.84 ± 0.78	0.06 ± 0.05
Largemouth bass*	3.65 ± 0.75	0.2 ± 0.05
Largemouth bass*	3.83 ± 0.78	0.16 ± 0.05
Largemouth bass*	2.46 ± 1.15	0.1 ± 0.07
Brown bullhead	4.49 ± 1.67	ND
Brown bullhead	2.26 ± 1.31	ND
Brown bullhead	2.42 ± 0.85	ND
Brown bullhead*	3.47 ± 1.19	0.13 ± 0.06
Bluegill (composite)	2.22 ±0.98	ND
Bluegill (composite)	1.22 ± 0.85	ND
Bluegill (composite)	2.69 ± 1.26	ND
Bluegill (composite)	1.74 ± 0.73	ND
Lower Lake, Carmans River		
Largemouth bass	ND	ND
Largemouth bass*	2.53 ± 0.73	0.05 ± 0.04
Largemouth bass	2.89 ± 0.90	ND
Brown bullhead	3.19 ± 0.84	ND
Brown bullhead	2.35 ± 0.81	ND
Brown trout	3.95 ± 1.06	ND
Largemouth bass (composite)	3.33 ± 0.82	ND
Largemouth bass (composite)	2.57 ± 0.72	ND
Brown bullhead (composite)	3.48 ± 0.89	ND

Notes:
All samples analyzed as edible portions (fillets).
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
Cs-137 = cesium-137
K-40 = potassium-40
* = estimated value for Cs-137 based on analytical laboratory qualifiers.
ND = not detected, based on analytical laboratory qualifiiers.

of Cs-137 that ranged from non-detectable in all species sampled to an estimated value of 0.05 pCi/g wet weight in a largemouth bass.

To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders). Cs-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.25 pCi/g wet weight. Largemouth bass from the Peconic River showed Cs-137 levels of 0.29 pCi/g wet weight or less. Levels of Cs-137 in all fish species appear to be declining, compared to historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides were released between the late 1950s and early 1970s. Concentrations continue to decline over time through natural decay. Cs-137 has a half-life of 30 years. No Cs-137 was released from the BNL Sewage Treatment Plant (STP) to the Peconic River between 2003 and 2008 (see Figure 5-4 for a trend of Cs-137 discharges). Additionally, the cleanup of both on- and off-site portions of the Peconic River in 2004 and 2005 removed approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Removal of this contamination is expected to result in further decreases in Cs-137 levels in fish.

6.3.4.2 Fish Population Assessment

BNL suspended fish sampling on site in 2001 because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. Sampling resumed in 2007 when multiple schools of small fish were observed throughout the on-site portions of the river. The relative sizes of fish caught during annual sampling events will be tracked, and modifications to future sampling events will be made as necessary to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis in 2008 indicated that populations are maintaining themselves and can support annual sampling.

6.3.4.3 Nonradiological Analysis of Fish

In 1997, under BNL's Environmental Restoration Program Operable Unit (OU) V Remediation Project, fish from the Peconic River on site were analyzed for metals, pesticides, and PCBs. From 2002 through 2006, analysis was limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. From 2000 through 2006, sampling was performed from July through August. Additionally, there has been a wide variation in fish size; therefore, samples have had to be composite whole-body to obtain significant mass for analysis. These variables make the comparisons from year to year difficult, as there can be significant seasonal variations in feeding, energy consumption, and incorporation of nutrients into various tissues. Beginning in 2005, all fish of sufficient size were analyzed as edible portions (fillets). Smaller fish, such as golden shiners, were composited for whole-body analysis. In 2007, fish sampling was moved to the spring months to lessen the effect of low oxygen levels on fish distributions. Nearly all samples were obtained between April and mid-June.

Table 6-4 shows the 2008 concentration of metals in fish taken for surveillance monitoring within the Peconic River and Lower Lake on the Carmans River. Due to the fact that values for arsenic, beryllium, cadmium, cobalt, silver, thallium, selenium, and vanadium were near or less than the MDL for the analytical procedure, they were not included in Table 6-4. Other metals tested but not included in the table include aluminum, antimony, and nickel, as most values reported for these metals were less than the MDL. Values that were above the MDL are discussed below. Fish taken on site are important to the post cleanup monitoring program; they are analyzed for mercury and the data are presented in Table 6-5.

Values for metals not shown in Table 6-4 because they were at or near MDL were as follows: antimony was found in various species in levels from less than the MDL to 0.725 mg/kg throughout the Peconic River; arsenic and cadmium were not detected in any sample taken from the Peconic River; nickel was recorded in Peconic River fish at levels less than MDL throughout the river to 1.03 mg/kg in a bluegill from Forge Pond; selenium was found in a brown bullhead from Forge Pond at 0.6 mg/kg; and silver was not found in any fish taken from the Peconic River. These reported values and those presented in Table 6-4 are not considered to pose any health risks to humans or other animals that may consume fish.

Due to its known health effects, mercury is the metal of highest concern. Mercury in Peconic River samples taken for surveillance purposes ranged from 0.008 mg/kg in a brown bullhead from Swan Pond to 0.47 mg/kg in a largemouth bass from Forge Pond. This compares to a range of 0.13 to 1.35 mg/kg in fish taken in 2007. This does not include fish taken for post cleanup monitoring related to the Peconic River Cleanup.

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Forge Pond								
Largemouth bass	0.108	0.123	< MDL	11	0.22	< MDL	0.444	6.88
Largemouth bass	0.105	0.223	< MDL	3.4	< MDL	< MDL	0.345	4.03
Largemouth bass	0.248	0.322	< MDL	< MDL	< MDL	0.431	0.369	5.01
Largemouth bass	< MDL	0.126	< MDL	6.75	< MDL	< MDL	0.473	4.26
Largemouth bass	0.843	0.537	< MDL	3.95	< MDL	1.65	0.201	8.69
Brown bullhead	0.176	0.133	< MDL	9.52	< MDL	0.259	0.017	6.72

(continued on next page)

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(concluded).*

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Brown bullhead	0.208	0.117	< MDL	8.08	1	0.203	0.056	5.53
Brown bullhead	0.23	< MDL	3.19	112	0.12	0.318	0.053	7.25
Brown bullhead	< MDL	0.13	< MDL	7.39	< MDL	< MDL	0.04	3.87
Bluegill	0.302	0.143	< MDL	11.6	< MDL	7.27	0.154	9.13
Bluegill	< MDL	0.145	< MDL	< MDL	0.11	< MDL	0.069	6.02
Bluegill	0.563	0.12	< MDL	18.7	< MDL	5.82	0.023	8.15
Bluegill	0.739	1.74	0.303	16.5	< MDL	2.04	0.117	10.7
Bluegill	0.372	0.256	< MDL	20.4	< MDL	0.996	0.109	11.1
Bluegill	< MDL	< MDL	< MDL	6.67	< MDL	< MDL	0.088	7.55
Bluegill	0.263	0.195	< MDL	9.5	0.18	1.32	0.023	12.5
Bluegill	0.115	0.282	< MDL	9.64	< MDL	1.45	0.167	11.6
Swan Pond (Peconic River control location)								
Largemouth bass	0.121	0.386	< MDL	4.89	< MDL	1.23	0.145	7.62
Black crappie	0.232	0.181	< MDL	7.48	< MDL	1.31	0.315	7.28
Black crappie	0.392	0.233	< MDL	< MDL	< MDL	5.36	0.101	7.3
Black crappie	< MDL	0.21	< MDL	< MDL	< MDL	< MDL	0.090	6.47
Brown bullhead	0.473	0.185	0.553	13.5	< MDL	3.24	0.008	7.99
Brown bullhead	2.95	2.02	0.486	39.2	< MDL	5.64	0.054	14.2
Brown bullhead	0.381	0.188	0.425	13.8	< MDL	1.82	0.013	9.62
Brown bullhead	0.595	0.167	0.326	5.11	< MDL	0.225	0.009	7.13
Yellow perch	0.129	0.515	< MDL	7.38	< MDL	1.65	0.066	8.32
Yellow perch	0.14	0.182	< MDL	< MDL	< MDL	0.266	0.099	6.14
Yellow perch	< MDL	0.235	< MDL	< MDL	< MDL	0.453	0.113	6.31
Yellow perch	0.342	0.297	< MDL	< MDL	< MDL	4.11	0.103	7.59
Yellow perch	0.925	0.384	0.49	3.87	< MDL	36.1	0.031	11.5
Yellow perch	< MDL	0.191	< MDL	2.59	< MDL	0.671	0.063	6.47
Yellow perch	< MDL	0.151	< MDL	10.1	< MDL	3.1	0.075	6.78
Yellow perch	0.116	0.222	< MDL	< MDL	< MDL	0.972	0.069	5.87
Yellow perch	0.211	0.186	0.372	4.44	< MDL	7.26	0.021	8.47
Lower Lake, Carmans River (control location)								
Largemouth bass	< MDL	0.141	< MDL	4.41	< MDL	0.242	0.066	5.72
Largemouth bass	< MDL	0.328	< MDL	4.47	< MDL	< MDL	0.143	5.1
Largemouth bass	0.173	1.47	< MDL	12	< MDL	0.808	0.044	7.6
Largemouth bass	< MDL	0.257	< MDL	3.24	< MDL	0.231	0.036	5.36
Largemouth bass	< MDL	0.187	< MDL	2.89	< MDL	0.395	0.031	4.22
Largemouth bass	0.153	0.196	< MDL	2.88	< MDL	1.17	0.026	8.19
Largemouth bass	< MDL	0.207	< MDL	2.79	< MDL	0.216	0.022	9.22
Brown bullhead	0.099	0.155	< MDL	9.72	< MDL	< MDL	0.029	3.67
Brown bullhead	0.119	0.139	< MDL	3.61	< MDL	< MDL	0.021	3
Brown bullhead	< MDL	0.219	< MDL	3.98	< MDL	< MDL	0.014	3.99
Brown bullhead	0.147	0.199	0.359	11.8	0.4	2.48	0.030	7.12
Brown trout	< MDL	0.455	0.362	6.68	< MDL	0.379	0.012	4.78

Notes:
See Figure 5-8 for sampling locations.
All fish were analyzed as edible portions (fillets).
MDL = Minimum Detection Limit

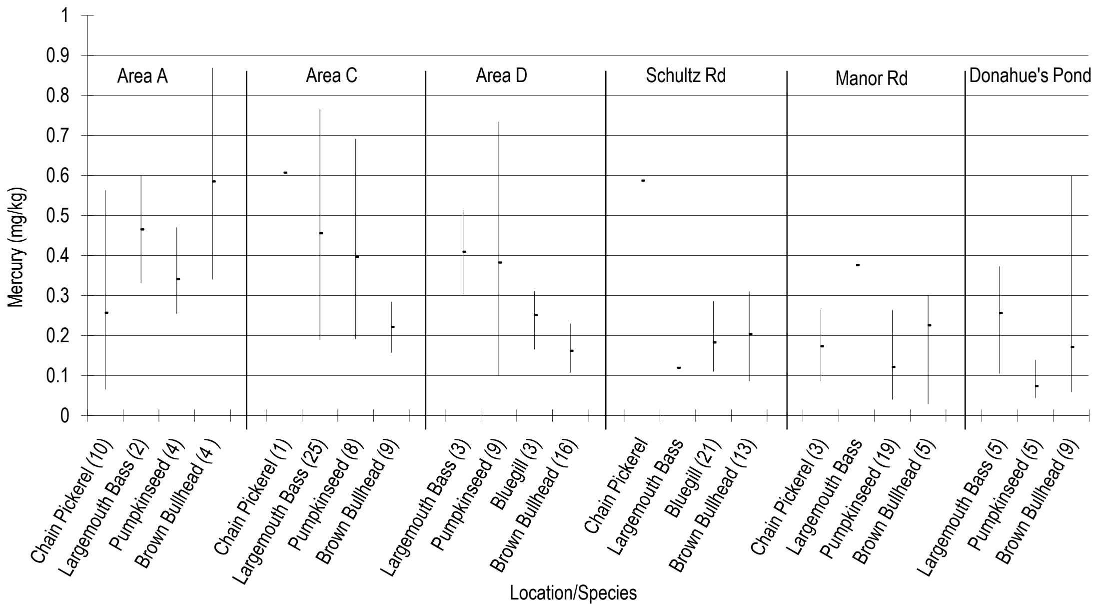
The post cleanup monitoring data for mercury analysis in fish is presented in Table 6-5 and is shown as a range of results by species and area sampled to reduce the size of the table. The data is presented graphically in Figure 6-4. Mercury values in Area A of the Peconic River (area nearest the Sewage Treatment Plant [STP] outfall) ranged from 0.065 mg/kg in chain pickerel to 0.869 mk/kg in a brown bullhead. At Area C, mercury ranged from 0.157 mg/kg in a brown bullhead to 0.765 mg/kg in a largemouth bass. Fish taken from Area D near the boundary of the Laboratory had mercury content ranging from 0.10 mg/kg to 0.734 mg/kg in pumpkinseed. At Schultz Road, mercury ranged from 0.086 mg/kg in a brown bullhead to 0.587 mg/kg in a chain pickerel. At Manor Road, mercury content ranged from 0.028 mg/kg in a brown bullhead to 0.376 mg/kg in a largemouth bass. The last location sampled as a part of the Peconic River Cleanup monitoring was Donahue's Pond, where mercury content in fish ranged from 0.44 mg/kg in a pumpkinseed to 0.598 mg/kg in a brown bullhead. In general, from the rough data presented, a trend of decreasing mercury content going downstream from BNL's STP is evident. A more detailed review of the data is covered in the Annual Report on Peconic River Sampling for 2008 (BNL 2009).

Pesticide analyses in fish was discontinued in 2008, since several years of sampling detected pesticides in only a few fish far off-site. PCB analyses in fish was also discontinued from surveillance monitoring, but continued to be completed on fish collected on site. Only a single composite sample of brown bullhead taken from Area A on site tested positive for PCBs. The value was reported as 22.4 µg/kg for Aroclor 1254. Historically, PCBs have been found in both fish and sediment at BNL and periodically at other locations in the Peconic River. The cleanup of the Peconic River that was completed in 2005 removed most PCBs within the sediments. Although BNL has discontinued most pesticide and PCB monitoring, the Laboratory may periodically test for PCBs and pesticides in fish to verify the presence/absence in fish tissue.

Table 6-5. Mercury Analysis of Fish from the Peconic River System Post Cleanup Monitoring.

Location/Species	Mercury mg/kg		
BNL, On Site			
Area A	Min	Max	Avg
Chain pickerel (10)	0.065	0.563	0.257
Largemouth bass (2)	0.331	0.599	0.465
Pumpkinseed (4)	0.254	0.470	0.341
Brown bullhead (4 with composites)	0.340	0.869	0.585
Area C	Min	Max	Avg
Chain pickerel (1)	0.607	0.607	0.607
Pumpkinseed (8)	0.191	0.691	0.396
Largemouth bass (25)	0.188	0.765	0.455
Brown bullhead (9 with composites)	0.157	0.284	0.222
Area D	Min	Max	Avg
Largemouth bass (3)	0.303	0.513	0.409
Pumpkinseed (9)	0.099	0.734	0.382
Bluegill (3)	0.165	0.311	0.251
Brown bullhead (16 with composites)	0.107	0.230	0.162
Schultz Road	Min	Max	Avg
Brown bullhead (13 with composites)	0.086	0.310	0.203
Bluegill (21)	0.110	0.286	0.183
Largemouth bass	0.119	0.119	0.119
Chain pickerel	0.587	0.587	0.587
Manor Road	Min	Max	Avg
Pumpkinseed (19)	0.040	0.264	0.121
Chain pickerel (3)	0.086	0.265	0.173
Largemouth bass	0.376	0.376	0.376
Brown bullhead (5 with composites)	0.028	0.301	0.226
Donahue's Pond	Min	Max	Avg
Brown bullhead (9)	0.058	0.598	0.171
Largemouth bass (5)	0.105	0.373	0.256
Pumpkinseed (5)	0.044	0.139	0.073

Notes:
Area letter designation refers to Peconic River cleanup areas on site.
All samples were analyzed as edible portions (fillets), including composite samples.
Full data sets are available in 2008 Peconic River Monitoring Report.



Note: Number in parentheses indicate the number of samples included.

Figure 6-4. Peconic River Post Cleanup Mercury Distribution in Fish Species (Minimum, Maximum, and Average Values).

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of sediment and vegetation in the Peconic River and a control location on the Carmans River was conducted in 2008. See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 for the locations of sampling stations. Additionally refer to Section 6.3.6 for a discussion of sediment and water analysis related to monitoring post-cleanup of the Peconic River. Because significant numbers of samples are now taken under this monitoring program, fewer samples are being taken through routine surveillance monitoring, to reduce duplication of effort and lessen the impact on the fish populations.

Table 6-6 summarizes the radiological data. Low levels of Cs-137 were detected in sediments and vegetation at Donahue's Pond. Swan Pond, Forge Pond, and Lower Lake on the Carmans River had only low levels of Cs-137 detected in sediments. No vegetation samples taken from on-site portions of the Peconic River had detections of Cs-137.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-7) were conducted on aquatic vegetation and sediments from the Peconic River and Lower Lake on the Carmans River. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the SCDHS soil cleanup objectives for heavy metals. Vegetation results are compared to soil cleanup standards, because metals in vegetation may accumulate via uptake from sediment. In general, metals are seen in vegetation at levels lower than in associated sediment.

Other metals analyzed for, but not listed in Table 6-7, include antimony, arsenic, beryllium, cadmium, magnesium, potassium, selenium, sodium, and thalium. In general, levels of these metals are either below detection limits, below action levels or cleanup objectives, or, like sodium, are common in the environment. Arsenic was detected above SCDHS cleanup objectives of 7.5 mg/kg in sediments at Donahue's Pond and Lower Lake (11 and 8.7 mg/kg, respectively). Cadmium was found in sediments at Lower Lake at a concentration of 1.16 mg/kg, which is above cleanup objectives but well below SCDHS action levels. Chromium was found above cleanup objectives of 10 mg/kg in sediment at Donahue's Pond, Swan Pond, and Lower Lake, and mercury was just above SCDHS cleanup objectives of 0.1 mg/kg at Donahue's Pond and Lower Lake.

Table 6-6. Radiological Analysis of Aquatic Vegetaion and Sediment from the Peconic River System and Carmans River, Lower Lake.

Location/Sample Type	K-40	Cs-137
	pCi/g	
BNL, OnSite		
Aquatic vegetation	3.99 ± 0.65	ND
Aquatic vegetation	4.43 ± 0.70	ND
Aquatic vegetation	4.36 ± 0.78	ND
Aquatic vegetation	3.33 ± 0.79	ND
Donahue's Pond		
Lillypads*	1.00 ± 0.28	0.05 ± 0.03
Sediment*	1.23 ± 1.00	0.19 ± 0.07
Forge Pond		
Lillypads	1.30 ± 0.32	ND
Sediment*	2.20 ± 0.49	0.08 ± 0.03
Swan Pond (Peconic River control location)		
Lillypads	2.00 ± 0.48	ND
Sediment	1.91 ± 0.68	0.23 ± 0.05
Lower Lake, Carmans River (control location)		
Lillypads	1.50 ± 0.35	ND
Sediment	2.54 ± 0.87	0.59 ± 0.08

Notes:
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
* = estimated values for Cs-137 based on Laboratory Qualifiers.
Aquatic vegetation values are reported as wet weight.
Sediment values are reported as dry weight.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs analyses of aquatic samples were discontinued in 2008, corresponding to the discontinuance of this sampling in fish. DDT and its breakdown products have been the primary pesticide observed in sediments due to its long persistence in the environment. BNL will periodically analyze aquatic sediments to track the continued degradation of this pesticide in the environment.

6.3.6 Peconic River Post-Cleanup Monitoring

Sediment from the Peconic River was remediated in 2004 and 2005 to remove mercury and associated contaminants from the river. The cleanup of sections of the river on site focused on sediment in known depositional areas. The goal of the cleanup was to reduce the average mercury concentrations on site to less than 1 milligram per kilogram (mg/kg), with an overall goal to reduce mercury concentrations in the remediated areas, both on site and off site, to less than 2 mg/kg. (One mg/kg equals one part per million, ppm). On-site remediation efforts resulted in a 96 percent reduction in average mercury concentrations in river sediments, from approximately 4.6 mg/kg to 0.2 mg/kg (Envirocon, 2005).

Cleanup of off-site locations focused on a more stringent cleanup target that would allow the greatest flexibility for use as County parkland or for potential development. Sediment was removed from ponded areas where methylation leading to bioaccumulation is most likely to occur, as well as other areas containing higher concentrations of contamination east of the BNL property line to sections of the river upstream and downstream of Manor Road. The cleanup goal was to reduce average mercury concentrations within the sediment to less than 0.75 mg/kg, with an overall mercury concentration goal of less than 2 mg/kg following the cleanup. Off-site remediation efforts resulted in a 95 percent reduction in average mercury concentrations in river sediments downstream of the BNL property line, from approximately 1.8 mg/kg to 0.09 mg/kg, excluding the Manor Road area, which had an 83 percent reduction, from 1.08 mg/kg to 0.19 mg/kg (Envirocon, 2005).

The Laboratory and DOE are committed to a multi-year post-cleanup sampling of sediment, surface water, fish, and wetland restoration. Sampling results for 2008 are summarized below. Detailed information on 2008 sampling results can be found in the 2008 Peconic River Monitoring Report (BNL, 2009).

6.3.6.1 Sediment Sampling

Sediment was sampled in June 2008 at 15 Peconic River routine sampling stations on site and 15 routine sampling stations off site. Ninety-seven percent of the 30 annual sediment samples collected in 2008 met the mercury

Table 6-7. Metals Analysis of Aquatic Vegetation and Sediment from the Peconic River System and Carmens River, Lower Lake.

Location/ Sample Type	Aluminum	Barium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Vanadium	Zinc
	mg/kg													
BNL, On Site														
Aquatic vegetation	< MDL	1.44	552	0.12	< MDL	0.557	13.4	< MDL	19.3	0.004	< MDL	< MDL	0.792	3.63
Aquatic vegetation	< MDL	18.8	1120	0.1	< MDL	1.48	17.9	< MDL	19.4	0.003	0.923	< MDL	< MDL	5.72
Aquatic vegetation	17.9	2.66	1540	0.216	< MDL	2.76	136	< MDL	107	0.004	0.782	0.177	0.261	10.8
Aquatic vegetation	27.8	4.4	1460	0.141	< MDL	1.63	24.2	< MDL	24.9	< MDL	0.41	< MDL	0.236	7.08
Donahue's Pond														
Lilypads	< MDL	24	1980	0.635	< MDL	0.383	175	0.1	107	< MDL	0.314	< MDL	0.191	3.58
Sediment	3090	60.4	3930	15.9	4.2	14.2	8100	28.8	101	0.163	5.56	< MDL	72.7	54.3
Forge Pond														
Lilypads	< MDL	31.3	1860	0.184	< MDL	< MDL	38.4	< MDL	149	< MDL	< MDL	< MDL	0.102	4.97
Sediment	964	7.22	102	1.06	< MDL	0.824	656	2.9	9.64	0.003	0.436	< MDL	1.73	3.38
Swan Pond (Peconic River control location)														
Lilypads	11.5	29.9	2830	0.419	< MDL	0.484	27.2	< MDL	835	< MDL	0.261	0.193	< MDL	5.74
Sediment	3300	72.1	6270	12.2	< MDL	9.22	3090	25.7	1900	0.061	6.64	< MDL	23	33.9
Carmans River, Lower Lake (control location)														
Lilypads	< MDL	34.2	1480	0.100	< MDL	0.849	43.5	< MDL	151	< MDL	0.104	< MDL	0.287	2.85
Sediment	6100	121	5090	31.1	4.83	13.6	10400	86.9	758	0.19	8.1	< MDL	22.4	113
SCDHS Action Levels	N/A	N/A	N/A	100	N/A	500	N/A	400	N/A	2	1000	100	N/A	N/A
Cleanup Objectives	N/A	N/A	N/A	10	N/A	25	N/A	100	N/A	0.1	13	5	N/A	N/A

Notes:
MDL = method detection level
N/A = not applicable
SCDHS = Suffolk County Department of Health Services

cleanup goal of 2.0 mg/kg. One on-site sample (2.1 mg/kg) exceeded the goal, and the sample results were shared with NYSDEC, EPA, and SCDHS. In 2009, five supplemental samples are scheduled for collection to further evaluate the 80 to 100 square feet area surrounding the single station with the exceeded mercury value.

Supplemental sampling conducted in 2007 at two off-site areas (Area 10 and 15) also had mercury values greater than 2.0 mg/kg. In Area 10, four of the seven transects sampled in 2007 had mercury concentrations in the sediment at the lateral extent of one side of the transect that was greater than 2.0 mg/kg. In 2008, each of the four transects in Area 10 were extended an additional 25 to 50 feet and seven supplemental samples were analyzed for mercury. All seven of the 2008 supplemental samples were less than 2.0 mg/kg.

In Area 15, five additional samples were collected at each of two 2007 supplemental sampling stations located 25 feet apart that had mercury values greater than 2.0 mg/kg. The 2008 supplemental sampling results confirmed that an area approximately 80 to 100 square feet surrounding each of these two supplemental sample locations contained sediment with mercury concentrations greater than 2.0 mg/kg.

BNL and DOE will evaluate remediation efforts of the area with EPA, NYSDEC, and SCDHS.

6.3.6.2 Water Column Sampling

In 2008, surface water was analyzed for total mercury and methylmercury at 20 Peconic River sampling stations, the STP, and one reference station on the Connetquot River. Samples were taken in June (18 samples) and July (11 samples). Not all stations could be sampled due to low water tables. The general trend of total mercury in the June and July water samples decreased with increasing distance downstream from the STP. One June on-site sample and one June off-site sample had elevated total mercury concentrations associated with collecting the samples in areas with low water levels and possibly suspending sediment into the sample. Post-cleanup Peconic River sediment has mercury concentrations in parts per million range, whereas the surface water has mercury concentrations in the parts per trillion range. Consequently, if a small amount of sediment is mixed into a surface water sample, the surface water concentration can be markedly elevated.

Peconic River methylmercury concentrations increased slightly from the STP outfall to the BNL site border. The methylmercury concentrations then decreased gradually with increasing distance downstream of the BNL site border. The June methylmercury concentration in Peconic River samples were slightly higher then the July samples, but decreased with increasing distance downstream of the site border until reaching the historic range of concentrations for the Connetquot River reference station. The July off-site methylmercury concentrations decreased until reaching the range of concentrations of the reference station at Manor Road. The decreasing methylmercury concentrations are associated with flow in downstream sections of the river with lower mercury concentrations in the sediment and dilution by flow into the river from ground water and tributaries.

6.3.6.3 Fish Sampling

In 2008, fish were collected from Area A downstream of the STP, Area C, Area D near North Street, Schultz Road, the Manor Road area, and Donahue's Pond. The average mercury concentration among all fish was 0.26 mg/kg. The EPA criterion for methylmercury concentration in fish tissue is 0.3 mg/kg. Mercury concentrations in fish generally declined with increasing distance downstream of the STP. The 2008 average PCB concentrations for fish collected on site (Area A and D) were close to or below the detection limit for all seven PCB isomers. The 2008 average value for Cs-137 was substantially lower than in previous years.

6.3.6.4 Wetland Sampling

The annual wetland invasive plant survey and removal operations were conducted by Roux Associates, Inc. during September 2008. Ninety-one 42-gallon bags of Phragmites shoots, stalks, and rhizomes were removed by hand from the previously remediated sections of the Peconic River on the Laboratory property. Although no Phragmites were found in the Manor Road cleanup area, four invasive species plants, purple loosestrife, were removed. BNL has now completed two years of wetland monitoring and invasive species control. A formal approval from EPA will be requested in 2009 that all Peconic River federal wetland restoration requirements have been met.

6.3.7 Vegetation Sampling

6.3.7.1 Farm and Garden Vegetables

On-site sampling of garden vegetables was completed in 2008 and the 5-year periodic confirmatory sampling of local farm vegetables was also carried out. The data on both farm and garden vegetables are presented in Table 6-8. Samples of zucchini, cucumber, tomato, pepper, string beans, eggplant, and peaches were analyzed for Cs-137 content. This radionuclide was not detected in any vegetables sampled from both the on-site garden or local farms, but was detected in soils at very low levels ranging from nondetectable at the BNL Garden and Bruno's Farm to 0.22 pCi/g at Riveroad Farm located approximately 5 miles east of BNL. These values for Cs-137 in soil are consistent with background levels resulting from worldwide fallout from historic above-ground nuclear testing.

Table 6-8. Radiological Analysis of Farm and Garden Vegetables and Associated Soils.

Location/Sample	K-40	Cs-137
	pCi/g	
Lewin's Farm		
Corn	2.47 ± 0.33	ND
Peaches	1.11 ± 0.09	ND
Zuchini	1.66 ± 0.15	ND
Soil*	9.92 ± 1.72	0.11 ± 0.07
May's Farm		
Corn	2.63 ± 0.34	ND
Cucumber	1.84 ± 0.16	ND
Melon	3.24 ± 0.26	ND
String Beans	2.91 ± 0.22	ND
Soil*	9.84 ± 1.69	0.09 ± 0.10
Bruno's Farm		
Corn	3.03 ± 0.29	ND
Eggplant	2.13 ± 0.19	ND
Potatoe	5.74 ± 0.47	ND
Tomato	2.83 ± 0.21	ND
Soil	8.07 ± 1.23	ND
River Road Farm		
Corn	3.15 ± 0.26	ND
Cucumber	1.58 ± 0.14	ND
Eggplant	2.40 ± 0.20	ND
Zuchini	2.09 ± 0.19	ND
Soil	11.2 ± 1.67	0.22 ± 0.08
BNL Garden		
Cucumber	1.89 ± 0.18	ND
Eggplant	2.55 ± 0.27	ND
Green Pepper	1.48 ± 0.15	ND
Tomato	2.39 ± 0.21	ND
Zuchini	1.39 ± 0.15	ND

Notes:
Vegetables are reported as wet weight values.
Soils are reported as dry weight values.
* = estimated values for Cs-137
K-40 = Potassium-40
Cs-137 = Cesium-137

6.3.7.2 Grassy Plants

Grassy vegetation sampling around the Laboratory was not conducted in 2008 following the established data quality objectives for this media. The Laboratory will be conducting grassy vegetation sampling and analysis in 2009 to support requirements for assessing dose to biota.

6.4 Other Monitoring

6.4.1 Soil Sampling

Soil sampling uses the same graded approach as that used for grassy vegetation sampling and was removed from the basic monitoring protocols in 2003. Confirmatory soil sampling was conducted along with the grassy vegetation sampling in 2007. Soil sampling will be conducted in 2009, concurrent with grassy vegetation sampling.

6.4.2 Basin Sediments

A 5-year testing cycle for basin sediment samples was established in 2003. Basin sediments were sampled in 2007 and results were presented in the 2007 Site Environmental Report. In 2007, at basins HO and HT-E, initial results of sampling identified several compounds above SCDHS action levels. Suffolk County was notified and a co-sampling event was conducted with BNL and Suffolk County participating. Both sets of results indicated that no issue existed, suggesting an error in the original sample results. Under the 5-year cycle for basin sediments, the next sampling will occur in 2012.

6.4.3 Chronic Toxicity Tests

Under the SPDES discharge permit, BNL conducted chronic toxicity testing of STP effluents. Results of this testing are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2009.

6.4.4 Radiological and Mercury Monitoring of Precipitation

As part of the BNL Environmental Monitoring Program, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-3 for station locations), and were analyzed for radiological content and total mercury (Table 6-9). Four samples were taken from each of these two stations in 2008. Gross alpha activity measurements were above the MDL at both P4 and S5 in the third quarter of 2008. Values were estimated at 1.37 and 0.78 pCi/L from the two stations, respectively.

Gross beta activity was measured in samples from all four quarters of both stations except for Station P4 during the third quarter of 2008. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation. Location P4 had a maximum gross beta activity level of 6.0 pCi/L, with an average of 4.11 pCi/L. Location S5 had a maximum gross beta activity level of 5.7 pCi/L, with an average of 4.24 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Beryllium-7 (Be-7) was the only radionuclide found above detection levels in precipitation samples. Be-7 was found during the first and third quarter sampling periods at station S5 with values of 95 and 79 pCi/L, respectively. Be-7 is produced in the atmosphere by cosmic radiation and is periodically found in precipitation.

Analysis of mercury in precipitation is completed to document the range of mercury deposition that occurs on site. This information is compared to Peconic River monitoring data and aids in understanding the sources of mercury within the Peconic River. Mercury was detected in precipitation samples in each quarter and at both sampling stations. Mercury ranged from 4.5 ng/L at station S5 in the fourth quarter to 13.7 ng/L at station P4 during the first quarter.

Table 6-9. Precipitation Monitoring (Radiological and Mercury).

Location/Period	Be-7	Gross Alpha	Gross Beta	Mercury
	pCi/L			ng/L
P4				
1st Quarter	ND	ND	6 ± 1.1	13.7
2nd Quarter	ND	ND	5.2 ± 1.3	5.9
3rd Quarter	ND	1.37 ± 0.69*	ND	8.8
4th Quarter	ND	ND	3.65 ± 0.91*	4.9
S5				
1st Quarter	95 ± 48	ND	5.7 ± 1	11.4
2nd Quarter	ND	ND	3.7 ± 1.1*	5.2
3rd Quarter	79 ± 41	0.78 ± 0.51*	5.6 ± 1.2	10.2
4th Quarter	ND	ND	1.97 ± 0.77*	4.5

Notes:
Method detection limit for mercury is 0.2 ng/L.
* = estimated values based on laboratory qualifiers.
P4 = precipitaion sampler near BNL Apartments area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.

6.5 WILDLIFE PROGRAMS

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

In 2008, the Environmental Protection Division (EPD) and FERN hosted 19 interns and one faculty member. Interns consisted of three high school interns, 14 undergraduate interns, and two school teachers during the summer. Two of the undergraduate interns worked with a faculty member from Southern University at New Orleans, as part of the Faculty and Student Teams Program. Interns worked on a variety of projects: surveying dragonflies and damselflies, radio tracking and genetics of red and grey foxes, analyzing the water chemistry of the Carmans and Peconic Rivers, investigating turtle and amphibian diseases, investigating the loss of the southern leopard frog on Long Island, assessing population health of the banded sunfish, analyzing soil microbial communities, performing statistical analysis of migratory bird data, and studying the distribution of aquatic invertebrates within the Carmans River. Teachers conducted habitat analysis on tiger beetle habitats and developed mapping techniques for small wetlands. Teachers also participated in a week-long workshop on environmental monitoring under the Open Space Stewardship Program (OSSP), which is managed by the BNL Office of Education Programs. In addition to intern projects, FERN began work on video-based instruction for protocols used within OSSP. A limited discussion concerning each project is presented below, and associated papers and posters are available at www.bnl.gov/esd/wildlife/research.asp.

An intern continued the long-term work on dragonflies and damselflies (Order *Odonata*) that was started in 2003, by working on the suitability of new protocols designed to quantify Odonate populations at selected ponds on site. These protocols involved repeated timed visits following set routes around ponds while counting numbers of individual species within 10-minute time blocks. Odonates are common aquatic insects around the ponds and Peconic River on site. The distribution of aquatic insects is useful for monitoring the health of aquatic systems.

In 2005, three eastern box turtles were found in one of BNL's many ponds. All three turtles had a fairly common infection of the ear. The turtles were taken to a wildlife rehabilitator for treatment and care. When two of the turtles subsequently died of their infections, their tissues were sent for analysis. In the analysis, an iridovirus implicated in amphibian declines was isolated. This resulted in a summer intern project started in 2006 that continued through 2008, in which samples from eastern box turtles were taken for virus identification. In 2007, range overlap was determined to be important for the potential of infected turtles to encounter non-infected turtles and transmit the virus. The 2008 study collected 19 samples from various locations of the Laboratory. While not an unqualified success, the study did identify that swabbing the mouth and cloacal cavities for virus isolation is not a suitable methodology, and that tissue samples are necessary.

Another intern continued working with a PhD candidate from Rutgers University on the distribution of the southern leopard frog and chytrid fungus on Long Island. The southern leopard frog has had precipitous population declines, possibly due to the fungus. The study attempted to find existing populations of this frog, and also to document whether chytrid fungus is present in other frog species across Long Island. The study also aimed to assess the survival of cage-reared tadpoles within historic leopard frog habitats. Wild populations of the southern leopard frog still have not been found in any of the water bodies investigated. A second part of this work, carried out by a high school intern, was to look at the potential for mosquitoes to transmit chytrid between infected frogs and non-infected frogs. While the experiment is an important one for frog conservation, the results were confounded by the fact that purchased frogs arrived already containing the chytrid fungus before inoculation.

Two interns continued a project conducted in 2005 and 2007 to look at the population health of the banded sunfish in an isolated pond on site, expanding the project to historic banded sunfish habitats throughout the Peconic River basin. This larger assessment was conducted in concert with a NYSDEC fisheries biologist. The data collected will be used by the State to establish a recovery and management plan for the banded sunfish.

The Faculty and Student Team (FaST), working with faculty at Dowling College, conducted extensive monitoring of approximately 60 forest health plots within the Central Pine Barrens. The work involved collecting soil samples at multiple depths and within multiple forest types to assess their microbial communities. The work is somewhat unique and the goal is to work toward establishing a microbial "fingerprint" of an entire forest ecosystem.

Two teachers participating in the Academies Creating Teacher Scientists (ACTS) program worked on developing simple outdoor experiments that can be utilized with biology and environmental classes. The teachers worked on analysis of soil components within habitats used by tiger beetles. They also learned methods for mapping entire communities within and around a coastal plain pond. As mentioned above, the teachers also attended a week-long workshop under the Open Space Stewardship Program called "Gaining Research Experience in the Environment (GREEN) Institute," where they shared their expertise with approximately 20 other teachers participating in OSSP so they could discuss the program within their home schools. The OSSP continues to grow throughout Suffolk County to foster a sense of stewardship in students and to gather much-needed environmental data on numerous open-space parcels throughout the county.

Another undergraduate student continued working on a project to isolate genetic material from fox droppings as well as trapping foxes to place radio transmitters on them for tracking. In 2008, two red fox kits were trapped, one being large enough to tag with a radio collar. The fox was followed for several days until it either ranged too far for tracking or the collar failed. The genetic isolation method using scat is a non-invasive genetic technique being utilized to look at the inter-relatedness of numerous fox families living on site, and to try to distinguish between red and gray fox. Gray fox was once thought to have been extirpated from Long Island, but a gray fox that had been struck by a car was found on site in 2004. Using non-invasive genetics techniques may also allow researchers to estimate population size and distribution of these two species.

With funding from the Norcross Foundation, BNL and FERN hosted three summer students who assisted in assessing the distribution of aquatic invertebrates within the Carmans River. This local river is in near-pristine condition and is currently the focus of intense interest for preservation and protection from over development within the watershed. Gaining an understanding of the basic biology and ecology of the river is important for understanding the potential impacts of management activities as well as development. The project is expected to continue in 2009 to gather further information based on refinements to the 2008 study.

Members of EPD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EPD also hosted several environmental events in association with Earth Day. In October, BNL hosted the Thirteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results.

The Laboratory also hosted the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. Using the Incident Command System of wildfire management, this academy trains fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. While plans were prepared for conducting a prescribed fire during the Academy, the conditions did not meet the requirements of the prescription. Post-fire monitoring on previous fires, conducted in 2007, indicated that prescribed fires have been somewhat effective at opening up the understory to allow forest regeneration. The Laboratory intends to continue the use of prescribed fire for fuel and forest management in the future, and is working with NYSDEC and The Nature Conservancy to prepare additional prescriptions for a larger portion of the northern and eastern sections of the BNL property.

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with the numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL, 2005) guides the management of all of BNL's historical resources. Along with achieving compliance with applicable regulations, one of the major goals of the CRM program is to fully assess both known and potential cultural resources. The range of the Laboratory's cultural resources includes buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are being developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to our history and culture are documented and available for interpretation. The Laboratory has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, and the WWI training trenches associated with Camp Upton. The BNL trenches are examples of the few surviving WWI earthworks in the United States. Cultural resource management activities performed in 2008 include acquiring storage space for cultural resources, and participating in the planning and execution of the 77th Division Casing of the Colors Ceremony.

On September 7, 2008 BNL hosted soldiers from the U.S. Army at a ceremony marking the retiring of the 77th U.S. Army Regional Readiness Command. This infantry division began its distinguished 91-year history at the Laboratory site, formerly Camp Upton, a U.S. Army induction and training center during WWI and WWII. The brigade formally retired its colors on October 7. Led by Major General William Terpeluk, the current commander of the 77th brigade, the event began with hundreds of soldiers marching in formation across the field under a large American flag proudly draped between two fire trucks. After remarks from U.S. Department of Energy Brookhaven Site Manager Michael Holland, BNL Director Samuel Aronson, and historian Robert Laplander, each unit requested permission to "retire the command." A U.S. Army band played as each unit marched off the field. The event concluded with a ceremonial 21-gun cannon salute while Terpeluk furled the division's flag and an echo of "Taps" played in the background. The division flag was retired at the Center of Military History in Washington, D.C. Soldiers currently serving in the 77th brigade have been reassigned to other units.

Additional outreach activities consisted of providing presentations on Laboratory cultural resources and tours of the WWI trenches to several small groups, including 77th Division officers.

REFERENCES AND BIBLIOGRAPHY

BNL. 1999. *Record of Decision: Operable Unit I and Radiologically Contaminated Soils.* BNL/OU1/12.1/1-57 05-OCT-99. Brookhaven National Laboratory, Upton, NY.

BNL. 2000. *1999 Site Environmental Report.* BNL-52553. Brookhaven National Laboratory, Upton, NY.

BNL. 2003a. *Natural Resource Management Plan for Brookhaven National Laboratory.* BNL-71870-2003. Brookhaven National Laboratory, Upton, NY.

BNL. 2003b. *Wildland Fire Management Plan for Brookhaven National Laboratory.* BNL-71629-2003. Brookhaven National Laboratory, Upton, NY.

BNL. 2005. *Cultural Resource Management Plan for Brookhaven National Laboratory.* BNL-73839-2005. Brookhaven National Laboratory, Upton, NY. March 2005.

BNL 2007. *2006 Peconic River Monitoring Report.* Brookhaven National Laboratory.

DOE-FWS. 2000. *Interagency Agreement Number AI02-01CH1107 Between the U.S. Department of Interior, U.S. Fish & Wildlife Service, Long Island National Wildlife Refuge Complex, and the U.S. Department of Energy Chicago Operations Office Brookhaven Group.*

Dwyer, Norval. 1966. *Brookhaven National Laboratory. Long Island Forum* (reprint), West Islip, NY.

Florendo, Esperanza. 2004. *"Seasonal Food Intake Affecting Cs-137 Levels in White-tailed Deer at Brookhaven National Laboratory."* CCI Paper. Brookhaven National Laboratory.

IAEA. 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards.* Technical Report Series No. 332. International Atomic Energy Agency, Vienna.

LMS. 1995. *Phase II Sitewide Biological Inventory Report, Final.* Lawler, Matusky & Skelly Engineers. Pearl River, NY.

Merwin, D, Manfra, A. 2007. *A Stage I Archaeological Survey for the Proposed NSLS-II at Brookhaven National Laboratory.* The Institute for Long Island Archaeology, Department of Anthropology, State University of New York at Stony Brook.

NYSDOH. 1996. *Radioactive Contamination in the Peconic River.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

NYSDOH. 1999. *Deer Meat Contaminated with Cesium-137 at Brookhaven National Laboratory.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

QEA. 2004a. *Peconic River 2003 Data Summary Report.* Quantitative Environmental Analysis, LLC. Montvale, NJ.

QEA. 2004b. 2004 *Methylmercury Sampling Program Results: Addendum to the Peconic River 2003 Data Summary Report.* Quantitative Environmental Analysis, LLC. Montvale, NJ.

QEA. 2006. 2*005 Peconic River Water Column Sampling Data Summary Report.* Quantitative Environmental Analysis, LLC. Montvale, NJ.

Snyder, S. and V. Titus. 2007. *"Spatial distribution of Iridovirus in the Eastern box turtle population at Brookhaven National Laboratory: Implications for transmittance based on home range size."* SULI Poster, Brookhaven National Laboratory.

Groundwater Protection

7

The Brookhaven National Laboratory Groundwater Protection Program is made up of four elements: prevention, monitoring, restoration, and communication. The Laboratory has implemented aggressive pollution prevention measures to protect groundwater resources. An extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. In 2008, BNL collected groundwater samples from 860 monitoring wells during 2,170 individual sampling events. Twelve groundwater remediation systems removed 220 pounds of volatile organic compounds and returned approximately 1.5 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the Laboratory has removed 6,117 pounds of volatile organic compounds by treating 14.4 billion gallons of groundwater. During 2008, two groundwater treatment systems removed approximately 3.4 millicuries of strontium-90 while remediating nearly 15 million gallons of groundwater. Since 2003, BNL has removed approximately 20.2 millicuries of strontium-90 from the groundwater while remediating 49.4 million gallons of groundwater.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's Groundwater Protection Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a manner that is consistent with federal, state, and local regulations. The program helps to fulfill the environmental monitoring requirements outlined in DOE Order 450.1, Environmental Protection Program. The program consists of four interconnecting elements: 1) preventing pollution of the groundwater, 2) monitoring the effectiveness of engineered and administrative controls at operating facilities and groundwater treatment systems, 3) restoring the environment by cleaning up contaminated soil and groundwater, and 4) communicating with stakeholders on groundwater protection issues. The Laboratory is committed to protecting groundwater resources from further chemical and radionuclide releases, and to remediating existing contaminated groundwater.

7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented a number of pollution prevention activities that are designed to protect groundwater resources (see Chapter 2). BNL has established a work control program that requires the assessment of all experiments and industrial operations to determine their potential impact on the environment. The program enables the Laboratory to integrate pollution prevention and waste minimization, resource conservation, and compliance into planning and decision making. Efforts have been implemented to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater (see Chapter 3). Examples include upgrading underground storage tanks, closing cesspools, adding engineered controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (e.g., reducing the toxicity and volume of chemicals in use

Table 7-1. Summary of BNL Groundwater Monitoring Program, 2008.

	CERCLA Program	Facility Monitoring Program
Number of wells monitored	735	125
Number of sampling events	1,901	269
Number of analyses performed	3,341	402
Number of results	71,442	4,647
Percent of nondetectable analyses	90	90
Number of permanent wells installed	21	0
Number of temporary wells installed	86	29
Number of wells abandoned	64	0

or storage). BNL's comprehensive groundwater monitoring program is used to confirm that these controls are working.

7.1.2 Monitoring

The Laboratory's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from former and current operations and to track cleanup progress. Each year, BNL collects groundwater samples from an extensive network of on- and off-site monitoring wells (see Table 7-1). Results from groundwater monitoring are used to verify that protection and restoration efforts are working. Groundwater monitoring is focused on two general areas: 1) Facility Monitoring (FM), designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) Comprehensive Environmental Response, Compensation and Liability (CERCLA) monitoring related to the Laboratory's obligations under the Federal Facilities Agreement (FFA). These monitoring programs are coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and decommissioning of wells. The monitoring program elements include data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and the installation, maintenance, and decommissioning of wells. These elements are integrated to create a cost-effective monitoring system and to ensure that water quality data are available for review and interpretation in a timely manner.

7.1.3 Restoration

BNL was added to the National Priorities List in 1989. To help manage the restoration effort, 31 separate Areas of Concern were grouped into six Operable Units (OUs). Remedial Investigation/Feasibility Studies have been conducted for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the FFA involving EPA, the New York State Department of Environmental Conservation (NYSDEC), and DOE.

7.1.4 Communication

BNL's Community Education, Government and Public Affairs Office ensures that the Laboratory communicates with its stakeholders in a consistent, timely, and accurate manner. A number of communication mechanisms are in place, such as press releases, web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include routine meetings with the Community Advisory Council and the Brookhaven Executive Roundtable (see Chapter 2, Section 2.4.2). Quarterly and annual technical reports that summarize data, evaluations, and program indices are prepared. In addition, BNL has developed a Groundwater Protection Contingency Plan (BNL 2008) that provides formal processes to promptly communicate off-normal or unusual monitoring results to Laboratory management, DOE, regulatory agencies, and other stakeholders, including the public and employees.

7.2 GROUNDWATER PROTECTION PERFORMANCE

BNL has made significant investments in environmental protection programs, and is making progress in achieving its goal of preventing new groundwater impacts and remediating previously contaminated groundwater.

No new impacts to groundwater quality have been identified since 2001. A new impact is defined as the detection and confirmation of previously unidentified groundwater contamination. The Groundwater Protection Contingency Plan, mentioned earlier as a communications tool, also is designed to ensure that appropriate and timely actions are taken if unusual or off-normal results are observed. The contingency plan provides guidelines for verifying the data, evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions. The Laboratory will continue efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

Since the start of active groundwater remediation in December 1996, BNL has made significant progress in restoring groundwater quality by removing over 6,100 pounds of volatile organic compounds (VOCs) and 20 millicuries (mCi) of strontium-90 (Sr-90) from the aquifer. Noticeable improvements in groundwater quality are evident in a number of on-site and off-site areas.

7.3 GROUNDWATER MONITORING

Elements of the groundwater monitoring program include installing monitoring wells; planning and scheduling; developing and following quality assurance procedures; collecting and analyzing samples; verifying, validating, and interpreting data; and reporting. Monitoring wells are used to evaluate BNL's progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater that enters and exits the site.

The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. The groundwater beneath the site is classified by New York State as Class GA groundwater, which is defined as a source of potable water. Federal drinking water standards (DWS), New York State DWS, and New York State Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and nonradiological contamination by comparing analytical results to the standards. Contaminant concentrations that are below the standards are also compared to background values to evaluate the potential effects of facility operations. The detection of low concentrations of facility-specific VOCs or radionuclides may provide important early indications of a contaminant release and allow for timely identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 860 on- and off-site wells (see SER Volume II, Groundwater Status Report, for details). In addition to water quality assessments, water levels are routinely measured in more than 875 on- and off-site wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions in the vicinity of the Laboratory are shown in Figure 7-1.

The following active facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP) area, Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), and several vehicle maintenance and petroleum storage facilities. Inactive facilities include the former Hazardous Waste Management Facility (HWMF), two former landfill areas, Waste Concentration Facility (WCF), Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and Brookhaven Medical Research Reactor (BMRR). As a result of detailed groundwater investigations, six significant VOC plumes and eight radionuclide plumes have been identified (see Figures 7-2 and 7-3).

7.4 SUPPLEMENTAL MONITORING OF WATER SUPPLY WELLS

Most of BNL's water supply is obtained from a network of six large-capacity wells (wells 4, 6, 7, 10, 11, and 12). A seventh well, number 9, is a small-capacity well that supplies process water to a facility where biological research is conducted. This well is in limited operation and is not routinely monitored. The locations of the

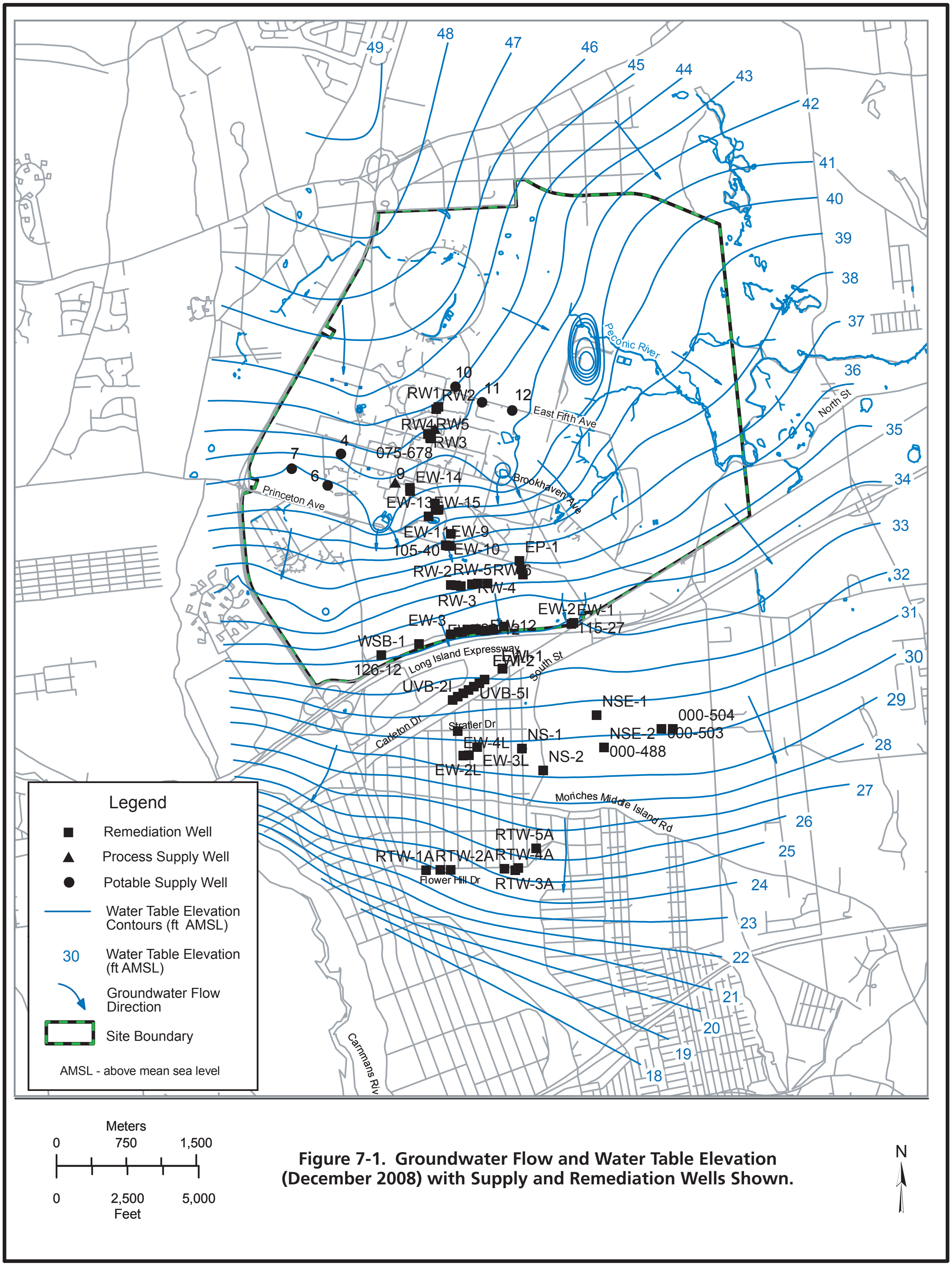


Figure 7-1. Groundwater Flow and Water Table Elevation (December 2008) with Supply and Remediation Wells Shown.

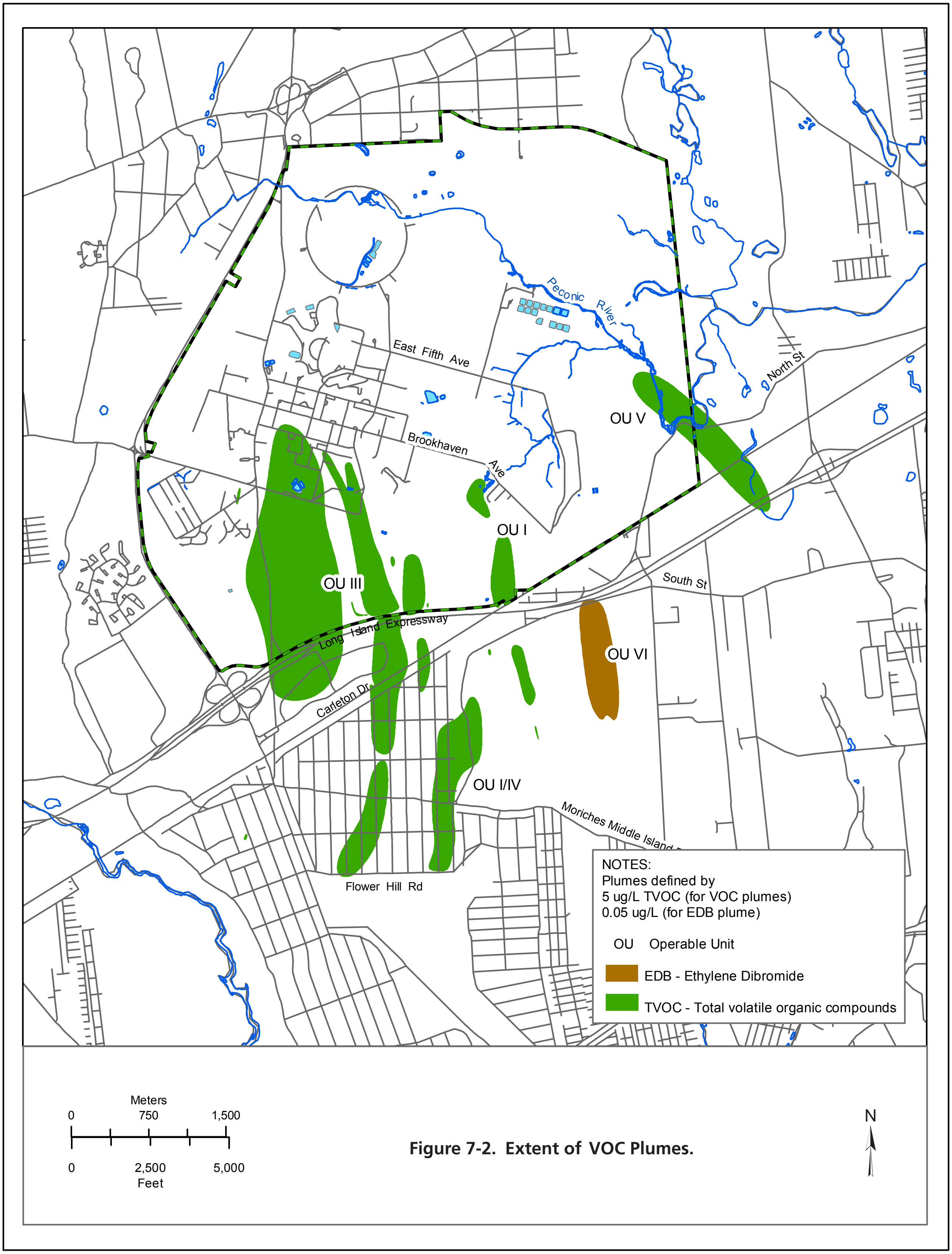


Figure 7-2. Extent of VOC Plumes.

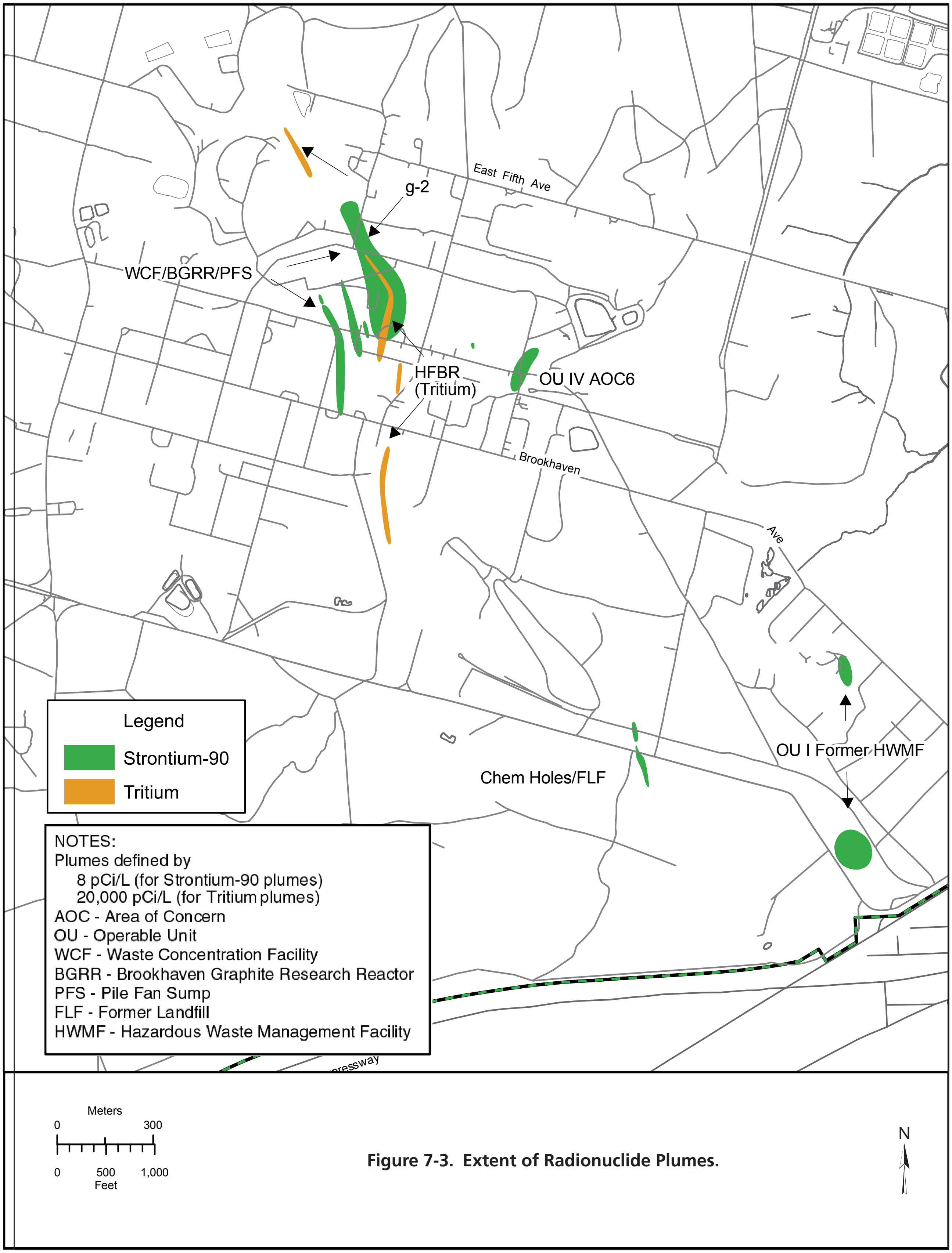


Figure 7-3. Extent of Radionuclide Plumes.

supply wells are shown in Figure 7-1. All of the Laboratory's supply wells are screened within the Upper Glacial aquifer.

As described in Chapter 3, the quality of the BNL potable water supply is monitored as required by the Safe Drinking Water Act (SDWA), and the analytical results are reported to the Suffolk County Department of Health Services (SCHDS). During 2008, the BNL potable water system fully complied with all drinking water requirements. The Laboratory conducts supplemental sampling of the water supply that goes beyond the minimum SDWA required testing. This additional testing is conducted because some of the potable supply wells are near known or suspected groundwater contamination plumes and source areas. This program includes additional testing for VOCs, anions, metals, strontium-90 (Sr-90) and tritium, which are known to have contaminated the groundwater in several areas of the site.

To better understand the geographical source of the Laboratory's drinking water and to identify potential sources of contamination within these geographical areas, BNL prepared a Source Water Assessment for Drinking Water Supply Wells (Bennett et al. 2000). In 2003, the New York State Department of Health (NYSDOH) prepared a source water assessment for all potable water supply wells on Long Island, including the BNL potable supply wells (NYSDOH 2003). The source water assessments are designed to serve as management tools in further protecting Long Island's sole source aquifer system.

Table 7-2. Potable Well Radiological Analytical Results.

Potable Well ID		Gross Alpha	Gross Beta	Tritium	Sr-90
		pCi/L			
Well 4	Samples	4	4	4	4
	Max.	< 1.88	< 2.18	< 310	< 0.71
	Avg.	0.51 ± 0.28	1.08 ± 0.83	64.62 ± 104.21	0.1 ± 0.2
Well 6	Samples	4	4	4	4
	Max.	< 1.86	< 2.25	< 310	< 0.76
	Avg.	0.58 ± 0.18	0.93 ± 0.76	30.17 ± 112.69	-0.02 ± 0.1
Well 7	Samples	4	4	4	4
	Max.	< 1.95	< 2.09	< 310	< 0.78
	Avg.	0.79 ± 0.54	0.79 ± 0.3	-17.1 ± 94.4	0.11 ± 0.47
Well 10	Samples	1	1	1	1
	Max.	< 1.96	< 2.62	< 257	< 0.5
	Avg.	N/A	N/A	N/A	N/A
Well 11	Samples	4	4	4	4
	Max.	1.95 ± 1.44	< 2.12	<310	< 0.89
	Avg.	0.89 ± 0.75	1.48 ± 0.63	110.88 ± 57.65	0.12 ± 0.09
Well 12	Samples	3	3	3	3
	Max.	< 1.96	2.85 ± 0.85	< 320	< 0.73
	Avg.	0.02 ± 0.72	1.7 ± 1.17	63.97 ± 66.61	0.02 ± 0.34
SDWA Limit (pCi/L)		**15** (a)	**4 mrem** (b)	**20,000**	**8**

Notes:
See Figure 7-1 for well locations.
All values presented with a 95% confidence interval.
Potable Well #10 has been shut down since 2000 due to its possible effect on groundwater flow direction in the vicinity of the g-2 Tritium Plume.
WS = Well shut down due to operational problems
(a) Excluding radon and uranium
(b) The drinking water standards were changed from 50 pCi/L concentration based to dose based in late 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table. Corresponding gamma analyses verified that no nuclide exceeded the 4 mrem limit.

7.4.1 Radiological Results

During 2008, samples collected from the six potable supply wells were analyzed for gross alpha and gross beta activity, tritium, and Sr-90 (see Table 7-2). Nuclide-specific gamma spectroscopy was also performed. All radioactivity levels in the potable water well samples were consistent with those of typical background water samples.

7.4.2 Nonradiological Results

In addition to the quarterly SDWA compliance samples described in Section 3.7 of Chapter 3, BNL collected supplemental VOC samples from active supply wells during the year. The samples were analyzed for VOCs following either EPA Standard Method 524 or 624. As in past years, low levels of several VOCs (e.g., chloroform, 1,1,1-trichloroethane [TCA], bromodichloromethane, and dibromochloromethane) were occasionally detected in the supply wells, but at concentrations well below the applicable drinking water standards. Samples were also analyzed for metals and anions one time during the year (see Tables 7-3 and 7-4). As in previous years, iron (Fe) was the only parameter detected

Table 7-3. Potable Water Supply Wells Water Quality Data.

Potable Well ID		Chlorides	Sulfates	Nitrate and Nitrite
		mg/L		
Well 4	N	1	1	1
	Value	26.4	8.7	0.22
Well 6	N	1	1	1
	Value	15.3	8.4	0.09
Well 7	N	1	1	1
	Value	24.4	10.1	0.23
Well 11	N	1	1	1
	Value	30.7	10.7	0.49
Well 12	N	1	1	1
	Value	24.3	12.9	0.46
NYS DWS		**250**	**250**	**10**
Typical MDL		**4**	**4**	**1**

Notes:
See Figure 7-1 for well locations.
Potable Well #10 has been shut down since 2000 due to its possible effect on groundwater flow direction in the vicinity of the g-2 Tritium Plume.
N = Number of samples
NYS DWS = New York State Drinking Water Standard
MDL = Minimum Detection Limit

at concentrations greater than the 0.3 mg/L DWS. The iron levels in wells 4, 6, and 7 were 1.3 mg/L, 2.9 mg/L, and 2.4 mg/L, respectively. Because high levels of iron are naturally present in some portions of the Upper Glacial aquifer on the western side of the Laboratory site, water obtained from wells 4, 6, and 7 is treated at the BNL Water Treatment Plant to reduce iron levels to below the 0.3 mg/L DWS before it is distributed.

7.5 FACILITY MONITORING PROGRAM

BNL's Facility Monitoring program includes groundwater monitoring at 10 active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage and waste management facilities). During 2008, groundwater samples were collected from 125 wells during 269 individual sampling events. Detailed descriptions and maps related to the FM groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Although no new impacts to groundwater quality have been discovered since 2001, groundwater quality continues to be impacted at two BNL facilities: continued periodic high levels of tritium at the g-2 tritium source area, and continued high levels of VOCs at the Upton service station. Highlights of the surveillance program are as follows:

- Tritium continues to be detected in the g-2 source area monitoring well, at concentrations above the 20,000 pCi/L DWS. A short-term spike in tritium levels was observed in January 2008, with a tritium concentration of 186,000 pCi/L detected in the source area. Tritium levels in the source area wells dropped to less than 50,000 pCi/L by the fourth quarter of the year. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicate that the continued release of tritium appears to be related to the flushing of residual tritium from the deep vadose zone following significant natural periodic fluctuations in the local water table.
- Monitoring of the downgradient areas of the g-2 tritium plume was accomplished using a combination of permanent and temporary wells. The highest tritium concentration in the downgradient segment of the plume was 80,700 pCi/L, observed immediately south of the HFBR. The southern extent of the plume was tracked to the Temple Place area, where a maximum tritium concentration of 33,300 pCi/L was detected. As a result of natural radioactive decay and dispersion in the aquifer, the tritium plume appears to be breaking up into discrete segments.
- Since April 2006, all tritium concentrations in the Brookhaven Linear Isotope Producer (BLIP) facility surveillance wells have been less than the 20,000 pCi/L DWS. The maximum tritium concentration during 2008 was 5,630 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding, and that the amount of residual tritium in the deep vadose zone is diminishing.
- At the Service Station, VOCs associated with petroleum products and the solvent PCE continue to be detected in the ground-

water directly downgradient of the facility. Total VOC concentrations in one well reached a maximum of 1,575 µg/L; with the contamination consisting mostly of xylenes, ethylbenzene, and trimethylbenzenes. Groundwater monitoring results indicate that the petroleum-related compounds break down within a short distance from the facility. Monitoring of the leak detection systems at the Upton Service Station indicates that the gasoline storage tanks and associated distribution lines are not leaking, and all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the contaminants detected in groundwater originate from historical vehicle maintenance activities and are not related to current operations.

7.6 CERCLA MONITORING PROGRAM

The CERCLA groundwater monitoring program is used to track the progress that the groundwater treatment systems are making toward plume remediation (see Section 7.7, below). During 2008, the CERCLA program monitored 735 monitoring wells during 1,901 individual groundwater sampling events.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively. Detailed descriptions and maps related to the CERCLA groundwater monitoring program can be found in SER Volume II, Groundwater Status Report. Highlights of the program are described below.

- The HFBR Pump and Recharge system was operational during all of 2008. Monitoring data indicate that the elevated zone of tritium is approaching newly installed extraction well EW-16. The system is expected to remain operational for several years until this elevated concentration zone has been completely captured, and tritium concentrations in the area decrease below the 20,000 pCi/L Drinking Water Standard (DWS).
- Following a combined soil boring and soil gas characterization effort, the source of the Building 96 tetrachloroethylene (PCE) plume was identified and delineated during

Table 7-4. Total Metals Concentration Data for Potable Water Supply Well Samples.

Well ID		Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
Well 4 *	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	< 50.0	< 5.0	30.2	< 2.0	< 2.0	< 5.0	< 5.0	5.3	1.28	< 0.2	230	17.8	< 10	<3.0	< 5.0	< 5.0	< 5.0	1	8.3
Well 6 *	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	< 50.0	< 5.0	19.1	< 2.0	< 2.0	< 5.0	< 5.0	11.6	2.91	< 0.2	173	10.1	27.9	<3.0	< 5.0	< 5.0	< 5.0	3.3	9.2
Well 7 *	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	< 50.0	< 5.0	22	< 2.0	< 2.0	< 5.0	< 5.0	16.9	2.35	< 0.2	70.3	17.1	< 10	< 3.0	< 5.0	< 5.0	< 5.0	2.5	7.7
Well 11	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	< 50.0	< 5.0	31.5	< 2.0	< 2.0	< 5.0	< 5.0	7.4	0.03	< 0.2	< 5.0	20.3	< 10	< 3.0	< 5.0	< 5.0	< 5.0	1.4	4.4
Well 12	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	< 2.0	< 50	< 5.0	27.9	< 2.0	< 2.0	< 5.0	< 5.0	5.3	< 0.05	< 0.2	< 5.0	16.9	< 10	< 3.0	< 5.0	< 5.0	< 5.0	3	2.1
NYS DWS		**100**	**SNS**	**50**	**2000**	**4**	**5**	**SNS**	**100**	**1300**	**0.3**	**2**	**300**	**SNS**	**SNS**	**15**	**6**	**50**	**2**	**SNS**	**5000**
Typical MDL		**2.0**	**50**	**5.0**	**20.0**	**2.0**	**2.0**	**5.0**	**5.0**	**10.0**	**0.05**	**0.2**	**5.0**	**0.3**	**10.0**	**3**	**5.0**	**5.0**	**5..0**	**5.0**	**10.0**

Notes:
See Figure 7-1 for location of wells.
Potable Well #10 has been shut down since 2000 due to its possible effect on groundwater flow direction in the vicinity of the g-2 Tritium Plume.
* Water from these wells is treated at the Water Treatment Plant for color and iron reduction prior to site distribution.
MDL = Minimum Detection Limit
NYS DWS = New York State Drinking Water Standard
SNS = Drinking Water Standard not specified
NS = Well was not in operation during sample period

2008. Plans are being made to excavate a small area of contaminated soils south of the former Building 96, and dispose of the soils off site. The removal of this source area is expected to significantly reduce PCE levels in the groundwater within three to five years, and allow for the groundwater treatment system to be turned off. A temporary plastic cover was placed over the contaminated soils source area until excavation is undertaken. An Explanation of Significant Differences (ESD) documenting the source area excavation will be submitted to the regulatory agencies in April 2009.

- A joint groundwater characterization effort was undertaken to define the present locations of the co-located downgradient segments of the g-2 tritium plume and the WCF Sr-90 plume. Monitoring results indicated that the highest Sr-90 concentrations are just northwest of the HFBR building, whereas the area of highest tritium concentrations is just south of the HFBR. Verification of the separation of these two plume segments will allow for the installation of additional extraction wells to capture the higher concentration segments of the Sr-90 plume without entraining significant amounts of tritium.
- Eight temporary wells were installed along the Middle Road in the Western South Boundary area to better define the VOC plume in this area of the site. VOC concentrations that were higher than expected (total VOC concentrations up to 120 µg/L) were observed, with the primary contaminants consisting of dichorodifluoromethane (a freon) and TCA. This contamination is projected to be captured by the Western South Boundary System.
- Because increased Sr-90 levels were observed during 2008 in a sentinel well used to track the downgradient edge of the Sr-90 plume south of the former HWMF, additional characterization of the plume and the installation of new permanent sentinel wells may be required.
- Because there has not been a rebound in contaminant concentrations since the Carbon Tetrachloride System was shut down in 2004, a petition for closure of this system will be prepared and submitted to the regulatory agencies in 2009.
- VOC concentrations in Industrial Park East and North Street East monitoring and extraction wells have decreased to levels well below the system capture goals. As a result, a petition for shutdown of this system will be submitted to the regulatory agencies in 2009.

7.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems and prevent additional groundwater contamination from migrating off site. The cleanup objectives will be met by a combination of active treatment and natural attenuation. The specific cleanup goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve MCLs for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070
- Achieve MCLs for Sr-90 at the Chemical Holes in the Upper Glacial aquifer by 2040

During 2008, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 14 groundwater treatment systems currently in operation. Table 7-5 provides a summary of the amount of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2008, 220 pounds of VOCs and approximately 3.4 mCi of Sr-90 were removed from the groundwater, and more than 1.5 billion gallons of treated groundwater were returned to the aquifer. To date, 6,117 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in the OU I South Boundary, OU III South Boundary, OU III Industrial Park, OU III Industrial Park East, OU III North Street, OU IV, Building 96, and Carbon Tetrachloride areas. Also to date, two of the treat-

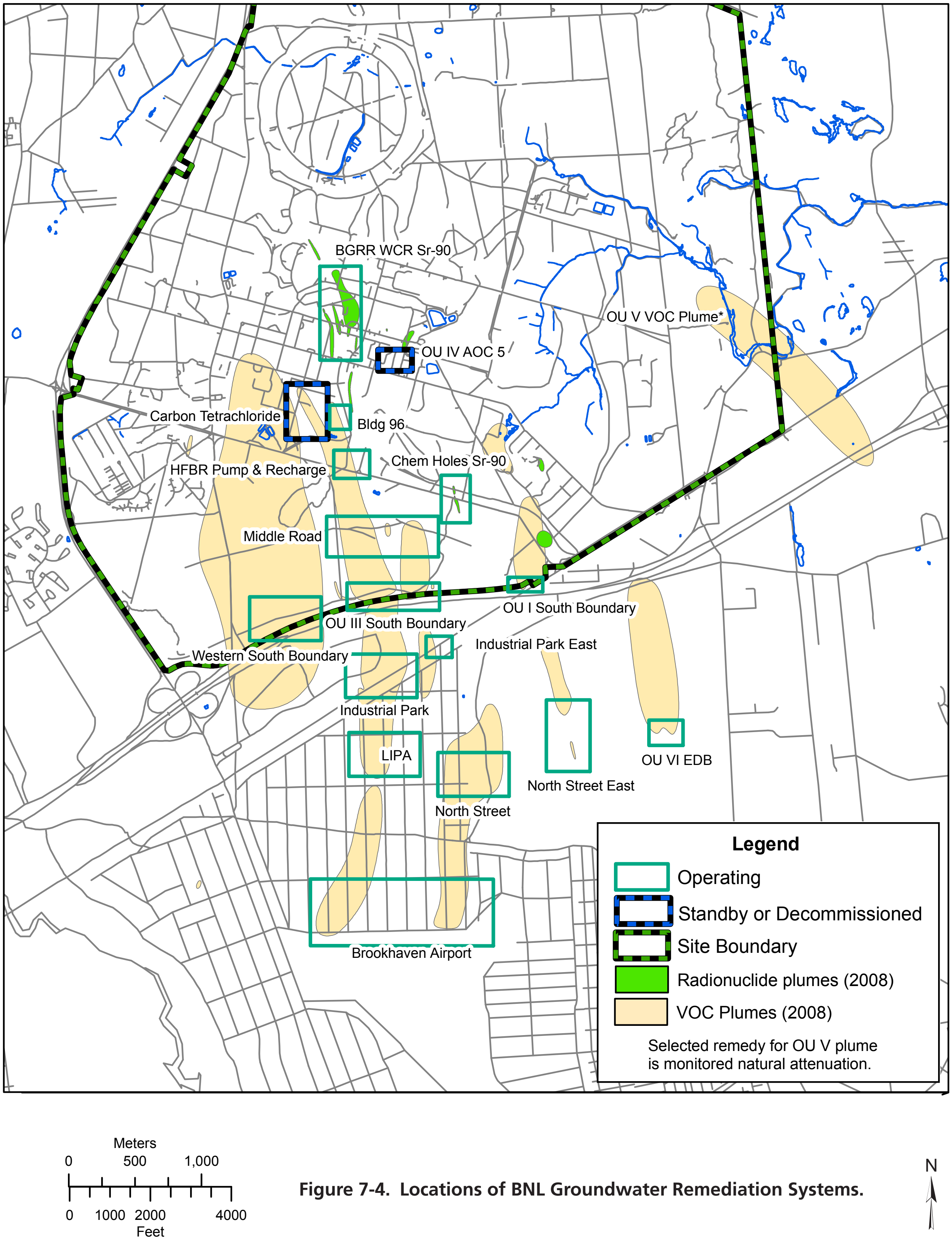


Figure 7-4. Locations of BNL Groundwater Remediation Systems.

Table 7-5. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2008.

		1997-2007		2008	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)
OU I South Boundary	12/1996	3,184,314,000	337	258,000,000	10
OU III HFBR Tritium Plume (a)	05/1997	248,987,000	180	86,000,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Not in Service	0
OU III Building 96	01/2001	138,297,416	71	34,000,000	13
OU III Middle Road	10/2001	1,267,411,550	741	150,000,000	56
OU III South Boundary	06/1997	3,184,952,850	2,569	135,000,000	60
OU III Western South Boundary	09/2002	602,647,000	49	65,000,000	5
OU III Industrial Park	09/1999	1,364,478,330	1010	128,000,000	24
OU III Industrial Park East	06/2004	287,172,000	33	33,000,000	3
OU III North Street	06/2004	689,122,000	268	180,000,000	21
OU III North Street East	06/2004	428,976,000	20	64,000,000	5
OU III LIPA/Airport	08/2004	846,887,000	235	226,000,000	23
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	471,711,000	(f)	153,000,000	(f)
Total		**12,868,485,221**	**5,897**	**1,512,000,000**	**220**

		2003–2007		2008	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)
OU III Chemical Holes Sr-90	02/2003	12,404,826	2.59	6,000,000	0.74
OU III BGRR/WCF Sr-90	06/2005	22,151,000	14.15	8,800,000	2.7
Total		**34,555,826**	**16.74**	**14,800,000**	**3.44**

Notes:

(a) System was reactivated in late 2007 as a contingency action.
(b) System was shut down on January 10, 2001 and decommissioned in 2003.
(c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance was measured by pounds of VOCs removed per cubic feet of air treated.
(d) System was shut down and placed in standby mode in August 2004.
(e) Values are rounded to the nearest whole number.
(f) Because EDB has only been detected at trace levels in the treatment system influent, no removal of VOCs is reported.

BGRR = Brookhaven Graphite Research Reactor
EDB = ethylene dibromide
HFBR = High Flux Beam Reactor
LIPA = Long Island Power Authority
OU = Operable Unit
VOCs = volitile organic compounds
WCF = Waste Concentration Facility

ment systems have removed approximately 20 mCi of Sr-90. Detailed information on the groundwater treatment systems can be found in SER Volume II, Groundwater Status Report.

REFERENCES AND BIBLIOGRAPHY

Bennett, D., D. Paquette, K. Klaus, and W. Dorsch. 2000. *Brookhaven National Laboratory, Source Water Assessment for Drinking Water Supply Wells.* BNL-52608. Brookhaven National Laboratory, Upton, NY. December 27, 2000.

BNL 2008. *Groundwater Protection Contingency Plan – Response to Unexpected Monitoring Results.* Environmental Monitoring Procedure EM-SOP-309. Brookhaven National Laboratory, Upton, NY. September 2008.

DOE 2003. DOE Order 450.1, *Environmental Protection Program.* U.S. Department of Energy, Washington, DC.

NYSDOH. 2003. *Long Island Source Water Assessment Summary Report.* New York Sate Department of Health, June 23, 2003.

8

Radiological Dose Assessment

All Laboratory operations, scientific experiments, and research projects are evaluated for safety and dose to workers and the environment before their implementation. Radiological assessment of operations, experiments, and remediation projects are performed as necessary, to ensure that the overall radiological dose impact from these activities is "As Low As Reasonably Achievable" (ALARA) to members of the public, BNL workers, visitors, and the environment. The assessments also ensure that facilities and operations are in compliance with federal, state, and local regulations. The potential radiological dose to members of the public is calculated at the site boundary as the maximum dose that could be received by a hypothetical individual defined as the "maximally exposed individual" (MEI). Therefore, all individual members of the public will receive dose less than the MEI. The dose to the MEI is the sum total from direct and indirect dose pathways to an individual via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat. The 2008 Total Effective Dose Equivalent (TEDE) from Laboratory operations was well below the EPA and DOE regulatory dose limits for the public, workers, and the environment.

The average annual on-site external dose from ambient sources was 69 ± 13 mrem (690 ± 130 µSv) and 63 ± 11 mrem (630 ± 110 µSv) at off-site locations. Both on- and off-site dose measurements include the contribution from natural terrestrial and cosmic background radiation. A statistical comparison of the average doses measured using thermoluminescent dosimeters (TLDs) at 49 on-site and 15 off-site locations showed that there was no external dose contribution from BNL operations above the natural background radiation level. An additional nine TLDs were used to measure on-site areas known to have radiation dose slightly elevated above natural background. The results of these measurements are described in Section 8.1.2.

The effective dose equivalent (EDE) from air emissions was calculated as 6.12E-02 mrem (0.61 µSv) to the MEI. The dose from the ingestion pathway was estimated as 12.48 mrem (125 µSv) from the consumption of deer meat, and 0.09 mrem (0.9 µSv) from the consumption of fish caught in the vicinity of the Laboratory. The total annual dose to the MEI from all the pathways was estimated as 12.63 mrem (126 µSv). The BNL dose from the air inhalation pathway was less than 1 percent of EPA's annual regulatory dose limit of 10 mrem (100 µSv). The total dose was less than 13 percent of DOE's annual dose limit of 100 mrem (1,000 µSv) from all environmental pathways.

Doses to aquatic and terrestrial biota were also evaluated and found to be well below DOE regulatory limits. Other short-term projects, such as remediation work and waste management disposal activities, were assessed for radiological emissions; the potential dose impacts from these activities were below regulatory limits and there was no radiological risk to the public, BNL employees, visitors, or the environment. In summary, the overall dose impact from all Laboratory activities in 2008 was comparable to natural background radiation levels.

8.1 DIRECT RADIATION MONITORING

Direct, penetrating beta and gamma radiation is measured using TLDs. The principle of TLD function is that when certain crystals are exposed to radiation, impurities in the crystals' low-temperature trapping sites are excited to higher energy states. These electrons remain in a high-energy state at normal ambient temperature. When the TLDs are heated (annealed), electrons return to the lower energy state, emitting photon energy (light), which is measured with a photomultiplier tube; the light intensity is directly proportional to the absorbed radiation dose. The environmental TLDs used at the Laboratory are composed of calcium fluoride and lithium fluoride crystals. Accuracy is verified by exposing the TLD to a known and characterized radiation source. BNL participates in the inter-comparison proficiency testing programs sponsored by DOE, as a check of its ability to measure radiation doses accurately.

A direct radiation-monitoring program is used to measure the external dose contribution to members of the public and workers from radiation sources at the Laboratory. This is achieved by measuring direct penetrating radiation exposures at both on- and off-site locations. The direct measurements taken at the off-site locations are with the premise that off-site exposures represent true natural background radiation (with contribution from both cosmic and terrestrial sources) and represent no contribution from BNL operations. On- and off-site external dose measurements were averaged, and then compared with each other using the statistical t-test to measure any variations in the averages and thus the contribution, if any, from Laboratory operations.

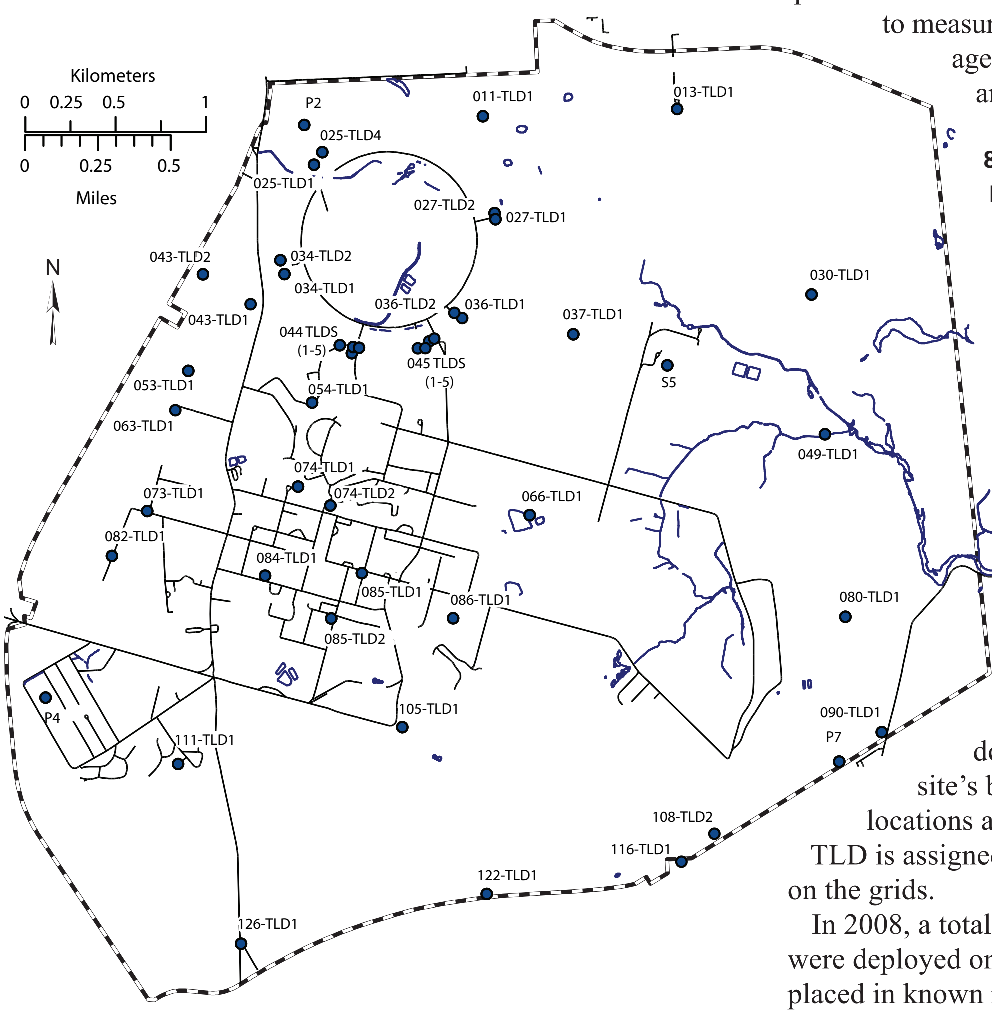


Figure 8-1. On-Site TLD Locations.

8.1.1 Ambient Radiation Monitoring

To assess the dose impact of direct radiation from BNL operations, TLDs are deployed on site and in the surrounding communities. On-site TLD locations are determined based on the potential for exposure to gaseous plumes, atmospheric particulates, scattered radiation, and the location of radiation-generating devices. The Laboratory perimeter is also posted with TLDs to assess the dose impact, if any, beyond the site's boundaries. On- and off-site locations are divided into grids, and each TLD is assigned an identification code based on the grids.

In 2008, a total of 58 environmental TLDs were deployed on site, of which nine were placed in known radiation areas. Another 15 TLDs were deployed at off-site locations (see Figures 8-1 and 8-2 for locations). An addi-

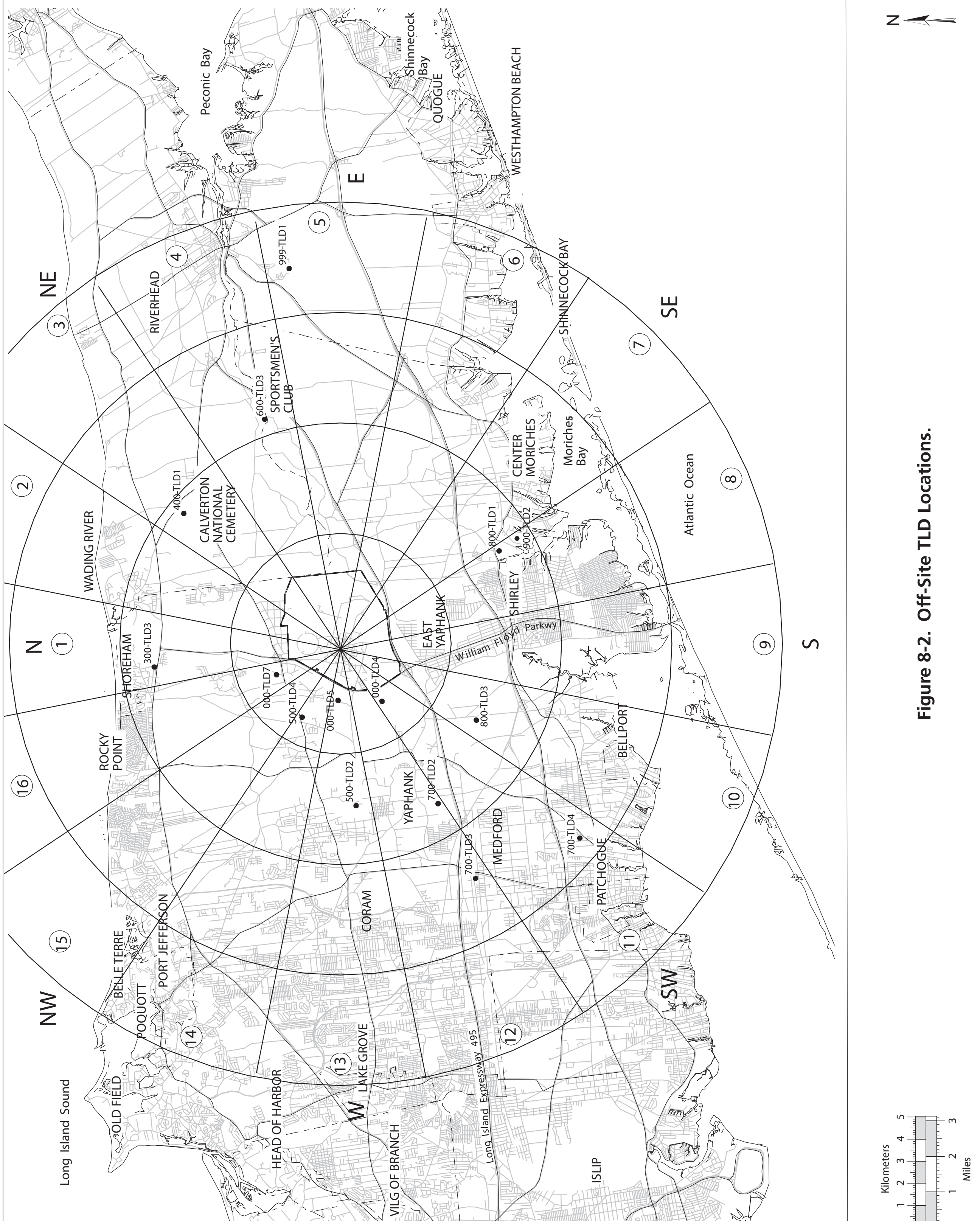


Figure 8-2. Off-Site TLD Locations.

tional 30 TLDs were stored in a lead-shielded container in Building 490 for use as reference and control TLDs for comparison purposes. The average of the control TLD values was reported as "075-TLD4" in Tables 8-1 and 8-2. Note that a small "residual" dose was reported for the control TLDs when they were annealed, because it is not possible to completely anneal and shield the TLDs from all natural background and cosmic radiation sources. The on- and off-site TLDs were collected and read quarterly to determine the external radiation dose measured.

Table 8-1 shows the quarterly and yearly on-site radiation dose measurements for 2008. The on-site average external doses for the first, second, third, and fourth quarters were 18.7 ± 4.3, 16.5 ± 3.3, 15.7 ± 3.7, and 17.7 ± 3.6 mrem, respectively. The on-site average annual external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 69 ± 13 mrem (690 ± 130 µSv).

Table 8-2 shows the quarterly and yearly off-site radiation dose measurements. The off-site average external doses for the first, second, third, and fourth quarters were 17.5 ± 2.7, 15.4 ± 2.6, 14.8 ± 3.4, and 15.0 ± 3.0 mrem, respectively. The off-site average annual ambient dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 63 ± 11 mrem (630 ± 110 µSv).

To determine the BNL contribution to the external direct radiation dose, a statistical t-test between the measured on- and off-site external dose averages was conducted. The t-test showed no significant difference between the off-site dose (63 ± 11 mrem) and on-site dose (69 ± 13 mrem) at the 95 percent confidence level. From the measured TLD doses, it can be safely concluded that there was no measurable external dose contribution to on- and off-site locations from Laboratory operations in 2008.

8.1.2 Facility Area Monitoring

Nine on-site TLDs were designated as facility-area monitors (FAMs) because they were

Table 8-1. On-Site Direct Ambient Radiation Measurements.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ± 2σ (95%)	Annual Dose ± 2σ (95%)
		(mrem)					
011-TLD1	North firebreak	15.8	13.6	11.8	14.6	14 ± 3	56 ± 13
013-TLD1	North firebreak	18.2	14.7	14.8	15.8	16 ± 3	64 ± 13
025-TLD1	Bldg. 1010 beam stop 1	16.4	16.5	14.8	15.8	16 ± 2	64 ± 6
025-TLD4	Bldg. 1010 beam stop 4	17.3	15.3	14.4	17.0	16 ± 3	64 ± 11
027-TLD1	Bldg. 1002A South	15.9	15.2	14.6	15.1	15 ± 1	61 ± 4
027-TLD2	Bldg. 1002D East	16.3	15.5	14.3	15.8	15 ± 2	62 ± 7
030-TLD1	Northeast firebreak	18.1	15.8	15.8	17.3	17 ± 2	67 ± 9
034-TLD1	Bldg. 1008 collimator 2	20.7	17.5	15.7	18.9	18 ± 4	73 ± 17
034-TLD2	Bldg. 1008 collimator 4	18.1	15.9	14.9	17.8	17 ± 3	67 ± 12
036-TLD1	Bldg. 1004B East	15.9	13.9	12.6	15.7	15 ± 3	58 ± 12
036-TLD2	Bldg. 1004 East	20.1	17.1	17.2	16.9	18 ± 3	71 ± 12
037-TLD1	S-13	17.4	15.4	15.2	16.6	16 ± 2	65 ± 8
043-TLD1	North access road	19.0	16.8	16.3	18.6	18 ± 3	71 ± 10
043-TLD2	North of Meteorology Tower	18.3	16.9	16.4	17.0	17 ± 2	69 ± 6
044-TLD1	Bldg. 1006	18.3	16.5	15.7	17.7	17 ± 2	68 ± 9
044-TLD2	South of Bldg. 1000E	22.5	15.6	15.3	16.2	17 ± 7	70 ± 27

(continued on next page)

Table 8-1. On-Site Direct Ambient Radiation Measurements *(concluded).*

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ± 2σ (95%)	Annual Dose ± 2σ (95%)
		(mrem)					
044-TLD3	South of Bldg. 1000P	17.0	14.3	13.1	15.7	15 ± 3	60 ± 13
044-TLD4	North-east of Bldg. 1000P	18.0	16.7	16.9	17.9	17 ± 1	70 ± 5
044-TLD5	North of Bldg. 1000P	17.7	15.2	15.3	17.5	16 ± 3	66 ± 11
045-TLD1	Bldg. 1005S	17.9	17.0	15.2	19.3	17 ± 3	69 ± 13
045-TLD2	East of Bldg. 1005S	19.0	16.5	17.3	17.7	18 ± 2	71 ± 8
045-TLD3	South-east of Bldg. 1005 S	20.6	15.6	14.1	16.8	17 ± 5	67 ± 22
045-TLD4	South-west of Bldg. 1005 S	18.1	15.4	14.4	16.2	16 ± 3	64 ± 12
045-TLD5	West South-west of Bldg. 1005 S	16.5	15.0	15.2	14.5	15 ± 2	61 ± 7
049-TLD1	East firebreak	17.3	15.1	16.8	19.3	17 ± 3	69 ± 14
053-TLD1	West firebreak	20.3	20.0	16.9	18.9	19 ± 3	76 ± 12
054- TLD1	Bldg. 914	19.0	15.2	12.7	18.4	16 ± 6	65 ± 23
063-TLD1	West firebreak	20.0	19.6	17.8	20.2	19 ± 2	78 ± 9
066-TLD1	Waste Management Facility	17.4	14.7	13.1	15.7	15 ± 4	61 ± 14
073-TLD1	Meteorology Tower/Bldg. 51	18.5	17.1	17.4	18.5	18 ± 1	72 ± 6
074-TLD1	Bldg. 560	22.4	17.2	17.4	19.0	19 ± 5	76 ± 19
074-TLD2	Bldg. 907	19.8	17.4	14.4	20.8	18 ± 6	72 ± 22
080-TDL1	East firebreak	20.6	18.4	21.6	21.0	20 ± 3	82 ± 11
082-TLD1	West firebreak	21.2	19.7	17.8	20.2	20 ± 3	79 ± 11
084-TLD1	Tennis courts	17.7	15.8	15.0	18.3	17 ± 3	67 ± 12
085-TDL2	Upton gas station	26.5	17.9	16.2	20.4	20 ± 9	81 ± 35
085-TLD1	Diversity Office	19.1	16.4	15.3	19.4	18 ± 4	70 ± 16
086-TLD1	Baseball fields	22.3	20.1	19.4	20.7	21 ± 2	83 ± 10
090-TLD1	North Street Gate	17.2	15.9	16.4	18.1	17 ± 2	68 ± 8
105-TLD1	South firebreak	20.7	19.4	17.5	17.3	19 ± 3	75 ± 13
108-TLD1	Water tower	16.8	14.7	19.0	15.8	17 ± 4	66 ± 14
108-TLD2	Tritium pole	23.4	20.0	14.9	22.5	20 ± 7	81 ± 30
111-TLD1	Trailer park	18.0	17.7	16.5	17.9	18 ± 1	70 ± 5
122-TLD1	South firebreak	17.1	16.0	16.2	16.5	16 ± 1	66 ± 4
126-TLD1	South gate	18.9	19.0	16.8	20.4	19 ± 3	75 ± 12
P2		14.8	14.6	13.0	17.5	15 ± 4	60 ± 15
P4		17.3	15.1	13.9	17.0	16 ± 3	63 ± 13
P7		18.0	15.7	16.0	16.1	16 ± 2	66 ± 8
S5		19.0	15.5	13.8	15.7	16 ± 4	64 ± 17
On-site average		**18.7**	**16.5**	**15.7**	**17.7**	**17 ± 3**	**69 ± 13**
Std. dev. (2 σ)		**4.3**	**3.3**	**3.7**	**3.6**		
075-TLD4	**Control TLD average**	**9.0**	**8.6**	**9.3**	**8.9**	**8.9 ± 1**	**36 ± 2**

Notes:
See Figure 8-1 for TLD locations.
L = TLD lost
NP = TLD not posted

Table 8-2. Off-Site Direct Radiation Measurements.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ± 2σ (95%)	Annual Dose ± 2σ (95%)
		(mrem)					
000-TLD4	Private property	17.9	13.6	13.6	13.5	15 ± 4	59 ± 17
000-TLD5	Longwood Estate	17.4	16.5	L	14.2	15 ± 3	61 ± 13
000-TLD7	Mid-Island Game Farm	16.4	15.7	L	16.4	16 ± 1	64 ± 4
300-TLD3	Private property	NP	NP	14.4	17.3	16 ± 0	63 ± 0
400-TLD1	Calverton Nat. Cemetary	17.9	17.9	18.8	19.3	18 ± 1	74 ± 5
500-TLD2	Private property	15.9	14.9	14.1	13.9	15 ± 2	59 ± 7
500-TLD4	Private property	18.8	L	L	NP	19 ± 0	75 ± 0
600-TLD3	Sportsmen's Club	17.6	15.7	14.8	15.8	16 ± 2	64 ± 9
700-TLD2	Private property	17.0	14.1	14.4	13.0	15 ± 0	59 ± 0
700-TLD3	Private property	17.3	13.8	14.4	15.4	15 ± 3	61 ± 12
700-TLD4	Private property	21.1	15.7	16.0	15.6	17 ± 5	68 ± 21
800-TLD1	Private property	17.8	NP	L	12.6	15 ± 7	61 ± 29
800-TLD3	Suffolk County CD	17.3	15.7	15.0	16.8	16 ± 2	65 ± 8
900-TLD2	Private property	15.5	NP	12.1	14.9	14 ± 0	57 ± 0
999-TLD1	Private property	NP	NP	NP	NP		
Off-site average		**17.5**	**15.4**	**14.8**	**15.3**	**16 ± 3**	**64 ± 11**
Std. dev. (2 σ)		**2.7**	**2.6**	**3.4**	**3.7**		
075-TLD4	**Control TLD average**	**9.5**	**9.8**	**9.7**	**10.0**	**9.8 ± 0**	**39 ± 2**

Notes:
See Figure 8-2 for TLD locations.
CD = Correctional Department
NP = TLD not posted for the quarter
L = TLD lost

posted in known radiation areas (near "facilities"). Table 8-3 shows the external doses measured with the FAM-TLDs. The environmental TLDs 088-TLD1 through 088-TLD4 are posted at the S-6 blockhouse location and on the fence of the former Hazardous Waste Management Facility (HWMF). These TLDs measured external doses that were slightly elevated compared to the normal natural background radiation doses measured from other areas of BNL. The elevated external dose measured at the former HWMF can be attributed to the presence of small amounts of soil contamination. However, a comparison of the 2008 dose rates to doses from previous years show that the dose rates have declined significantly since the removal of most of the radioactive soil contained within the former HWMF. As recorded in Table 8-3, the dose is currently just slightly above natural background levels. The former HWMF is fenced; access is controlled, and only trained staff members are allowed inside the facility.

Two TLDs (075-TLD3 and 075-TLD5) near Building 356 showed much higher than normal quarterly averages: 25 ± 6 mrem (250 ± 60 µSv) and 27 ± 7 mrem (270 ± 70 µSv), respectively. The yearly doses were measured at 100 ± 24 mrem (1000 ± 240 µSv) for 075-TLD3, and 110 ± 28 mrem (1100 ± 280 µSv) for 075-TLD5. The direct doses are higher than the on-site annual average because Building 356 houses a cobalt-60 (Co-60) source, which is used to irradiate materials, parts, and electronic circuit boards. The elevated dose from Building 356 is attributed to the "sky-shine" phenomenon. Although it is conceivable that individuals who use the parking lot adjacent to Building 356 could receive a dose from this source, the dose

Table 8-3. Facility Area Monitoring.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Average ± 2σ (95%)	Annual Dose ± 2σ (95%)
		(mrem)					
054-TLD2	North-east of Bldg. 913-B	26.3	17.9	14.6	19.1	19 ± 10	78 ± 39
054-TLD3	North-west of Bldg. 913-B	20.3	15.6	15.1	15.8	17 ± 5	67 ±19
S6		18.9	17.8	17.5	19.1	18 ± 2	73 ± 6
088-TLD1	FWMF-50’ East of S-6	20.5	16.6	17.5	18.6	18 ± 3	73 ± 13
088-TLD2	FWMF-50’ West of S-6	21.8	20.7	19.7	20.0	21 ± 2	82 ± 7
088-TLD3	FWMF-100’ West of S-6	22.1	19.3	19.5	20.1	20 ± 3	81 ± 10
088-TLD4	FWMF-150’ West of S-6	19.4	17.4	17.7	18.6	18 ± 2	73 ± 7
075-TLD3	Bldg. 356	29.4	23.3	22.8	24.8	25 ± 6	100 ± 24
075-TLD5	North Corner of Bldg. 356	32.6	26.0	26.6	24.5	27 ± 7	110 ± 28

Notes:
See Figure 8-1 for TLD locations.
FWMF = Former Waste Management Facility

would be minimal due to the limited time an individual spends in the parking lot.

Two FAM-TLDs placed on the fence northeast and northwest of Building 913-B (the Alternating Gradient Synchrotron tunnel access) showed higher than average ambient external dose. The first-quarter dose at that site was measured at 26.3 mrem for 054-TLD2 and 20.3 mrem for 054-TLD3 (compared to the sitewide first-quarter dose of 18.7 ± 4.3). For the remaining three quarters, both TLDs showed dose comparable to the natural background radiation.

8.2 DOSE MODELING

EPA regulates radiological emissions from DOE facilities under the requirements set forth in 40 CFR 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPs). This regulation specifies the compliance and monitoring requirements for reporting radiation doses received by members of the public from airborne radionuclides. The regulation mandates that no member of the public shall receive a dose from DOE operations that is greater than 10 mrem (100 μSv) in a year. The emission monitoring requirements are set forth in Subpart H, Section 61.93(b) and include the use of a reference method for continuous monitoring at major release points (defined as those with a potential to exceed 1 percent of the 10 mrem standard), and a periodic confirmatory measurement for all other release points. The regulations also require DOE facilities to submit an annual NESHAPs report to EPA that describes the major and minor emission sources and dose to the MEI. The dose estimates from various facilities are given in Table 8-4, and the actual emissions for 2008 are discussed in detail in Chapter 4.

As a part of the NESHAPs review process at BNL, any source that has the potential to emit radioactive materials is evaluated for regulatory compliance. Although the activities conducted under the Environmental Restoration (ER) Program are exempt under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), these activities are also monitored and assessed for any potential to release radioactive materials, and to determine their dose contribution, if any, to the environment. Any new processes or activities are evaluated for compliance with NESHAPs regulations using EPA’s approved dose modeling software (see Section 8.2.1 for details). Because this model was designed to treat all radioactive emission sources as continuous over the course of a year, it is not well suited for estimating short-term or acute releases. Consequently, it overestimates potential dose contributions from short-term projects and area sources. For that

Table 8-4. MEI Effective Dose Equivalent From Facilities or Routine Processes.

Building No.	Facility or Process	Construction Permit No.	MEI Dose (mrem) (a)	Notes
348	Radiation Protection	None	ND	(b)
463	Biology Facility	None	ND	(b)
490	Medical Research	BNL-489-01	5.70E-11	(b)
490A	Energy and Environment National Security	None	ND	(b)
491	Brookhaven Medical Research Reactor	None	ND	(e)
510	Calorimeter Enclosure	BNL-689-01	ND	(f)
510A	Physics	None	ND	(b)
535	Instrumentation	None	ND	(b)
555	Chemistry Facility	None	ND	(b)
725	National Synchrotron Light Source	None	ND	(b)
750	High Flux Beam Reactor	None	1.07E-4	(c)
801	Target Processing Lab	None	1.14E-6	(b), (c)
802B	Evaporator Facility	BNL-288-01	NO	(e)
820	Accelerator Test Facility	BNL-589-01	ND	(d)
830	Environmental Science Department	None	ND	(d)
865	Reclamation Building	None	ND	(c)
906	Medical-Chemistry	None	ND	
925	Accelerator Department	None	ND	(b)
931	Brookhaven Linac Isotope Producer	None	6.12E-2	(c)
938	REF/NBTF	BNL-789-01	ND	(g)
942	Alternate Gradient Syncrotron Booster	BNL-188-01	ND	(h)
---	Relativistic Heavy Ion Collider	BNL-389-01	ND	(d)
Total Potential Dose from BNL Operations			**6.13E-2**	
EPA Limit			**10.0 mrem**	

Notes:
Diffuse, Fugitive, and Other sources are not included in this table since they are short-term emissions.
MEI = Maximally Exposed Individual
NBTF = Neutron Beam Test Facility
REF = Radiation Effects Facility
(a) "Dose" in this table means effective dose equivalent to MEI.
(b) Dose is based on emissions calculated using 40 CFR 61, Appendix D methodology.
(c) Emissions are monitored at the facility.
(d) ND = No dose from emissions source in 2008.
(e) NO = Not operational in 2008.
(f) This has become a zero-release facility since original permit application.
(g) This facility is no longer in use; it produces no radioactive emissions.
(h) Booster ventilation system prevents air release through continuous air recirculation.

reason, the results are considered to be "conservative"—that is, erring on the side of caution.

8.2.1 Dose Modeling Program

Compliance with NESHAPs regulations is demonstrated through the use of EPA dose modeling software and the Clean Air Act Assessment Package-1988 (CAP88-PC), Versions 2.1 and 3.0. This computer program uses a Gaussian plume model to estimate the average dispersion of radionuclides released from elevated stacks or diffuse sources. It calculates a final value of the projected dose at the specified distance from the release point by computing dispersed radionuclide concentrations in air, rate of deposition on ground surfaces, and intake via the food pathway (where applicable). CAP88-PC calculates both the EDE to the MEI and the collective population dose within a 50-mile radius of the emission source. In most cases, the CAP88-PC model provides conservative doses. For the purpose of modeling the dose to the MEI, all emission points are located at the center of the developed portion of the BNL site. The dose calculations are based on very low concentrations of environmental releases and on chronic, continuous intakes in a year. The input parameters used in the model include radionuclide type, emission rate in curies (Ci) per year, stack parameters such as height and diameter, and emission exhaust velocity. Site-specific weather and population data are factored into the dose assessment. Weather data are supplied by measurements from the Laboratory's meteorological tower. These measurements include wind speed, direction, frequency, and air temperature (see Chapter 1 for details). Population data used in the model are based on the Long Island Power Authority population survey (LIPA 2000). Because visiting researchers and their families may reside at the BNL on-site apartment area for extended periods, these residents are included in the population file used for dose assessment.

8.2.2 Dose Calculation Methods and Pathways

8.2.2.1 Maximally Exposed Individual

The MEI is defined as a hypothetical person who resides at the site boundary and has a lifestyle such that no other member of the public could receive a higher dose than the MEI. This person is assumed to reside 24 hours a day, 365 days a year at the BNL site boundary in the downwind direction, and to consume significant amounts of fish and deer containing radioactivity attributable to Laboratory operations based on projections from the New York State Department of Health (NYSDOH). In reality, it is highly unlikely that such a combination of "maximized dose" to any single individual would occur, but the concept is useful for evaluating maximum potential risk and dose to members of the public.

8.2.2.2 Effective Dose Equivalent

The EDE to the MEI for low levels of radioactive materials dispersed into the environment was calculated using the CAP88-PC dose modeling program, Versions 2.1 and 3.0. Site meteorology data were used to calculate annual dispersions for the midpoint of a given wind sector and distance. Facility-specific radionuclide release rates (Ci/yr) were used for continuously monitored facilities. For small sources, the emissions were calculated using the method set forth in 40 CFR 61, Appendix D. The Gaussian dispersion model calculated the EDE at the site boundary and the collective population dose values from immersion, inhalation, and ingestion pathways. These dose and risk calculations to the MEI are based on low emissions and chronic intakes.

8.2.2.3 Dose Calculation: Fish Ingestion

To calculate the EDE from the fish consumption pathway, the intake is estimated. Intake is the average amount of fish consumed by a person engaged in recreational fishing in the Peconic River. Based on a NYSDOH study, the consumption rate is estimated at 15 pounds (7 kg) per year (NYSDOH 1996). For each radionuclide of concern for fish samples, the dry weight activity concentration was converted to picocuries per gram (pCi/g) wet weight, since "wet weight" is the form in which fish are caught and consumed. A dose conversion factor was used for each radionuclide to convert the activity concentration into the EDE. For example, the committed dose equivalent conversion factor for cesium-137 (Cs-137) is 5.0E-02 rem/µCi, as set forth in DOE/EH-0071. The dose was calculated as: *dose* (rem/yr) = *intake* (kg/yr) × *activity in flesh* (µCi/kg) × *dose factor* (rem/µCi).

8.2.2.4 Dose Calculation: Deer Meat Ingestion

The dose calculation for the deer meat ingestion pathway is similar to that for fish consumption. The Cs-137 radionuclide dose conversion factor was used to estimate dose, based on the U.S. Environmental Protection Agency Exposure Factors Handbook (EPA 1996). The total quantity of deer meat ingested during the course of a year was estimated as 64 pounds (29 kg) (NYSDOH 1999).

8.3 SOURCES: DIFFUSE, FUGITIVE, "OTHER"

Diffuse sources are described as releases of radioactive contaminants to the atmosphere that do not have a well-defined emission point such as a stack or vent. Such sources are also known as nonpoint or area sources. Fugitive sources include releases to the air not through an actively ventilated air stream (i.e., leaks from vents are fugitive sources). As a part of the NESHAPs review process, in addition to stack emissions, any fugitive or diffuse emission source that could potentially emit radioactive materials to the environment is evaluated. Although CERCLA-prompted actions, such as remediation projects, are exempt from the procedural requirements to obtain federal, state, or local permits, any BNL activity or process with the potential to emit radioactive material must be evaluated and assessed for dose impact to members of the public. The following radiological sources were evaluated in 2008 for potential contribution to the overall site dose.

8.3.1 Brookhaven Graphite Research Reactor

The Brookhaven Graphite Research Reactor (BGRR) has been identified as an Area of Concern (AOC), and is being decontaminated under the Interagency Agreement and a Record of Decision (ROD) among DOE, EPA, and New York State. In 2008, a preliminary NESHAPs evaluation for the BGRR was performed for the removal of the graphite pile and the bioshield. The graphite pile is housed within the biological shield and acted as the neutron moderator during the operation of the reactor. The graphite pile is a 25-foot cube made from 60,000 graphite blocks of various sizes and shapes. Both the graphite pile and bioshield are contaminated with activation and fission products due to routine "fuel failures." The following radionuclides were identified as major contaminants: H-3, C-14, Co-60, Ni-63, I-129, Cs-137, Sr-90, Eu-152, Eu-154, Am-241, Th-232, Pu-238, Pu-239, and Pu-240.

During the decontamination of the graphite pile and bioshield, approximately 1.4 million pounds of activated graphite blocks and 5,000 tons of activated concrete from the bioshield will be removed, packaged, transported and disposed at an off-site location. The graphite pile removal actions will be performed within a fire-retardant, contamination containment enclosure (CCE) with a remote controlled Brokk manipulator. Multiple engineering barriers, special remote tools, and administrative controls will be used to minimize the generation and spread of dispersible contaminants. The CCE will have a dedicated filtration system with alarms to detect releases above the derived air concentration (DAC) guide limits.

The enclosure will be maintained at a slightly negative pressure with respect to Building 701 by a temporary high-efficiency particulate air (HEPA) ventilation system. Four 6,000-cfm HEPA fan units will be installed outside Building 701 in a weather-tight enclosure that will have common inlet and outlet ducts. The fan units will have two-stage HEPA filters with single-stage pre-filter systems. At any given time, three fan units will be operational, providing 18,000 cfm airflow, and one unit will remain in standby mode.

A preliminary NESHAP evaluation for the graphite pile and bioshield removal process gave an effective dose equivalent of 1.29E-01 mrem/year to the MEI. Since the potential dose exceeds 0.1 mrem, the facility will be continuously monitored for the stated radionuclides in accordance with the ANSI N13.1-1999 standard during the removal of the graphite pile and bioshield.

8.3.2 National Synchrotron Light Source II

The National Synchrotron Light Source II (NSLS-II) is a new research facility being constructed to achieve very high average brightness, intensity, position, energy, and flux of the synchrotron radiation in order to study materials. NSLS-II will enable research on materials with 1 nanometer spatial resolution, 0.1 meV energy resolutions, and with sufficient sensitivity to image the spectrum of a single atom. During the normal operation of the NSLS II, small quantities of the short-lived radioactive gases (C-11, N-13, and O-15) will be produced inside the accelerator enclosure by photon–neutron interactions. The short-lived gases will remain inside the accelerator enclosure with the exception of some fugitive and diffusive losses through apertures and openings at the facility. The diffuse source term calculations were based on the saturation activities of the short-lived gases for 5,000 hours of NSLS II operations in a year. During operations, potential beam loss locations include the Linac beam stop, booster beam stop, booster extractor magnet, and storage ring septum. In order to estimate the source term, it was assumed that the fugitive losses were in a steady state with the environment. The source term was assumed to have an area of 49, 941 m^2 with a height of 4 meters. The total steady state activity of the short-lived gases used in the calculations was C-11 at 21.4 µCi, N-13 at 349.5 µCi, and O-15 at 16.1 µCi. Based on the site-specific input parameters, the EDE from NSLS-II operations was calculated to be 2.95E-08 mrem in a year. Therefore, the dose impact to members of the public from the new NSLS-II facility will be negligible.

8.3.3 Waste Management Facility (Building 865)

The EF-108 fume hood in Building 865 was utilized to empty residual radioactive gases in glassware before their disposition at a licensed facility. A NESHAPs evaluation was completed to assess the risk to the members of public from this release. The source term was based on the process knowledge as Ar-39 at 4.7 µCi, Ar-42 at 0.013 µCi, C-14 at 1.16 µCi and Kr-85 at 0.005 µCi. The effective dose equivalent to the MEI for the release was estimated to be 1.58E-09 mrem/year. Based on the dose risk evaluation, it was concluded that there was no adverse impact to the environment and members of public.

In 2008, it was confirmed that there were no other emissions from the six stacks in Building 865, which are used during the process of repackaging and segregating radioactive waste materials for disposal at a licensed off-site facility. The stacks are sampled every year or during their use to show compliance with NESHAPs regulations.

8.3.4 Center for Functional Nanomaterials

The Center for Functional Nanomaterials provides state-of-the-art capabilities for atomic-level fabrication and study of nanomaterials. Because nanoscience is a recent development, there have been concerns about the emission of nanomaterials to the environment. Therefore, all work involving unbound nanomaterials is handled and processed in HEPA-filtered exhaust hoods, glove boxes, or sealed enclosures. The uncertainties of possible nanomaterial hazards are handled by minimizing the use of unbound nanomaterials, using a precautionary approach, and minimizing the release of nanomaterials into the environment.

8.4 DOSE FROM POINT SOURCES

8.4.1 Brookhaven Linac Isotope Producer

Source term descriptions for point sources are given in Chapter 4. The Brookhaven Linac Isotope Producer (BLIP) facility is the only emission source with any potential to contribute dose to members of the public greater than 1 percent of the EPA limit (i.e., 0.1 mrem, or 1.0 µSv). The BLIP facility uses the excess beam capacity of the Linear Accelerator (Linac) to produce short-lived radioisotopes for medical diagnostic procedures, medical imaging, and scientific research. During the irradiation process, the targets are cooled continuously by recirculating water in a 16-inch-diameter shaft. The principal gaseous radionuclides produced as a result of activation of the cooling water are O-15, C-11, and trace amounts of N-13. Because the BLIP facility has the potential to exceed 1 percent of the EPA emission limit, the facility emissions are directly measured using a low-resolution gamma spectrometer with an in-line sampling system connected to the air exhaust, to measure the short-lived gaseous products that cannot be sampled and analyzed by conventional analytical methods. Particulates and radioiodine are monitored with paper and granular activated charcoal filters, which are exchanged weekly for analysis by a contract analytical laboratory. A tritium sampler also operates continuously, with samples collected weekly.

In 2008, the BLIP facility operated over a period of 23 weeks. During the year, 856 Ci of C-11 and 1,774 Ci of O-15 were released from the facility. A small quantity of tritiated water vapor from activation of the targets' cooling water was also released at 4.57E-02 Ci. The EDE to the MEI was calculated to be 6.12E-02 mrem (0.61 µSv) in a year from BLIP operations. In 2008, anticipating an increase in usage of the facility and therefore a potential for increased emissions, BNL applied to EPA for a NESHAPs permit to increase dose from facility emissions to a maximum of 0.2 mrem. The EPA approved the increase in a letter dated September 25, 2008. EPA requested that the Laboratory continue its efforts to maintain the dose "as low as reasonably achievable."

8.4.2 High Flux Beam Reactor

In 2008, the High Flux Beam Reactor (HFBR) facility was in a "cold" shutdown mode and had been downgraded from a nuclear facility to a radiological facility in 2007. In June 2008, the frequency for tritium monitoring was increased from monthly to weekly when the reactor vessel, primary cooling water system, and fuel canal were filled with domestic water to prepare for removal of the control rod blades. The reactor vessel was periodically opened and, because of that, tritium levels in the building were much higher than observed in recent years. The total tritium emissions for 2008 were measured and calculated to be 20.1 curies, which could contribute to the MEI dose of 1.01E-4 mrem (1 nSv) in a year.

8.4.3 Brookhaven Medical Research Reactor

In 2008, the Brookhaven Medical Research Reactor (BMRR) facility was in a "cold" shutdown mode. There was no dose contribution from the BMRR.

8.4.4 Unplanned Releases

There were no unplanned releases in 2008.

8.5 DOSE FROM INGESTION

Deer and fish bioaccumulate radionuclides in their tissues, bones, and organs; consequently, samples from deer and fish were analyzed to evaluate the dose contribution to humans from the ingestion pathway. As discussed in Chapter 6, deer meat samples collected off site and less than 1 mile from the BNL boundary were used to assess the potential dose impact to the MEI. Four samples of deer meat (flesh) were used to calculate the "off site and less than 1 mile" average concentration of radionuclides in tissue. Potassium-40 (K-40) and Cs-137 were the two radionuclides detected in the tissue samples. K-40 is a naturally occurring radionuclide and is not related to BNL operations. In 2008, the average K-40 concentrations in tissue samples (off site < 1 mile) were 3.3 ± 1.5 pCi/g (wet weight) in the flesh and 2.8 ±1.3 pCi/g (wet weight) in the liver. The maximum Cs-137 concentrations were 8.61 ± 0.57 pCi/g (wet weight) in the flesh and 2.03 ± 0.15 pCi/g (wet weight) in the liver (see Table 6-2). The average Cs-137 concentration was calculated at 1.89 ± 0.64 pCi/g; however, the maximum concentration of 8.61 pCi/g was used for the purpose of MEI dose calculations. The maximum estimated dose to humans from consuming deer meat containing the maximum Cs-137 concentration was estimated to be 12.48 mrem (125 µSv) in a year. The dose was above the health advisory limit of 10 mrem (100 µSv) established by NYSDOH; however, the maximized estimated dose is to a hypothetical individual and would not be actualized, as no deer hunting is permitted on the BNL site.

In collaboration with the New York State Department of Environmental Conservation (NYSDEC) Fisheries Division, BNL maintains an ongoing program of collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. In 2008, chain pickerel samples collected in the Peconic River at the Manor Road site had the highest concentration of Cs-137, at 0.26 ± 0.04 pCi/g; this was used to estimate the EDE to the MEI. The potential dose from consuming 15 pounds of chain pickerel annually was calculated to be 0.09 mrem (0.9 µSv)—well below the NYSDOH health advisory limit of 10 mrem.

8.6 DOSE TO AQUATIC AND TERRESTRIAL BIOTA

DOE-STD-1153-2002, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota, provides the guidelines for screening methods to estimate radiological doses to aquatic animals, terrestrial plants, and terrestrial animals, using site-specific environmental surveillance data. The RESRAD-BIOTA 1.21 biota dose level 2 program was used to evaluate compliance with the requirements for protection of biota specified in DOE Order 5400.5 (1990), Radiation Protection of the Public and the Environment, and DOE Order 450.1, General Environmental Protection Program.

Table 8-5. BNL Site Dose Summary.

Pathway	Dose to Maximally Exposed Hypothetical Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose per year
Inhalation			
Air	0.06 mrem (0.61 µSv)	<1%	0.20 person-rem
Ingestion			
Drinking water	None	None	None
Fish	0.09 mrem (0.9 µSv)	<1%	Not tracked
Deer Meat	12.48 mrem (125 µSv)	<13%	Not tracked
All Pathways	12.63 mrem (125 µSv)	<13%	0.20 person-rem

In 2008, the terrestrial animal and plant doses were evaluated based on 0.22 pCi/g of Cs-137 found in the surface soils on the River Road farm and Sr-90 concentration of 3.87 pCi/L in the surface waters at Donahue Pond. The dose to terrestrial animals was calculated to be 0.01 mGy/day, and to plants, 9.97 E-04 mGy/day. The doses to terrestrial plants and animals were well below the biota dose limit of 1 mGy/day.

To calculate the dose to aquatic and riparian animals, Sr-90 radionuclide concentration values for surface water from Donohue's Pond and the average Cs-137 in the Peconic River sediments were used. The Cs-137 sediment concentration was 0.57 pCi/g, and the Sr-90 concentration in surface water was 3.87 pCi/L. The calculated dose to aquatic animals was 3.03E-06 Gy/day and to riparian animals was 1.95E-05 Gy/day. Therefore, the dose to aquatic and riparian animals was also well below the 10 mGy/day limit specified by the regulations.

8.7 CUMULATIVE DOSE

Table 8-5 summarizes the potential cumulative dose from the BNL site in 2008. The total dose to the MEI from air and ingestion pathways was estimated to be 12.63 mrem (126 µSv). In comparison, the EPA regulatory limit for the air pathway is 10 mrem (100 µSv) and the DOE limit from all pathways is 100 mrem (1,000 µSv). The cumulative population dose would be 0.20 person-rem (2 person-mSv) in a year. The effective dose was well below the DOE and EPA regulatory limits, and the ambient TLD dose was within normal background levels seen at the Laboratory site. The potential dose from drinking water was not estimated, because most of the residents adjacent to the BNL site get their drinking water from the Suffolk County Water Authority rather than private wells.

To put the potential dose impact into perspective, a comparison was made with other sources of radiation. The annual dose from all natural background sources and radon is approximately 300 mrem (3.0E-3 µSv). A diagnostic chest x-ray would result in a 5 to 20 mrem (50–200 µSv) dose per exposure. Using natural gas in homes yields approximately a 9 mrem (90 µSv) dose per year, cosmic radiation yields 26 mrem (260 µSv), and natural potassium in the body yields approximately 39 mrem (390 µSv) of internal dose. Even with worst-case estimates of dose from the air pathway and ingestion of local deer meat and fish, the cumulative dose from BNL operations was equivalent to the dose that could be received from a single chest x-ray.

REFERENCES AND BIBLIOGRAPHY

40 CFR 61, Subpart H. *National Emissions Standard for Hazardous Air Pollutants.* U.S. Environmental Protection Agency, Washington, DC. 1989.

66 FR 25380. May 14, 2001. U.S. Department of Energy. 10 CFR 834, *Radiation Protection of the Public and the Environment.* Federal Register.

ANSI/HPS. 1999. *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities.* N13.1-1999.

DOE. 2002. *A Graded Approach for Evaluation of Radiation Doses to Aquatic and Terrestrial Biota.* DOE-STD-1153-2002. U.S. Department of Energy, Washington, DC. July 2002.

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

DOE Order 450.1. 2003. *General Environmental Protection Program.* U.S. Department of Energy, Washington, DC. Jan.15, 2003.

DOE/EH-0071. *Internal Dose Conversion Factors for Calculations of Dose to the Public.* July 1988.

EPA. 1992. *User's Guide for CAP88-PC, Version 2.1.1.* EPA 402B92001. U.S. Environmental Protection Agency, Washington, DC.

EPA. 1996. *Food Ingestion Factors, Exposure Factors Handbook-Volume II.* EPA600P95002FB. U.S. Environmental Protection Agency, Washington, DC.

LIPA. 2000. *Population Survey 1999: Current Population Estimates for Nassau and Suffolk Counties and the Rockaway Peninsula.* Long Island Power Authority, Uniondale, NY. October 1999.

NCRP. 1987. *Exposure of the Population of the United States and Canada from Natural Background Radiation.* NCRP Report No. 94. National Council on Radiation Protection and Measurements, Bethesda, MD.

NYSDOH. 1993. *Environmental Radiation in New York State*. Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

NYSDOH. 1996. *Radioactive Contamination in the Peconic River.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

NYSDOH. 1999. *Deer Meat Contaminated With Cs-137 at Brookhaven National Laboratory*. Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

Quality Assurance

9

Quality assurance is an integral part of every activity at Brookhaven National Laboratory (BNL). A comprehensive Quality Assurance/Quality Control (QA/QC) Program is in place to ensure that all environmental monitoring samples are representative and that data are reliable and defensible. QC in the contract analytical laboratories is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated as required by project-specific quality objectives before being used to support decision making. The multilayered components of QA monitored at BNL ensure that all analytical data reported for the 2008 Site Environmental Report are reliable and of high quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by DOE Order 450.1A, Environmental Protection Program, BNL has established a QA/QC Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent with the requirements of Title 10 of the Code of Federal Regulations, Part 830 (10 CFR 830), Subpart A, Quality Assurance Requirements (2000) and DOE Order 414.1A, Quality Assurance. The responsibility for quality at BNL starts with the Laboratory director, who approves the policies and standards of performance governing work, and extends throughout the entire organization. The purpose of the BNL Quality Management (QM) System is to implement QM methodology throughout the various Laboratory management systems and associated processes, in order to:

- Plan and perform BNL operations in a reliable and effective manner to minimize any impact on the health and safety of the public, employees, and the environment
- Standardize processes and support continual improvement in all aspects of Laboratory operations
- Enable the delivery of products and services that meet customers' requirements and expectations

For environmental monitoring, QA is deployed as an integrated system of management activities. These activities involve planning, implementation, control, reporting, assessment, and continual improvement. QC activities measure each process or service against the QA standards. QA/QC practices and procedures are documented in manuals, plans, and a comprehensive set of standard operating procedures (SOPs) for environmental monitoring (EM-SOPs). Staff members who must follow these procedures are required to document that they have reviewed and understand them.

The ultimate goal of the environmental monitoring and analysis QA/QC program is to ensure that results are representative and defensible, and that data are of the type and quality needed to verify protection of the public, employees, and the environment. Figure 9-1 depicts the flow of the QA/QC elements of BNL's Environmental Monitoring Program and indicates the sections of this chapter that discuss each element in more detail.

Laboratory environmental personnel determine sampling requirements using the EPA Data Quality Objective (DQO) process (EPA 2000) or its equivalent. During this process, the project manager for each environmental program determines the type, amount, and quality of data needed to support decision making, the legal requirements, and stakeholder concerns. An environmental monitoring plan or project-specific sampling plan is then prepared, specifying the location, frequency, type of sample, analytical

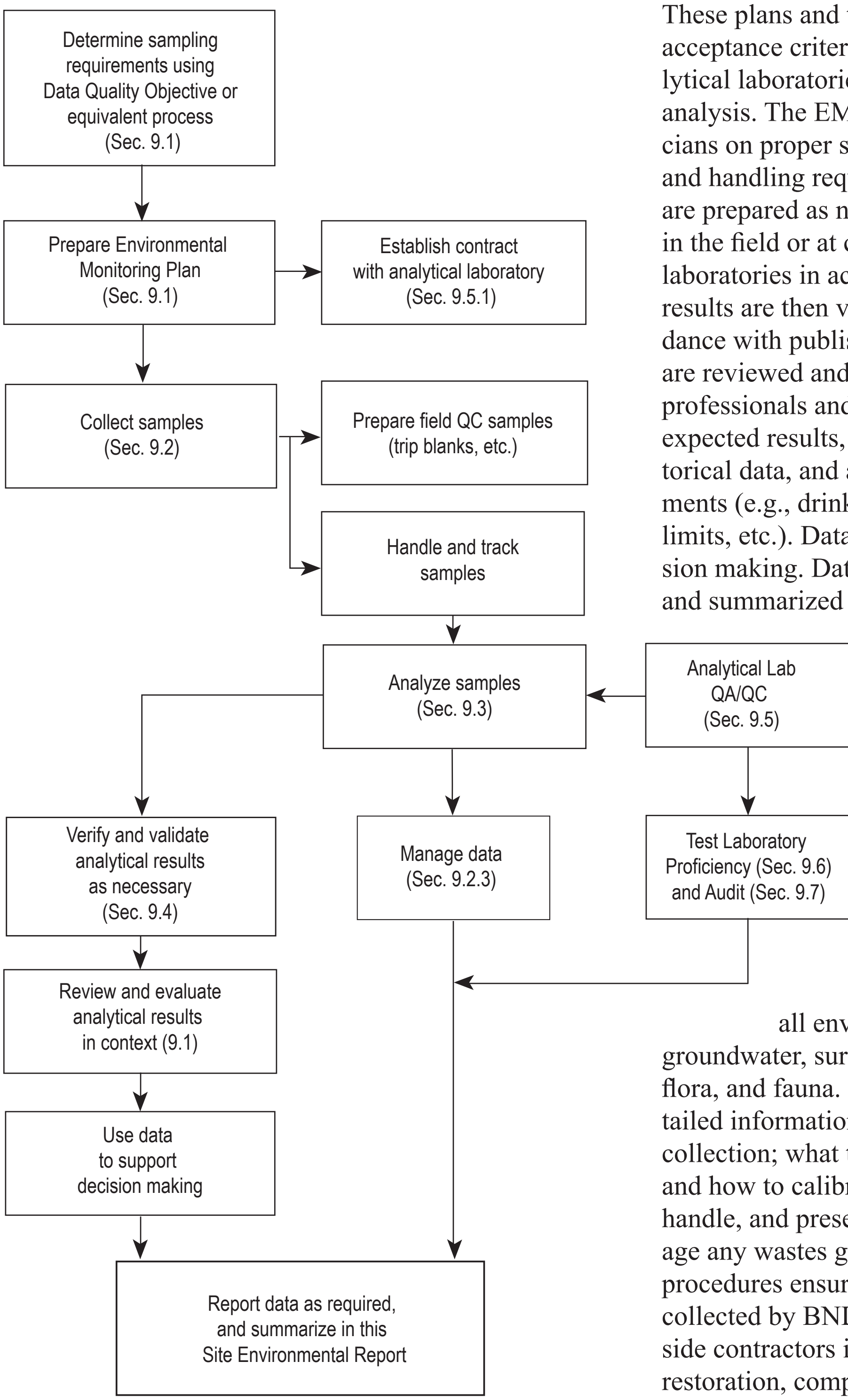


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

methods to be used, and a sampling schedule. These plans and the EM-SOPs also specify data acceptance criteria. Contracts with off-site analytical laboratories are established for sampling analysis. The EM-SOPs direct sampling technicians on proper sample collection, preservation, and handling requirements. Field QC samples are prepared as necessary. Samples are analyzed in the field or at certified contract analytical laboratories in accordance with EM-SOPs. The results are then validated or verified in accordance with published procedures. Finally, data are reviewed and evaluated by environmental professionals and management in the context of expected results, related monitoring results, historical data, and applicable regulatory requirements (e.g., drinking water standards, permit limits, etc.). Data are then used to support decision making. Data are also reported as required and summarized in this annual report.

9.2 SAMPLE COLLECTION AND HANDLING

In 2008, environmental monitoring samples were collected as specified by EM-SOPs, the BNL Environmental Monitoring Plan Update (BNL 2008), and project-specific work plans, as applicable.

BNL has sampling SOPs for all environmental media, including groundwater, surface water, soil, sediment, air, flora, and fauna. These procedures contain detailed information on how to prepare for sample collection; what type of field equipment to use and how to calibrate it; how to properly collect, handle, and preserve samples; and how to manage any wastes generated during sampling. The procedures ensure consistency between samples collected by BNL sampling personnel and outside contractors in support of the environmental restoration, compliance, and surveillance programs.

QC checks of sampling processes include the collection of field duplicates, matrix spike samples, field blanks, trip blanks, and equipment blanks. For example, field readings of water quality parameters are taken until all parameters are within acceptable limits. Also, specific sampling methodologies include QC checks. An example of this is the low-flow groundwater sampling technique, which includes checks to ensure that monitoring wells are properly purged before readings are taken.

All wastes generated during sampling (contaminated equipment, purge water from wells, etc.) are managed in accordance with applicable requirements. A factor considered during sample collection is minimizing the amount of waste generated, consistent with the Pollution Prevention Program described in Chapter 2.

9.2.1 Field Sample Handling

To ensure the integrity of samples, chain-of-custody (COC) was maintained and documented for all samples collected in 2008. A sample is considered to be in the custody of a person if any of the following rules of custody are met: 1) the person has physical possession of the sample, 2) the sample remains in view of the person after being in possession, 3) the sample is placed in a secure location by the custody holder, or 4) the sample is in a designated secure area. These procedures are outlined in EM-SOP 109, "Chain-of-Custody, Storage, Packaging, and Shipment of Samples" (BNL 2008). All environmental monitoring samples in 2008 maintained a valid COC from the time of sample collection through sample disposal by the contract analytical laboratories.

9.2.1.1 Custody and Documentation

Field sampling technicians are responsible for the care and custody of samples until they are transferred to a receiving group or contract analytical laboratory. Samples requiring refrigeration are placed immediately into a refrigerator or a cooler with cooling media, and kept under custody rules. The technician signs the COC form when relinquishing custody, and contract analytical laboratory personnel sign the COC form when accepting custody.

As required by EM-SOP-201, "Documentation of Field Activities" (BNL 2007a), the field sampling technician is also required to maintain a bound, weatherproof field logbook, which is used to record sample ID number, collection time, description, collection method, and COC number. Daily weather conditions, field measurements, and other appropriate site-specific observations also are recorded in the logbook.

9.2.1.2 Preservation and Shipment

Before sample collection, the field sampling technicians prepare all bottle labels and affix them to the appropriate containers, as defined in the QA program plan or applicable EM-SOPs. Appropriate preservatives are added to the containers before or immediately after collection; in appropriate cases, samples are refrigerated. For example, samples collected for methyl mercury are cooled immediately and shipped to the contract analytical laboratory on the day of collection. After samples arrive at the laboratory, they are preserved with hydrochloric acid.

Sample preservation is maintained as required throughout shipping. If samples are sent via commercial carrier, a bill-of-lading is used. COC seals are placed on the shipping containers; their intact status upon receipt indicates that custody was maintained during shipment. These procedures are outlined in EM-SOP 109.

9.2.2 Field Quality Control Samples

Field QC samples collected for the environmental monitoring program include equipment blanks, trip blanks, field blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples. The rationale for selecting specific field QC samples, and minimum requirements for their use in the environmental monitoring program, are provided in the BNL EM-SOP 200 series. Equipment blanks and trip blanks (see below) were collected for all appropriate media in 2008.

An ***equipment blank*** is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool after decontamination. The rinse water is collected and tested to verify that the sampling tool is not contaminated. Equipment blank samples are collected, as needed, to verify the effectiveness of the decontamination procedures on nondedicated or reusable sampling equipment.

A ***trip blank*** is provided with each shipping container of samples to be analyzed for volatile organic compounds (VOCs). The use of trip blanks provides a way to determine whether contamination of a sample occurred during shipment from the manufacturer, while in bottle storage, in shipment to a contract analytical laboratory, or during analysis at a lab. Trip blanks consist of an aliquot of laboratory-grade water sealed in a sample bottle, usually prepared by the contract analytical laboratory prior to shipping the sample bottles to BNL. If trip blanks were not provided by the lab, then field sampling technicians prepare trip blanks before they collect the samples. Trip blanks were included with all shipments of aqueous samples for VOC analysis in 2008.

Field blanks are collected to check for cross-contamination that may occur during sample collection. For the Groundwater Monitoring Program, one field blank is collected for every 20 samples, or one per sampling round, whichever is more frequent. Field blanks are analyzed for the same parameters as groundwater samples. For other programs, the frequency of field blank collection is based on their specific DQOs.

In 2008 (as in other years), the most common contaminants detected in the trip, field, and equipment blanks included methylene chloride, methyl chloride, toluene, and chloroform. These compounds are commonly detected in blanks and do not pose significant problems with the reliability of the analytical results. Several other compounds were also detected, such as acetone and strontium-90 (Sr-90), at low levels. When these contaminants are detected, validation or verification procedures are used, where applicable, to qualify the associated data as "nondetects," (see Section 9.4). The results from blank samples collected during 2008 did not indicate any significant impact on the quality of the results.

Field duplicate samples are analyzed to check the reproducibility of sampling and analytical results, based on EPA Region II guidelines (EPA 2006). For example, in the Groundwater Monitoring Program, duplicates are collected for 5 percent of the total number of samples collected for a project per sampling round. During 2008, 42 duplicate samples were collected for nonradiological analyses, and 66 duplicate samples were collected for radiological analyses. All duplicate samples were acceptable for input into BNL's Environmental Information Management System (EIMS) database, which is used to manage the Laboratory's environmental data. Duplicates were analyzed only for the parameters relevant to the program they monitored. Of the 4,160 nonradiological parameters analyzed in 2008, 99 percent of the analyses met QA criteria. Of the 288 radiological parameters monitored, 99 percent met QA criteria.

Matrix spike and ***matrix spike duplicates*** are performed to determine whether the sample matrix (e.g., water, soil, air, vegetation, bone, or oil) adversely affected the sample analysis. A *spike* is a known amount of analyte added to a sample. Matrix spikes are performed at a rate specified by each environmental program's DQOs. The rate is typically one per 20 samples collected per project. No significant matrix effects were observed in 2008 for routine matrices such as water and soil. Nonroutine matrices, such as oil, exhibited the expected matrix issues.

9.2.3 Tracking and Data Management

Most environmental monitoring samples and analytical results were tracked in the EIMS. The small number of environmental samples that were not tracked in the EIMS were from Chemtex Lab, which cannot produce the electronic data deliverables needed to enter the data into BNL's EIMS. Tracking was initiated when a sample was recorded on a COC form. Copies of the COC form and supplemental forms were provided to the project manager or the sample coordinator and forwarded to the data coordinator to be entered into the EIMS. Each contract analytical laboratory also maintained its own internal sample tracking system.

Following sample analysis, the contract analytical laboratory provides the results to the project manager or designee and, when applicable, to the validation subcontractor, in accordance with their contract. Once results of the analyses are entered into the EIMS, reports can be generated by project personnel and DOE Brookhaven Site Office staff using a web-based data query tool.

9.3 SAMPLE ANALYSIS

In 2008, environmental samples were analyzed by one of five contract laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to EPA-approved methods, where such methods exist, and by standard industry methods where there are no EPA methods. In addition, field sampling technicians performed field monitoring for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity.

9.3.1 Qualifications

BNL used the following contract analytical laboratories for analysis of environmental samples in 2008:

- General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes
- H2M Lab in Melville, New York, for nonradiological analytes
- Test America (TA), formerly Severn-Trent Lab, based in St. Louis, Missouri, for radiological and nonradiological analytes
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes
- Brooks Rand in Seattle, Washington, for mercury and methylmercury analyses

The process of selecting off-site contract analytical laboratories involves a number of factors: 1) their record on performance evaluation (PE) tests, 2) their contract with the DOE Integrated Contract Procurement Team, 3) pre-selection bidding, and 4) their adherence to their own QA/QC programs, which must be documented and provided to BNL. Routine QC procedures that laboratories must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. All the laboratories contracted by BNL in 2008 were certified by the New York State Department of Health (NYSDOH) for the relevant analytes, where such certification existed. The laboratories also were subject to PE testing and DOE-sponsored audits (see Section 9.7).

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject to data verification and, in certain cases, data validation, when the data quality objectives of the project require this step. For example, groundwater samples collected for the Long Term Remedial Action (LTRA) group undergo data verification, whereas specific data collected for specific waste streams undergo full validation.

The data ***verification*** process involves checking for common errors associated with analytical data. The following criteria can cause data to be rejected during the data verification process:

- *Holding time missed* – The analysis is not initiated or the sample is not extracted within the time frame required by EPA or by the contract.
- *Incorrect test method* – The analysis is not performed according to a method required by the contract.
- *Poor recovery* – The compounds or radioisotopes added to the sample before laboratory processing are not recovered at the recovery ratio required by the contract.
- *Insufficient QA/QC data* – Supporting data received from the contract analytical laboratory are insufficient to allow validation of results.
- *Incorrect minimum detection limit (MDL)* – The contract analytical laboratory reports extremely low levels of analytes as "less than minimum detectable," but the contractually required limit is not used.
- *Invalid chain-of-custody* – There is a failure to maintain proper custody of samples, as documented on COC forms.
- *Instrument failure* – The instrument does not perform correctly.
- *Preservation requirements not met* – The requirements identified by the specific analytical method are not met or properly documented.
- *Contamination of samples from outside sources* – These possible sources include sampling equipment, personnel, and the contract analytical laboratory.

- *Matrix interference* – Analysis is affected by dissolved inorganic/organic materials in the matrix.

Data ***validation*** involves a more extensive process than data verification. Validation includes all the verification checks, as well as checks for less common errors, including instrument calibration that was not conducted as required, internal analyte standard errors, transcription errors, and calculation errors. The amount of data checked varies, depending on the environmental media and on the DQOs for each project. Data for some projects, such as long-term groundwater monitoring, may require only verification. Data from some waste streams receive the more rigorous validation testing, performed on 20 to 100 percent of the analytical results. The results of the verification or validation process are entered into the EIMS.

9.4.1 Checking Results

Nonradiological data analyzed in 2008 were verified and/or validated, when project DQOs required, using BNL EM-SOPs in the 200 Series and EPA contract laboratory program guidelines (EPA 1992, 2006). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 2002, DOE 1994). During 2008, the verifications were conducted using a combination of manually checking the hard copy data packages and the use of a computer program developed at BNL to verify that the information reported electronically is stored in the EIMS.

9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2008, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology. QC checks performed included: analyzing blanks and instrument background; using Amersham Radiopharmaceutical Company or National Institute for Standards and Technology (NIST) traceable standards; and analyzing reference standards, spiked samples, and duplicate samples. Analytical laboratory contracts specify analytes, methods, required detection limits, and deliverables—which include standard batch QA/QC performance checks. As part of the laboratory selection process, candidate laboratories are required to provide BNL with copies of their QA/QC manuals and QA program plans.

When discrepancies were found in field sampling designs, documented procedures, COC forms, data analyses, data processing systems, and QA software, or when failures in PE testing occurred, nonconformance reports were generated. Following investigation into the root causes, corrective actions were taken and tracked to closure.

9.6 PERFORMANCE OR PROFICIENCY EVALUATIONS

Four of the contract analytical laboratories (GEL, TA, H2M, and Brooks Rand) participated in several national and state PE testing programs in 2008. The fifth contractor, Chemtex Laboratory, did not participate in PE testing because there is no testing program for the specific analytes Chemtex analyzed: tolytriazole, polypropylene glycol monobutyl ether, and 1,1-hydroxyethylidene diphosphonic acid. Each of the participating laboratories took part in at least one testing program, and several laboratories participated in multiple programs. Results of the tests provide information on the quality of a laboratory's analytical capabilities. The testing was conducted by Environmental Resource Associates (ERA), the National Voluntary Laboratory Accreditation Program (NVLAP), the voluntary Mixed Analyte Performance Evaluation Program (MAPEP), and NYSDOH Environmental Laboratory Accreditation Program (ELAP). The results from these tests are summarized in Section 9.6.1. Because Brooks Rand only analyzed samples for mercury and methylmercury, their PE results are not summarized. Brooks Rand maintained the required certification when performing analyses for BNL in 2008.

9.6.1 Summary of Test Results

In Figures 9-2 and 9-3, results are plotted as percentage scores that were "Acceptable," "Warning (But Acceptable)," or "Not Acceptable." A Warning (But Acceptable) is considered by the testing organization to be "satisfactory." An "average overall satisfactory" score is the sum of results rated as Acceptable and those rated as Warning (But Acceptable), divided by the total number of results reported. A Not Acceptable rating reflects a result that is greater than three standard deviations from the known value—a criterion set by the independent testing organizations.

Figure 9-2 summarizes radiological performance scores in the ERA and MAPEP programs. As in 2007, during 2008 the New York State ELAP did not provide radiological samples for PE testing, so there were no ELAP scores. GEL and TA had average overall satisfactory scores of 85 and 95 percent, respectively. More details about the radiological assessments are in Section 9.6.1.1.

Figure 9-3 summarizes the nonradiological performance results of the three participating laboratories (GEL, H2M, and TA) in the ERA, MAPEP, and ELAP tests. For nonradiological tests, the average overall satisfactory results ranged from 92 to 100 percent. Additional details on nonradiological evaluations are in Section 9.6.1.2.

9.6.1.1 Radiological Assessments

Both GEL and TA participated in the ERA radiological PE studies. Of GEL's tests on radiological samples, 72.5 percent were in the Acceptable range and 94.1 percent were Acceptable**.**

GEL and TA also participated in the MAPEP evaluations: 90.6 percent of GEL's tests on radiological samples were in the Acceptable range and 6.6 percent were in the Warning (But Acceptable) range. Of TA's MAPEP tests on radiological samples, 92.3 percent were in the Acceptable range and 3.8 percent were in the Warning (But Acceptable) range.

9.6.1.2 Nonradiological Assessments

In 2008, H2M and GEL participated in the NYSDOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 97.9 percent of H2M's nonradiological tests to be in the Acceptable range and 90.1 percent of GEL's nonradiological tests to be in the Acceptable range. TA, which is certified through the National Environmental Laboratory Accreditation Conference (NELAC), was not required to participate in ELAP evaluations.

H2M, TA, and GEL voluntarily participated in the ERA water supply and water pollution studies, although this evaluation is not required for New York State certification. ERA found that 100 percent of H2M's tests were in the Acceptable range and 98.5 percent of TA's tests were in the Acceptable range, as were 94.4 percent of GEL's tests**.**

TA and GEL also voluntarily participated in MAPEP nonradiological evaluations, which showed that 96.5 percent of TA's tests were in the Acceptable range and 95.94 percent of GEL's were in the Acceptable range.

9.7 AUDITS

As part of DOE's Integrated Contract Procurement Team Program, TA and GEL were audited during 2008 (DOE 2008a, b). During the audits, errors are categorized into Priority I and Priority II findings. Priority I status indicates a problem that can result in unusable data or a finding that the contract analytical laboratory cannot adequately perform services for DOE. Priority II status indicates problems that do not result in unusable data and do not indicate that the contract analytical laboratory cannot adequately perform services for DOE (DOE 2002). There were no Priority I findings for GEL. TA had one Priority I finding and one Priority II finding.

The results of the TA audit included one Priority I finding from their inorganic division and one Priority II finding, also from their inorganic division. The Priority I finding originated from a failure to obtain acceptable PE test results for antimony in a soil matrix. After the audit findings were issued, TA adjusted their soil preparation methods and received passing scores on the next two PE samples for antimony in a soil matrix. DOE accepted these results and closed this finding on August 28, 2008 (DOE 2008c). The Priority II finding dealt with inorganic lab practices that did not exactly meet internal SOPs. TA updated their SOPs, and this finding was also closed on August 28, 2008.

The results of the GEL audit included two Priority II findings. The first Priority II finding

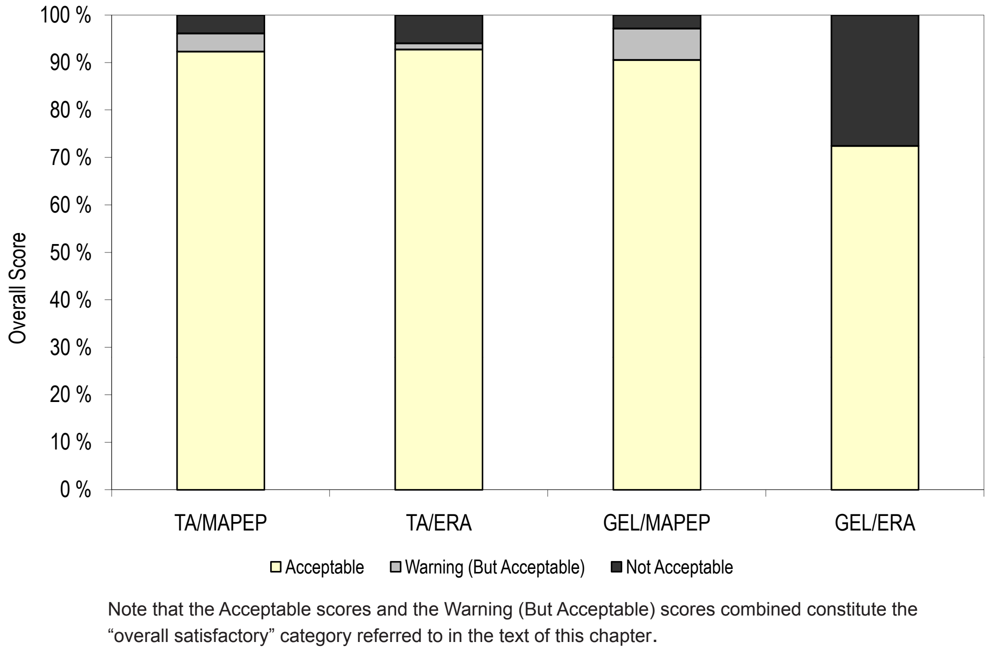


Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs.

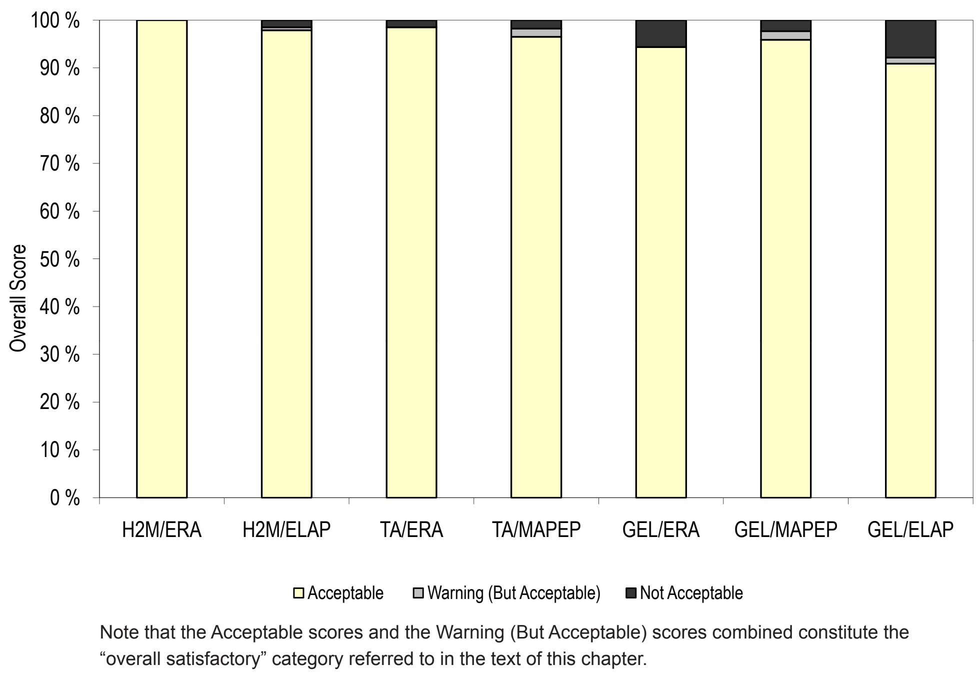


Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.

stated that the GEL SOP for semivolatile analysis did not contain sufficient information on method blanks. The lab's corrective action for this finding was to update the SOP. The second Priority II finding indicated a failure to pass the PE sample for selenium in a soil matrix. The manufacturers of the PE sample were contacted, and due to the difficulty of analysis of this analyte, it was determined that this finding would be a Priority II, rather than a Priority I finding. Since this PE result, GEL has changed analysis techniques for selenium in soil and has obtained acceptable results on PE samples. DOE has accepted these corrective actions and both these findings were closed on August 6, 2008 (DOE, 2008d).

Based on the audits, the analytical data met DOE's criteria for Acceptable status.

9.8 CONCLUSION

Based on the data validations, data verifications, and results of the independent Performance Evaluation assessments, the chemical and radiological results reported in this 2008 Site Environmental Report are of acceptable quality.

REFERENCES AND BIBLIOGRAPHY

10 CFR 830 Subpart A. U.S. Department of Energy. *Quality Assurance Requirements.* U.S. Code of Federal Regulations. 2000.

BNL. 2006. EM-SOP 209. "Radiochemical Data Validation." Brookhaven National Laboratory, Upton, NY.

BNL 2007a. EM-SOP-201 "Documentation of Field Activities." Brookhaven National Laboratory, Upton, NY.

BNL. 2008. *Brookhaven National Laboratory Environmental Monitoring Plan Update January 2008.* BNL-52676-2006. Brookhaven National Laboratory, Upton, NY.

BNL. 2008. EM-SOP 109. "Chain-of-Custody, Storage, Packaging, and Shipment of Samples." Brookhaven National Laboratory. Upton, NY.

DOE. 1994. *RD-4 Guidance for Radiochemical Data Validation.* Draft. Report EM-73. U.S. Department of Energy, Washington, DC.

DOE. 2008a. *Continuing Qualification Audit of Severn Trent Laboratories, Inc.* Earth City, Mo. June 16, 2008.

DOE. 2008b. *Continuing Qualification Audit of General Engineering Laboratories, Inc.* Charleston, South Carolina. June 25, 2008.

DOE 2008c. Corrective Action Plan Acceptance for Audit ID: 080424-TAS, August 28, 2008.

DOE 2008d. Corrective Action Plan Acceptance for Audit ID: 080508-GEL, August 6, 2008.

DOE. Order 450.1A. 2008. *Environmental Protection Program.* U.S. Department of Energy. Washington, DC. 1-15-03.

DOE. Order 414.1A. 2001. *Quality Assurance.* U.S. Department of Energy. Washington, DC. November 24, 1998.

DOE. 2002. *Environmental Management Consolidated Audit Program EMCAP Procedure Number 1.0 Revision 2.* October 1, 2002.

EPA. 1992. *Evaluation of Metals Data for the Contract Laboratory Program.* EPA Region-II SOP HW-2. U.S. Environmental Protection Agency, Washington, DC.

EPA. 1998. *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations.* Report QA/R-5. U.S. Environmental Protection Agency, Washington, DC.

EPA. 2000. "Guidance for the Data Quality Objectives Process (QA/G-4)." U.S. Environmental Protection Agency, Washington, DC.

EPA. 2006. *CLP Organic Data Review and Preliminary Review.* EPA Region-II SOP HW-6. U.S. Environmental Protection Agency, Washington, DC. Revision 14, September 2006.

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Acronyms and Abbreviations

These acronyms and abbreviations reflect the typical manner in which terms are used for this specific document and may not apply to all situations. Items with an asterisk (*) are described in the glossary of technical terms, which follows this list.

AEC	Atomic Energy Commission
AGS	Alternating Gradient Synchrotron
ALARA*	"As Low As Reasonably Achievable"
AMSL	above mean sea level
AOC*	area of concern
APG	Analytical Products Group
ARARs	Applicable, Relevant, and Appropriate Requirements
ARPA*	Archeological Resource Protection Act
AS/SVE*	air sparging/soil vapor extraction
AST	aboveground storage tank
AWQS	Ambient Water Quality Standards
BAF	Booster Applications Facility
BGD	belowground duct
BGRR	Brookhaven Graphite Research Reactor
BHSO	DOE Brookhaven Site Office
BLIP	Brookhaven Linac Isotope Producer
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
BOD*	biochemical oxygen demand
Bq*	becquerel
Bq/g	becquerel per gram
Bq/L	becquerel per liter
BRAHMS	Broad Range Hadron Magnetic Spectrometer
BSA	Brookhaven Science Associates
Btu	British thermal units
CAA*	Clean Air Act
CAAA*	CAA Amendments (1990)
CAC	Community Advisory Council
CAP	Clean Air Act Assessment Package
CBS	chemical bulk storage
CCR	Consumer Confidence Report
CEGPA	Community, Education, Government and Public Affairs
CERCLA*	Comprehensive Environmental Response, Compensation and Liability Act
CFC-11	an ozone-depleting refrigerant
cfm, cfs	cubic feet per minute, per second
CFN	Center for Functional Nanomaterials
CFR	U.S. Code of Federal Regulations
Ci*	curie
CO	certificate to operate
COC*	chain-of-custody
CRM	Cultural Resource Management
CRMP	Cultural Resource Management Plan
Cs	cesium
CSF	Central Steam Facility
CTN	Center for Transitional Neuroimaging
CWA*	Clean Water Act
CY	calendar year
D_2O*	heavy water
DAC	Derived Air Concentration
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG*	derived concentration guide
D&D	decontamination and decommissioning
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DMR	Discharge Monitoring Report
DOE*	U.S. Department of Energy
DOE CH	DOE Chicago Operations Office
DQO	Data Quality Objective
DSA	Documented Safety Analysis
DSB	Duct Service Building
DUV – FEL	Deep UltraViolet – Free Electron Laser
DWS	Drinking Water Standards
EA*	Environmental Assessment
EDB*	ethylene dibromide
EDE*	Effective Dose Equivalent
EDTA	ethylenediaminetetraacetic acid
EE/CA	Engineering Evaluation/Cost Analysis
EIMS*	Environmental Information Management System
ELAP	Environmental Laboratory Approval Program
EML	Environmental Measurements Laboratory
EMP	Environmental Monitoring Plan
EMS*	Environmental Management System
EPA*	U.S. Environmental Protection Agency
EPCRA*	Emergency Planning and Community Right-to-Know Act
EPD	Environmental Protection Division
ERP	Environmental Restoration Projects
ERA	Environmental Resource Associates
ERD	Environmental Restoration Division
ES*	environmental surveillance
ESR	Experimental Safety Review

ES&H	Environment, Safety, and Health
ESA*	Endangered Species Act
ESH&Q	Environment, Safety, Health, and Quality Directorate
ESPC	Energy Savings Performance Contract
ESSH	Environmental Safety, Security and Health
FAMS	Facility area monitors
FERN	Foundation for Ecological Research in the Northeast
FFCA*	Federal Facilities Compliance Act
FFA	Federal Facilities Agreement
FIFRA*	Federal Insecticide, Fungicide, and Rodenticide Act
FM	Facility Monitoring
FRP	Facility Response Plan
FWS*	U.S. Fish & Wildlife Service
FY	fiscal year
GBq	giga (billion or E+09) becquerel
GAB	gross alpha and beta
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GDS	Groundwater Discharge Standard
GEL	General Engineering Laboratory, LLC
GeV	giga (billion) electron volts
gge	gas gallon equivalent
GIS	Geographical Information System
GWh	gigawatt hour
H2M	H2M Labs, Inc.
HEPA	high efficiency particulate air
HFBR	High Flux Beam Reactor
HITL	Heavy Ion Transfer Line
HSS	Health, Safety and Security
HTO	tritiated water (liquid or vapor)
HVAC	heating/ventilation/air conditioning
HWMF	Hazardous Waste Management Facility
I	Iodine
IAEA	International Atomic Energy Agency
IAG	Interagency Agreement
IC	ion chromatography
ICP/MS	inductively coupled plasma/mass spectrometry
ISMS	Integrated Safety Management System
ISO*	International Organization for Standardization
K	potassium
kBq	kilobecquerels (1,000 Bq)
KeV	kilo (thousand) electron volts
Kr	kryptonite
kwH	kilowatt hours
LDR	Land Disposal Restriction
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
LIE	Long Island Expressway
LIMS	Laboratory Information Management System
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LSTPD	Laboratory Science Teacher Professional Development
LTRA	Long Term Remedial Action
MACT	Maximum Available Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
MAR	Materials-at-risk
MCL	maximum contaminant level
MDL*	minimum detection limit
MEI*	maximally exposed individual
MeV	million electron volts
MGD	million gallons per day
mg/L	milligrams per liter
MMBtu	million British thermal units
MOA	Memorandum of Agreement
MPF	Major Petroleum Facility
MPN	most probable number
mrem	milli (thousandth of a) rem
MRI	Magnetic Resonance Imaging
MRC	Medical Research Center
MSL*	mean sea level
mSv	millisievert
MTBE	methyl tertiary butyl ether
MW	megawatt
µg/L	micrograms per liter
NA	not analyzed
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NEAR	Neighbors Expecting Accountability and Remediation
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NEPA*	National Environmental Policy Act
NESHAPs*	National Emission Standards for Hazardous Air Pollutants
ng/J	nano (one-billionth) gram per Joule
NHPA*	National Historic Preservation Act
NIST	National Institute for Standards and Technology
NO_2	nitrogen dioxide
NOV	Notice of Violation
NO_x*	nitrogen oxides
NOEC	no observable effect concentration
NPDES	National Pollutant Discharge Elimination System
NR	not required
NRMP	Natural Resource Management Plan
NS	not sampled
NSF-ISR	NSF-International Strategic Registrations, Ltd.
NSLS	National Synchrotron Light Source

NSRC	Nanoscale Science Research Centers
NSRL	NASA Space Radiation Laboratory
NT	not tested
NTS	Nevada Test Site
NYCRR*	New York Codes, Rules, and Regulations
NYISO	New York Independent System Operator
NYPA	New York Power Authority
NYS	New York State
NYSDEC	NYS Department of Environmental Conservation
NYSDOH	NYS Department of Health
NYSHPO	NYS Historic Preservation Office
O_3*	ozone
O&M	Operation and Maintenance
ODS	ozone-depleting substances
OHSAS	Occupational Health and Safety Assessment Series
OMC	Occupational Medical Clinic
ORC	oxygen-releasing compound
ORPS*	Occurrence Reporting and Processing System
OSHA	Occupational Health and Safety Administration
OSSP	Open Space Stewardship Program
OU*	operable unit
P2*	pollution prevention
PAAA*	Price-Anderson Act Amendment
PAF	Process Assessment Form
Pb	lead
PBT	persistent, bioaccumulative, and toxic
PCBs*	polychlorinated biphenyls
PCE	tetrachloroethylene (or perchloroethylene)
pCi/g	picocuries per gram
PE	performance evaluation
PET	positron emission tomography
ppb	parts per billion
ppm	parts per million
PRAP	Proposed Remedial Action Plan
QA*	quality assurance
QAPP	Quality Assurance Program Plan
QC*	quality control
QM	Quality Management
R-11 (etc.)	ozone-depleting refrigerant
RA*	removal action
RACT	Reasonably Available Control Technology
RATA	Relatiivistic accuracy test
RCRA*	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RF	resuspension factor
RHIC	Relativistic Heavy Ion Collider
ROD*	Record of Decision
RPD	relative percent difference
RSB	Research Support Building
RFT	Radiation Therapy Facility
RWMB	Radioactive Waste Management Basis
RWP	Radiological Work Permit
SARA*	Superfund Amendments and Reauthorization Act
SBMS*	Standards Based Management System
SCDHS	Suffolk County Department of Health Services
SCR	Special Case Resource
SCSC	Suffolk County Sanitary Code
SDL	Source Development Laboratory
SDWA*	Safe Drinking Water Act
SER	Site Environmental Report
SI	International System (measurement units)
SNS	standard not specified
SO_2	sulfur dioxide
SOP	standard operating procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES*	State Pollutant Discharge Elimination System
Sr	strontium
STAR	Solenoid Tracker at RHIC
STEM	Scanning Transmission Electron Microscope
STL	Severn Trent Laboratories, Inc.
STP	Sewage Treatment Plant
SU	standard unit
SUNY	State University of New York
Sv*	sievert; unit for assessing radiation dose risk
SVE*	soil vapor extraction
SVOC*	semivolatile organic compound
$t_{1/2}$*	half-life
TAG	Technical Advisory Group
TBq	tera (trillion, or E+12) becquerel
TCA	1,1,1-trichloroethane
TCAP	Transportation Safety and Operations Compliance Assurance Process
TCE*	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TEAM	Transformational Energy Action Management
TKN	Total Kjeldahl nitrogen
TLD*	thermoluminescent dosimeter
TPL	Target Processing Laboratory
TRE	Toxic Reduction Evaluation
TRI	Toxic Release Inventory
TSCA*	Toxic Substances Control Act
TVDG	Tandem Van de Graaff
TVOC*	total volatile organic compounds
UIC*	underground injection control
UST*	underground storage tank
VOC*	volatile organic compound
VUV*	very ultraviolet
WAC	waste acceptance criteria
WBS	Work Breakdown Structure

WCPP	Waste Certification Program Plan
WCF	Waste Concentration Facility
WET	Whole Effluent Toxicity
WLA	Waste Loading Area
WM	Waste Management
WMF	Waste Management Facility
WTP	Water Treatment Plant

Technical Terms

These definitions reflect the typical manner in which the terms are used for this specific document and may not apply to all situations. Bold-face words in the descriptions are defined in separate entries.

A

AA (atomic absorption) – A spectroscopy method used to determine the elemental composition of a sample. In this method, the sample is vaporized and the amount of light it absorbs is measured.

accuracy – The degree of agreement of a measurement with an accepted reference or true value. It can be 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 high energy particles.

activation product – A material that has become radioactive by bombardment with neutrons, protons, or other high energy particles.

activity – Synonym for radioactivity.

Administrative Record – A collection of documents established in compliance with **CERCLA**. Consists of information the CERCLA lead agency uses in its decision on the selection of response actions. The Administrative Record file should be established at or near the facility and made available to the public. An Administrative Record can also be the record for any enforcement case.

aerobic – An aerobic organism is one that lives, acts, or occurs only in the presence of oxygen.

aerosol – A gaseous suspension of very small particles of liquid or solid.

ALARA (As Low As Reasonably Achievable) – A phrase that describes an approach to minimize exposures to individuals and minimize releases of radioactive or other harmful material to the **environment** to levels as low as social, technical, economic, practical, and public policy considerations will permit. ALARA is not a dose limit, but a process with a goal to keep dose levels as far below applicable limits as is practicable.

alpha radiation – The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of only an inch or so. Despite its low penetration ability, alpha radiation is densely ionizing and therefore very damaging when ingested or inhaled. Naturally occurring radioactive sources such as radon emit alpha radiation.

air stripping – A process for removing **VOCs** from contaminated water by forcing a stream of air through the water in a vessel. The contaminants evaporate into the air stream. The air may be further treated before it is released into the atmosphere.

ambient air – The surrounding atmosphere, usually the outside air, as it exists around people, animals, plants, and structures. It does not include the air immediately adjacent to emission sources.

analyte – A constituent that is being analyzed.

anneal – To heat a material and then cool it. In the case of thermoluminescent dosimeters (TLDs), this is done to reveal the amount of radiation the material had absorbed.

anion – A negatively charged ion, often written as a superscript negative sign after an element symbol, such as Cl^-.

anthropogenic – Resulting from human activity; anthropogenic radiation is human-made, not naturally occurring.

AOC (area of concern) – Under **CERCLA**, this term refers to an area where releases of hazardous substances may have occurred or a location where there has been a release or threat of a release of a hazardous substance, pollutant, or contaminant (including **radionuclide**s). 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, scrap yards, cesspools, tanks, and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

aquifer – A water-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.

ARPA (Archaeological Resources Protection Act) This law, passed in 1979, has been amended four times. It protects any material remains of past human life or activities that are of archaeological interest. Known *and potential* sites of interest are protected from uncontrolled excavations and pillage, and artifacts found on public and Indian lands are banned from commercial exchange.

AS/SVE (air sparging/soil vapor extraction) – A method of extracting **volatile organic compounds** from the **groundwater**, in place, using compressed air. (In contrast, air stripping occurs in a vessel.) The vapors are typically collected using a soil vapor extraction system.

B

background – A sample or location used as reference or control to compare BNL analytical results to those in areas that could not have been impacted by BNL operations.

background radiation – **Radiation** present in the environment as a result of naturally occurring radioactive materials in the Earth, cosmic radiation, or human-made radiation sources, including fallout.

beta radiation – Beta radiation is composed of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is more penetrating than alpha radiation, but it may be stopped by materials such as aluminum or Lucite™ panels. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

blank – A sample (usually reagent-grade water) used for quality control of field sampling methods, to demonstrate that cross contamination has not occurred.

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).

BOD (biochemical oxygen demand) – 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.

Bq (becquerel) – A quantitative measure of **radioactivity**. This alternate measure of activity is used internationally and with increasing frequency in the United States. One Bq of activity is equal to one nuclear decay per second.

bremsstrahlung – Translates as "fast braking" and refers to electromagnetic radiation produced by the sudden retardation of a charged particle in an intense electric field.

C

CAA (Clean Air Act), CAA Amendments (CAAA) – The original Clean Air Act was passed in 1963, but the U.S. air pollution control program is based on the 1970 version of the law. The 1990 Clean Air Act Amendments (CAAA) are the most far-reaching revisions of the 1970 law. In common usage, references to the CAA typically mean to the 1990 amendments. (*source*: EPA's "Plain English Guide to the Clean Air Act" glossary, accessed 3-7-05)

caisson – A watertight container used in construction work under water or as a foundation.

cap – A layer of natural or synthetic material, such as clay or gunite, used to prevent rainwater from penetrating and spreading contamination. 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).

carbon tetrachloride – A poisonous, nonflammable, colorless liquid, CCl_4.

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) – Pronounced "sir-klah" and commonly known as Superfund, this law was enacted by Congress on December 11, 1980. It created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified

The law authorizes two kinds of response actions: short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response, and long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on **EPA**'s National Priorities List (NPL). CERCLA was amended by the Superfund Amendments and Reauthorization Act (**SARA**) on October 17, 1986, accessed 03-7-05)

CFR (Code of Federal Regulations) – A codification of all regulations developed and finalized by federal agencies in the Federal Register. The CFR is arranged by "title," with Title 10 covering energy- and radiation-related issues, and Title 40 covering protection of the environment. Subparts within the titles are included in citations, as in "40 CFR Subpart H."

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.

Ci (**curie**) – A quantitative measure of radioactivity. One Ci of activity is equal to 3.7E+10 decays per second. One curie has the approximate activity of 1 gram of radium. It is named after Marie and Pierre Curie, who discovered radium in 1898.

Class GA groundwater – New York State Department of Environmental Conservation classification for high quality groundwater, where the best intended use is as a source of drinking water supply.

closure – Under **RCRA** regulations, this term refers to a hazardous or solid waste management unit that is no longer operating and where potential hazards that it posed have been addressed (through clean up, immobilization, capping, etc.) to the satisfaction of the regulatory agency.

COC (chain-of-custody) – 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.

cocktail – a mixture of chemicals used for **scintillation** counting.

collective Effective Dose Equivalent – A measure of health risk to a population exposed to radiation. It is the sum of the **EDEs** of all individuals within an exposed population, frequently considered to be within 50 miles (80 kilometers) of an environmental release point. It is expressed in person-**rem** or person-**sievert**.

Committed Effective Dose Equivalent – The total **EDE** received over a 50-year period following the internal deposition of a **radionuclide**. It is expressed in **rems** or **sieverts**.

composite sample – A sample of an environmental medium containing a certain number of sample portions collected over a period of time, possibly from different locations. The constituent samples may or may not be collected at equal time intervals over a predefined period of time, such as 24 hours.

confidence interval – A numerical range within which the true value of a measurement or calculated value lies. In the SER, radiological values are shown with a 95 percent confidence interval: there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range. *See also* "Uncertainty" discussion in Appendix B.

conservative – Estimates that err on the side of caution because all possibly deleterious components are included at generous or high values.

contamination – Unwanted radioactive and/or hazardous material that is dispersed on or in equipment, structures, objects, air, soil, or water.

control – *See* **background**.

cooling water – Water used to cool machinery and equipment. *Contact* cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal; *noncontact* cooling water has no direct contact with any process material or final product. *Process wastewater* cooling water is water used for cooling that may have become contaminated through contact with process raw materials or final products.

cover boards – Sheets of plywood placed on the ground near ponds to serve as attractive habitat for salamanders, as part of a population study.

curie – *See* **Ci**.

CWA (Clean Water Act) – Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. It established the basic structure for regulating discharges of pollutants into the waters of the United States, giving **EPA** the authority to implement pollution control programs such as setting wastewater standards for industry. The CWA also continued requirements to set water quality standards for all contaminants in surface waters and made it unlawful for any person to discharge any pollutant from a **point source** into navigable waters unless a permit was obtained. The CWA also funded the construction of sewage treatment plants and recognized the need for planning to address the critical problems posed by **nonpoint source pollution**.

Revisions in 1981 streamlined the municipal construction grants process. Changes in 1987 phased out the construction grants program. Title I of the Great Lakes Critical Programs Act of 1990 put into place parts of the Great Lakes Water Quality Agreement of 1978, signed by the U.S. and Canada; the two nations agreed to reduce certain toxic pollutants in the Great Lakes. Over the years many other laws have changed parts of the CWA**,** accessed 03-7-05)

D

D_2O – *See* **heavy water**.

daughter, progeny – A given **nuclide** produced by radioactive decay from another nuclide (the "parent"). *See also* **radioactive series**.

DCG (derived concentration guide) – 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, absorption, or ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The values were established in **DOE Order 5400.5**.

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.

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.

disposal – Final placement or destruction of waste.

DOE (Department of Energy) – The federal agency that promotes scientific and technical innovation to support the national, economic, and energy security of the United States. DOE has responsibility for 10 national laboratories and for the science and research conducted at these laboratories, including Brookhaven National Laboratory.

DOE Order 231.1A – This order, Environment, Safety, and Health Reporting, is dated 8/19/03. It replaces the 1995 version, Order 231.1, as well as the "ORPS" order, DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information, dated 7/21/97, and Order 210.1, Performance Indicator…, dated 9/27/95.

DOE Order 450.1 – This order, Environmental Protection Program, is dated 1/15/03. It replaces DOE Order 5400.1, General Environmental Protection Program, dated 11/9/88.

DOE Order 5400.5 – This order, Radiation Protection of the Public and the Environment, was first published by **DOE** in 1990 and was modified in 1993. It established the standards and requirements for operations of DOE and DOE contractors with respect to protecting the public and the **environment** against undue risk from radiation.

dose – *See* **EDE**.

dosimeter – A portable detection device for measuring exposure to ionizing radiation. See Chapter 8 for details.

downgradient – In the direction of **groundwater** flow from a designated area; analogous to "downstream."

DQO (Data Quality Objective) –The Data Quality Objective (DQO) process was developed by **EPA** for facilities to use when describing their environmental monitoring matrices, sampling methods, locations, frequencies, and measured parameters, as well as methods and procedures for data collection, analysis, maintenance, reporting, and archiving. The DQO process also addresses data that monitor quality assurance and quality control.

drift fence – A stretch of temporary fencing to prevent an animal population from leaving the area, used at BNL as part of a population study.

dry weight – The dry weight concentration of a substance is after a sample is dried for analysis. Dry weight concentrations are typically higher than wet weight values.

D-waste – Liquid waste containing radioactivity.

E

EA (Environmental Assessment) – A report that identifies potentially significant effects from any federally approved or funded project that might change the physical **environment**. If an EA identifies a "significant" potential impact (as defined by **NEPA**), an Environmental Impact Statement (EIS) must be researched and prepared.

EDB (ethylene dibromide) – A colorless, nonflammable, heavy liquid with a sweet odor; slightly soluble in water. Although the U.S. Department of Health and Human Services has determined that ethylene dibromide may reasonably be anticipated to be a carcinogen, 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.

EDE (Effective Dose Equivalent) – A value used to express the health risk from radiation exposure to tissue in terms of an equivalent whole body exposure. It is a "normalized" value that 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. The EDE equals the sum of the doses to different organs of the body multiplied by their respective **weighting factors**. It includes the sum of the EDE due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of **radionuclide**s. EDE is expressed in **rems** or **sieverts**.

effluent – Any liquid discharged to the environment, including stormwater **runoff** at a site or facility.

EIMS (Environmental Information Management System) – A database system used to store, manage, verify, protect, retrieve, and archive BNL's environmental data.

EM (environmental monitoring) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

emissions – Any gaseous or particulate matter discharged to the atmosphere.

EMS (Environmental Management System) – The BNL EMS meets the requirements of the **ISO 14001 EMS standard**, with emphasis on compliance assurance, pollution prevention, and community outreach. An extensive environmental monitoring program is one component of BNL's EMS.

environment – Surroundings (including air, water, land, natural resources, flora, fauna, and humans) in which an organization operates, and the interrelation of the organization and its surroundings.

environmental aspect – Elements of an organization's activities, products, or services that can interact with the surrounding air, water, land, natural resources, flora, fauna, and humans.

environmental impact – Any change to the surrounding air, water, land, natural resources, flora, and fauna, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services.

environmental media – Includes air, **groundwater**, surface water, soil, flora, and fauna.

environmental monitoring or **surveillance** – *See* **EM**.

EPA (U. S. Environmental Protection Agency) – The federal agency responsible for developing and enforcing environmental laws. Although state or local regulatory agencies may be authorized to administer environmental regulatory programs, EPA generally retains oversight authority.

EPCRA (Emergency Planning and Community Right-to-Know Act) – Also known as Title III of SARA, EPCRA was enacted by Congress as the national legislation on community safety, to help local groups protect public health, safety, and the environment from chemical hazards. To implement EPCRA, Congress required each state to appoint a State Emergency Response Commission (SERC). The SERCs were required to divide their states into Emergency Planning Districts and to name a Local Emergency Planning Committee for each district

Broad representation by fire fighters, health officials, government and media representatives, community groups, industrial facilities, and emergency managers ensures that all necessary elements of the planning process are represented.

ES (environmental surveillance) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

ESA (Endangered Species Act) – This provides a program for conserving threatened and endangered plants and animals and their habitats. The **FWS** maintains the list of 632 *endangered* species (326 are plants) and 190 *threatened* species (78 are plants). Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Anyone can petition FWS to include a species on this list. The law prohibits any action, administrative or real, that results in a "taking" of a listed species *or* adversely affects habitat. Likewise, import, export, interstate, and foreign commerce of listed species are all prohibited. **EPA**'s decision to register pesticides is based in part on the risk of adverse effects on endangered species as well as environmental fate (how a pesticide will affect habitat). Under **FIFRA**, EPA can issue emergency suspensions of certain pesticides to cancel or restrict their use if an endangered species will be adversely affected.

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 aboveground tissue.

exposure – A measure of the amount of ionization produced by **x-rays** or **gamma rays** as they travel through air. The unit of radiation exposure is the roentgen (**R**).

F

fallout – Radioactive material, made airborne as a result of aboveground nuclear weapons testing, that has been deposited on the Earth's surface.

FFCA (Federal Facility Compliance Act) – Formerly, the federal government maintained that it was not subject to fines and penalties under solid and hazardous waste law because of the doctrine of "sovereign immunity." The State of Ohio challenged this in *Ohio v. the Department of Energy (1990)*. The U.S. Circuit Court of Appeals found in favor of the State (June 11, 1990), writing that the federal government's sovereign immunity is waived under both the **CWA** sovereign immunity provision and **RCRA**'s citizen suit provision. The Circuit Court decision was overturned by the Supreme Court on April 21, 1992, in *DOE v. Ohio,* which held that the waiver of sovereign immunity in RCRA and CWA is not clear enough to allow states to impose civil penalties directly. After the high court's ruling, the consensus among lawmakers was that a double standard existed: the same government that developed laws to protect human health and the environment and required compliance in the private sector, was itself not assuming the burden of compliance. As a result, Congress enacted the FFCA (October 6, 1992, Pub. Law 102-386), which effectively overturned the Supreme Court's ruling. In the legislation Congress specifically waived sovereign immunity with respect to RCRA for federal facilities.

Under section 102, FFCA amends section 6001 of RCRA to specify that federal facilities are subject to "all civil and administrative penalties and fines, regardless of whether such penalties or fines are punitive or coercive in nature." These penalties and fines can be levied by **EPA** or by authorized states. In addition, FFCA states that "the United States hereby expressly waives any immunity otherwise applicable to the United States." Although federal agents, employees, and officers are not liable for civil penalties, they are subject to criminal sanctions. No departments, agencies, or instrumentalities are subject to criminal sanctions. Section 104 (1) and (2) require EPA to conduct annual RCRA inspections of all federal facilities.

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) – The primary focus of this law was to provide federal control of pesticide distribution, sale, and use. **EPA** was given authority under FIFRA not only to study the consequences of pesticide usage but also to require users (farmers, utility companies, and others) to register when purchasing pesticides. Through later amendments to the law, users also must take exams for certification as applicators of pesticides. All pesticides used in the U.S. must be registered (licensed) by EPA. Registration assures that pesticides will be properly labeled and that if used in accordance with specifications, will not cause unreasonable harm to the environment.

FS (feasibility study) – A process for developing and evaluating remedial actions using data gathered during the remedial investigation. The FS defines the objectives of the remedial program for the site and broadly develops remedial action alternatives, performs an initial screening of these alternatives, and performs a detailed analysis of a limited number of alternatives that remain after the initial screening stage.

FWS (U.S. Fish & Wildlife Service) – The U.S. Fish and Wildlife Service is the principal federal agency responsible for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats for the continuing benefit of the people of the United States. FWS manages the 95-million-acre National Wildlife Refuge System, which encompasses 544 national wildlife refuges, thousands of small wetlands, and other special management areas. It also operates 69 national fish hatcheries, 64 fishery resources offices, and 81 ecological services field stations. The agency enforces federal wildlife laws, administers the Endangered Species Act, manages migratory bird populations, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, and helps foreign and Native American tribal governments with their conservation efforts. It also oversees the Federal Assistance Program, which distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies.

fugitive source – Unanticipated sources of volatile hazardous air pollutants due to leaks from valves, pumps, compressors, relief valves, connectors, flanges, and various other pieces of equipment.

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.

gamma spectroscopy – This analysis technique identifies specific **radionuclide**s. 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."

geotextile – A product used as a soil reinforcement agent and as a filter medium. It is made of synthetic fibers manufactured in a woven or loose manner to form a blanket-like product.

grab sample – A single sample collected at one time and place.

Green Building – Construction that adheres to guidelines established by the Green Building Council, a coalition of leaders from across the building industry working to promote structures that are environmentally responsible, profitable, and healthy places to live and work.

groundwater – Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.

gunite – A mixture of cement, sand, and water sprayed over a mold to form a solid, impermeable surface. Formerly a trademarked name, now in general usage.

H

half-life ($t_{1/2}$) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

halon – An ozone-depleting fire suppressant; suffixes (-1301, etc.) indicate variants.

hazardous waste – Toxic, corrosive, reactive, or ignitable materials that can injure human health or damage the environment. It can be liquid, solid, or sludge, and include heavy metals, organic solvents, reactive compounds, and corrosive materials. It is defined and regulated by **RCRA**, Subtitle C.

heat input – The heat derived from combustion of fuel in a steam generating unit. It does not include the heat from preheated combustion air, recirculated flue gases, or the exhaust from other sources.

heavy water (D_2O) – A form of water containing deuterium, a nonradioactive isotope of hydrogen.

herpetofaunal – Relating to the study of reptiles.

hot cell – Shielded and air-controlled facility for the remote handling of radioactive material.

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

I

inert – Lacking chemical or biological action.

influent – Liquid (such as stormwater runoff or wastewater) flowing into a reservoir, basin, or treatment plant.

intermittent river – A stream that dries up on occasion, usually as a result of seasonal factors or decreased contribution from a source such as a wastewater treatment plant.

ionizing radiation – Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage. *See also* **alpha, beta, gamma radiation; x-rays**.

ISO 14001 EMS standard – The International Organization for Standardization (ISO) sets standards for a wide range of products and management operations. Following the success of the ISO 9000 Standards for quality management, ISO introduced the 14000 series for environmental management. BNL was the first DOE Office of Science laboratory to obtain third-party registration to this globally recognized environmental standard.

isotope – Two or more forms of a chemical element having the same number of protons in the nucleus (the same atomic number), but having different numbers of neutrons in the nucleus (different atomic weights). Isotopes of a single element possess almost identical chemical properties.

L

leaching – The process by which soluble chemical components are dissolved and carried through soil by water or some other percolating liquid.

light water – As used in this document, tap water, possibly filtered.

liquid scintillation counter – An analytical instrument used to quantify tritium, carbon-14, and other beta-emitting **radionuclide**s. *See also* **scintillation**.

M

matrix, matrices – The natural context (e.g., air, vegetation, soil, water) from which an environmental sample is collected.

MDL (minimum detection limit) – 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 that have a reduced statistical confidence associated with them (less than 95 percent confidence).

MEI (maximally exposed individual) – The hypothetical 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.

metamorphic – In the state of changing from larval to mature forms.

mixed waste – Waste that contains both a hazardous waste component (regulated under Subtitle C of **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.

MSL (mean sea level) – The average height of the sea for all stages of the tide. Used as a benchmark for establishing **groundwater** and other elevations.

N

NEPA (National Environmental Policy Act) – Assures that all branches of government give proper consideration to the environment before any land purchase or any construction projects, including airports, buildings, military complexes, and highways. Project planners must assess the likely impacts of the project by completing an Environmental Assessment (EA) and, if necessary, an Environmental Impact Statement (EIS).

NESHAPs (National Emissions Standards for Hazardous Air Pollutants) – Standards that limit emissions from specific sources of air pollutants linked to serious health hazards. NESHAPs are developed by **EPA** under the CAA. Hazardous air pollutants can be chemical or radioactive. Their sources may be human-made, such as vehicles, power plants, and industrial or research processes, or natural, such as radioactive gas in soils.

neutrino – A small, neutral particle created as a result of particle decay. Neutrinos were believed to be massless, but recent studies have indicated that they have small, but finite, mass. Neutrinos interact very weakly.

NHPA (National Historic Preservation Act) – With passage of the National Historic Preservation Act in 1966, Congress made the federal government a full partner and a leader in historic preservation. The role of the federal government is fulfilled through the National Park Service. State participation is through State Historic Preservation Offices. “Before 1966, historic preservation was mainly understood in one-dimensional terms: the proverbial historic shrine or Indian burial mound secured by lock and key—usually in a national park—set aside from modern life as an icon for study and appreciation. NHPA largely changed that approach, signaling a much broader sweep that has led to the breadth and scope of the vastly more complex historic preservation mosaic we know today.”

nonpoint source pollution – Nonpoint source pollution occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into **groundwater**. Nonpoint source pollution also includes adverse changes to the hydrology of water bodies and their associated aquatic habitats. After Congress passed the Clean Water Act in 1972, the nation’s water quality community emphasized **point source** pollution (coming from a discrete conveyance or location, such as industrial and municipal waste discharge pipes). Point sources were the primary contributors to the degradation of water quality then, and the significance of nonpoint source pollution was poorly understood. Today, nonpoint source pollution remains the largest source of water quality problems. It is the main reason that approximately 40 percent of surveyed rivers, lakes, and estuaries are not clean enough to meet basic uses such as fishing or swimming.

NO_X – Nitrogen oxides are gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced, for example, by the combustion of fossil fuels in vehicles and electric power plants. In the atmosphere, NO_X can contribute to the formation of smog, impair visibility, and have health consequences. NO_X are considered “criteria air pollutants” under the CAA.

nuclide – A species of atom characterized by the number of protons and neutrons in the nucleus.

NYCRR (New York Codes, Rules, and Regulations) The NYCRR primarily contains state agency rules and regulations adopted under the State Administrative Procedure Act. There are 22 Titles: one for each state department, one for miscellaneous agencies and one for the Judiciary. Title 6 addresses environmental conservation, so many references in the SER are to “6 NYCRR.”

O

O_3 – *See* ozone.

on site – 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 (**CAA**), a measurement of the degree to which smoke (emissions other than water vapor) reduces the transmission of light and obscures the view of an object in the background.

ORPS (Occurrence Reporting and Processing System) A system for identifying, categorizing, notifying, investigating, analyzing, and reporting to DOE events or conditions discovered at the BNL site. It was originally established by DOE Order 232.1, which has been replaced by **DOE Order 231.1A.**

OU (operable unit) – 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 actions that are concurrent, but located in different parts of a site. An OU can receive specific investigation and a particular remedy may be proposed. A Record of Decision (**ROD**) is prepared for each OU.

outfall – The place where wastewater is discharged.

oxides of nitrogen (NO_x) – *See* **NO_x**.

ozone (O_3) – A very reactive type of oxygen formed naturally in the upper atmosphere which provides a shield for the earth from the sun's ultraviolet rays. At ground level or in the lower atmosphere, it is pollution that forms when oxides of nitrogen and hydrocarbons react with oxygen in the presence of strong sunlight. Ozone at ground level can lead to health effects and cause damage to trees and crops.

P

P2 (pollution prevention) – Preventing or reducing the generation of pollutants, contaminants, hazardous substances, or wastes at the source, or reducing the amount for treatment, storage, and disposal through recycling. Pollution prevention can be achieved through reduction of waste at the source, segregation, recycle/reuse, and the 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.

PAAA (Price-Anderson Act Amendments) – The Price-Anderson Act (PAA) was passed in 1957 to provide for prompt compensation in the case of a nuclear accident. The PAA provided broad financial coverage for damage, injury, and costs, and required DOE to indemnify contractors. The amended act of 1988 (PAAA) extended indemnification for 15 years and required DOE to establish and enforce nuclear safety rules. The PAAA Reauthorization, passed in December of 2002, extended current indemnification levels through 2004. 10 CFR 820 and its Appendix A provide DOE enforcement procedure and policy.

Parshall flume – An engineered channel used to measure the flow rate of water. It was named after the inventor, who worked for the U.S. government as an irrigation research engineer.

PCBs (polychlorinated biphenyls) – A family of organic compounds used from 1926 to 1979 (when they were banned by **EPA**) in electrical transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into different and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process.

percent recovery – For analytical results, the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

permit – An authorization issued by a federal, state, or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including **CAA**, **CWA**, **RCRA**, and **TSCA**. Permits grant permission to operate, to discharge, to construct, and so on. Permit provisions may include emission/effluent limits and other requirements such as the use of pollution control devices, monitoring, record keeping and reporting. Also called a "license" or "certificate" under some regulatory programs.

pH – A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, neutral solutions have a pH of 7, and basic solutions have a pH greater than 7 and up to 14.

plume – A body of contaminated **groundwater** or polluted air flowing from a specific source. The movement of a groundwater plume 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. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

point source – Any confined and discrete conveyance (e.g., pipe, ditch, well, or stack) of a discharge.

pollutant – Any hazardous or radioactive material naturally occurring or added to an environmental medium, such as air, soil, water, or vegetation.

potable water – Water of sufficient quality for use as drinking water without endangering the health of people, plants, or animals.

precision – A statistical term describing the dispersion of data 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 6 **NYCRR** Part 360.

Q

QA (quality assurance) – In environmental monitoring, any action to ensure the reliability of monitoring and measurement data. Aspects of QA include procedures, inter-laboratory comparison studies, evaluations, and documentation.

QC (quality control) – In environmental monitoring, the routine application of procedures 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.

qualifier – A letter or series of letter codes in a graph or chart indicating that the associated value did not meet analytical requirements or was estimated.

quenching – Anything that interferes with the conversion of decay energy to electronic signal in the photomultiplier tubes of detection equipment, usually resulting in a reduction in counting efficiency.

R

R (roentgen) – A unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. It is named after the German scientist Wilhelm Roentgen, who discovered x-rays.

RA (removal actions, "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, **EPA** may respond to releases or threats of releases of hazardous substances by starting an RA to stabilize or clean up an incident or site that immediately threatens public health or welfare. Removal actions are less comprehensive than *remedial* actions. However, removal actions must contribute to the efficiency of future remedial actions.

radiation – Some atoms possess excess energy, causing them to be physically unstable. Such atoms become stable when the excess energy is released in the form of charged particles or electromagnetic waves, known as radiation.

radiation event – A single detection of a charged particle or electromagnetic wave.

radioactive series – A succession of **nuclide**s, 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 waves from the atom. Also known as "activity."

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.

RCRA (Resource Conservation and Recovery Act) Pronounced "rick-rah," this act of Congress gave **EPA** the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of nonhazardous wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (*see* CERCLA). In 1984, amendments to RCRA called the Hazardous and Solid Waste Amendments (HSWA, pronounced "hiss-wa") required phasing out the land disposal of hazardous waste. Some other mandates of this strict law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank (UST) program.

recharge – The process by which water is added to a zone of saturation (aquifer) from surface infiltration, typically when 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.

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.

rem – Stands for "**roentgen** equivalent man," a unit by which human radiation dose is assessed (*see also* **Sv**). The rem is a risk-based value used to estimate the potential health effects to an exposed individual or population. 100 rem = 1 sievert.

remedial (or **remediation) alternatives** – Options considered under **CERCLA** for decontaminating a site such as an operable unit (**OU**) or area of concern (**AOC**). Remedial actions are long-term activities that prevent the possible release, or stop or substantially reduce the actual release, of substances that are hazardous but not immediately life-threatening. *See also* feasibility study (**FS**) and Record of Decision (**ROD**).

residual fuel – Crude oil, Nos. 1 and 2 fuel oil that have a nitrogen content greater than 0.05 weight percent, and all fuel oil Nos. 4, 5, and 6, as defined by the American Society of Testing and Materials in ASTM D396-78, *Standard Specifications for Fuel Oils,* (c. 2001).

riparian – An organism living on the bank of a river, lake, or tidewater.

ROD (Record of Decision) – A document that records a regulatory agency's decision for the selected remedial action. The ROD also includes a 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.

roentgen – *See* R.

RPD (relative percent difference) – A measure of precision, expressed by the formula: RPD = [(A-B)/(A+B)] x 200, where A equals the concentration of the first analysis and B equals the concentration of the second analysis.

runoff – The movement of water over land. Runoff 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.

SARA (Superfund Amendments and Reauthorization Act) – This Act of Congress in 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Title III of SARA also authorized EPCRA.

SBMS (Standards-Based Management System) – A document management tool used to develop and integrate systems, and to demonstrate BNL's conformance to requirements to perform work safely and efficiently.

scintillation – Flashes of light produced in a phosphor by a radioactive material.

SDWA (Safe Drinking Water Act) – The Safe Drinking Water Act was established to protect the quality of drinking water in the United States. It focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources. The SDWA authorized **EPA** to establish safe standards of purity and required all owners or operators of public water systems to comply with health-related standards. State governments assume regulatory power from EPA.

sediment – The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers.

sensitivity – The minimum amount of an analyte that can be repeatedly detected by an instrument.

sievert – *See* **Sv**.

skyshine – Radiation emitted upward from an open-topped, shielded enclosure and reflected downward, resulting in the possibility that flora and fauna (including humans) outside the shielded enclosure can be exposed to radiation.

sludge – Semisolid residue from industrial or water treatment processes.

sole source aquifer – An area defined by **EPA** as being the primary source of drinking water for a particular region. Includes the surface area above the sole source aquifer and its recharge area.

SPDES (State Pollutant Discharge Elimination System) This permit program is delegated to the states, but the effluent limitations and other requirements are set by the federal government. 6 NYCRR Section 750-1.11(a) concerns the provisions of SPDES permits and lists the citations for the various effluent limitations from the Federal Register and the **CFR**.

stable – Nonradioactive.

stakeholder – People or organizations with vested interests in BNL and its environment and operations. Stakeholders include federal, state, and local regulators; the public; DOE; and BNL staff.

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.

Sv (sievert) – A unit for assessing the risk of human radiation dose, used internationally and with increasing frequency in the United States. One sievert is equal to 100 rem.

SVE (soil vapor extraction) – An *in situ* (in-place) method of extracting **VOCs** from soil by applying a vacuum to the soil and collecting the air, which can be further treated to remove the VOCs, or discharged to the atmosphere.

SVOC – A general term for volatile organic compounds that vaporize relatively slowly at standard temperature and pressure. See also VOC.

synoptic – Relating to or displaying conditions as they occur over a broad area.

T

$t_{1/2}$ (half-life) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

TCE (trichloroethylene, also known as **trichloroethene)** 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 when inhaled or ingested, or through skin contact, and can damage vital organs, especially the liver. S*ee also* **VOC**.

Tier III reports – Reports, required by **SARA**, that are prepared to document annual emissions of toxic materials to the environment. These are also known as TRI Section 313 reports.

TLD (thermoluminescent dosimeter) – A device used to measure radiation dose to occupational workers or radiation levels in the environment.

tritium – The heaviest and only radioactive nuclide of hydrogen, with a **half-life** of 12.3 years and a very-low-energy radioactive decay (tritium is a **beta** emitter).

TSCA (Toxic Substances Control Act) – Enacted by Congress in1976, TSCA empowers **EPA** to track the 75,000 industrial chemicals produced or imported into the United States. EPA repeatedly screens these chemicals and can require reporting or testing of any that may pose an environmental or human health hazard. EPA can ban the manufacture or import of chemicals that pose an unreasonable risk.

TVOC (total volatile organic compounds) – A sum of all individual **VOC** concentrations detected in a given sample.

U

UIC (underground injection control) – A hole with vertical dimensions greater than its largest horizontal dimensions; used for disposal of wastewater.

UST (underground storage tank) – A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10 percent or more of the volume of the tank system is below the surface of the ground.

upgradient/upslope – A location of higher **groundwater** elevation; analogous to "upstream."

V

vadose – Relating to water in the ground that is above the permanent groundwater level.

vernal pool – A small, isolated, and contained basin that holds water on a temporary basis, most commonly during winter and spring. It has no aboveground outlet for water and is extremely important to the life cycle of many amphibians (such as the tiger salamander), as it is too shallow to support fish, a major predator of amphibian larvae.

VOC (volatile organic compound) –A general term for organic compounds capable of a high degree of vaporization at standard temperature and pressure. Because VOCs readily evaporate into the air, the potential for human exposure is greatly increased. Due to widespread industrial use, VOCs are commonly found in soil and groundwater.

VUV – Stands for "very ultraviolet" and refers to a beamline at the NSLS with wavelengths at the far ultraviolet end of the spectrum.

W

waste minimization – Action that avoids or reduces the generation of waste, consistent with the general goal of minimizing current and future threats to human health, safety, and the environment. Waste minimization activities include recycling, improving energy usage, reducing waste at the source, and reducing the toxicity of hazardous waste. This action is associated with pollution prevention, but is more likely to occur after waste has been generated.

water table – The water-level surface below the ground where the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer will 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. *See also* **EDE**.

wet weight – The wet weight concentration of a substance is before a sample is dried for analysis (in other words, in its "natural" state), and is the form most likely to be consumed. Wet weight concentrations are typically lower than dry weight values.

wind rose – A diagram that shows the frequency of wind from different directions at a specific location.

X

x-rays – A form of electromagnetic **radiation** with short wavelength, generated when high-energy electrons strike matter or when lower-energy **beta** radiation is absorbed in matter. **Gamma** radiation and x-rays are identical, except for the source.

Z

zeolite – A naturally occurring group of more than 100 minerals, formed of silicates and aluminum, with unique and diverse crystal properties. Zeolites can perform ion exchange, filtering, odor removal, and chemical sieve and gas absorption tasks. Synthetic zeolites are now used for most applications.

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Understanding Radiation

This section introduces the general reader to some basic concepts of radioactivity and an understanding of the radiation emitted as radioactive materials decay to a stable state. To better comprehend the radiological information in the Site Environmental Report (SER), it is important to remember that not all radiations are the same and that different kinds of radiation affect living beings differently.

This appendix includes discussions on the common sources of radioactivity in the environment, types of radiation, the analyses used to quantify radioactive material, and how radiation sources contribute to radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides that are of environmental interest at BNL. The discussion begins with some definitions and background information on scientific notation and numerical prefixes used when measuring dose and radioactivity. The definitions of commonly used radiological terms are found in the Technical Topics section of the glossary, Appendix A, and are indicated in boldface type here only when the definition in the glossary provides additional details.

RADIOACTIVITY AND RADIATION

All substances are composed of atoms that are made of subatomic particles: protons, neutrons, and electrons. The protons and neutrons are tightly bound together in the positively charged nucleus (plural: nuclei) at the center of the atom. The nucleus is surrounded by a cloud of negatively charged electrons. Most nuclei are stable because the forces holding the protons and neutrons together are strong enough to overcome the electrical energy that tries to push them apart. When the number of neutrons in the nucleus exceeds a threshold, then the nucleus becomes unstable and will spontaneously "decay," or emit excess energy ("nuclear" energy) in the form of charged particles or electromagnetic waves. Radiation is the excess energy released by unstable atoms. Radioactivity and radioactive refer to the unstable nuclear property of a substance (e.g., radioactive uranium). When a charged particle or electromagnetic wave is detected by radiation-sensing equipment, this is referred to as a radiation event.

Radiation that has enough energy to remove electrons from atoms within material (a process called ionization) is classified as ionizing radiation. Radiation that does not have enough energy to remove electrons is called nonionizing radiation. Examples of nonionizing radiation include most visible light, infrared light, microwaves, and radio waves. All radiation, whether ionizing or not, may pose health risks. In the SER, radiation refers to ionizing radiation.

Radioactive elements (or radionuclides) are referred to by name followed by a number, such as cesium-137. The number indicates the mass of that element and the total number of neutrons and protons contained in the nucleus of the atom. Another way to specify cesium-137 is Cs-137, where Cs is the chemical symbol for cesium in the Periodic Table of the Elements. This type of abbreviation is used throughout the SER.

SCIENTIFIC NOTATION

Most numbers used for measurement and quantification in the SER are either very large or very small, and many zeroes would be required to express their value. To avoid this, scientific notation is used, with numbers represented in multiples of 10. For example, the number two million five hundred thousand (two and a half million, or 2,500,000) is written in scientific notation as 2.5×10^6, which represents "2.5 multiplied by 10 raised to the power of 6." Since even "2.5×10^6" can be cumbersome, the capital letter E is substituted for the phrase "10 raised to the power of …" Using this format, 2,500,000 is represented as 2.5E+06. The "+06" refers to the number of places the decimal point was moved to the left to create the shorter version. Scientific notation is also used to represent numbers smaller than zero, in which case a

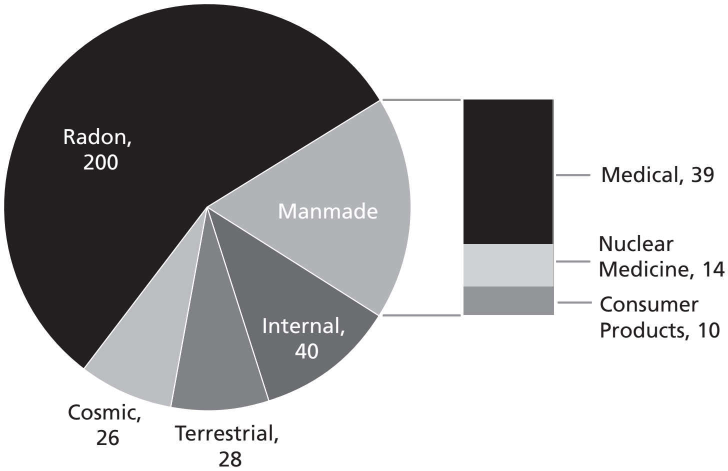

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 93 (NCRP 1987)*

minus sign follows the E rather than a plus. For example, 0.00025 can be written as 2.5 x 10^{-4} or 2.5E-04. Here, "-04" indicates the number of places the decimal point was moved to the right.

NUMERICAL PREFIXES

Another method of representing very large or small numbers without using many zeroes is to use prefixes to represent multiples of ten. For example, the prefix *milli* (abbreviated m) means that the value being represented is one-thousandth of a whole unit; 3 mg (milligrams) is 3 thousandths of a gram or E-03. See Appendix C for additional common prefixes, including *pico* (p), which means trillionth or E-12, *giga* (G), which means billion or E+09, and *tera* (T), which means trillion, E+12.

SOURCES OF IONIZING RADIATION

Radiation is energy that has both natural and manmade sources. Some radiation is essential to life, such as heat and light from the sun. Exposure to high-energy (ionizing) radiation has to be managed, as it can pose serious health risks at large doses. Living things are exposed to radiation from natural background sources: the atmosphere, soil, water, food, and even our own bodies. Humans are exposed to ionizing radiation from a variety of common sources, the most significant of which follow.

Background Radiation **–** Radiation that occurs naturally in the environment is also called background activity. Background radiation consists of cosmic radiation from outer space, radiation from radioactive elements in soil and rocks, and radiation from radon and its decay products in air. Some people use the term background when referring to all non-occupational sources commonly present. Other people use natural to refer only to cosmic and terrestrial sources, and background to refer to common man-made sources such as medical procedures, consumer products, and radioactivity present in the atmosphere from former nuclear testing. In the SER, the term natural background is used to refer to radiation from cosmic and terrestrial radiation.

Cosmic **–** Cosmic radiation primarily consists of charged particles that originate in space, beyond the earth's atmosphere. This includes ionizing 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. Exposure to cosmic radiation increases with altitude, because at higher elevations the atmosphere and the earth's magnetic field provide less shielding. Therefore, people who live in the mountains are exposed to more cosmic radiation than people who live at sea level. The average dose from cosmic radiation to a person living in the United States is approximately 26 mrem per year. (For an explanation of dose, see *effective dose equivalent* in Appendix A. The units *rem* and *sieverts* also are explained in Appendix A.)

Terrestrial **–** Terrestrial radiation is released by radioactive elements that have been present in the soil since the formation of the earth. Common radioactive elements that contribute 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 approximately 28 mrem per year, but may vary considerably depending on the local geology.

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. People can ingest radionuclides when they eat contaminated plant matter or meat from animals that have consumed contaminated plants. The average dose from food for a person living in the United States is about 40 mrem per year. A larger exposure, for most people, comes from breathing the decay products of naturally occurring radon gas. The average dose from breathing air with radon byproducts is about 200 mrem per year, but that amount varies depending on geographical location. An Environmental Protection Agency (EPA) map shows that BNL is located in one of the regions with the lowest potential radon risk.

Medical – Every year in the United States, millions of people undergo medical procedures that use ionizing radiation. Such procedures include chest and dental x-rays, mammography, thallium heart stress tests, and tumor irradiation therapies. The average doses from nuclear medicine and x-ray examination procedures are about 14 and 39 mrem per year, respectively.

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

COMMON TYPES OF IONIZING RADIATION

The three most common types of ionizing radiation are described below.

Alpha Radiation – An alpha particle is identical in makeup to the nucleus of a helium atom, consisting of two neutrons and two protons. 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. However, if alpha-emitting material is ingested, alpha particles can pose a health risk inside the body. Naturally occurring radioactive elements such as uranium emit alpha radiation.

Beta Radiation – Beta radiation is composed of particles that are identical to electrons. Therefore, beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha radiation, but most beta radiation can be stopped by materials such as aluminum foil and plexiglass panels. Beta radiation has a range in air of several feet. Naturally occurring radioactive elements such as potassium-40 emit beta radiation. Some beta particles present a hazard to the skin and eyes.

Gamma Radiation – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. Gamma rays are emitted from a radioactive nucleus along with alpha or beta particles. Gamma radiation is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete. Gamma radiation is identical to x-rays except that x-rays are more energetic. Only a fraction of the total gamma rays a person is exposed to will interact with the human body.

TYPES OF RADIOLOGICAL ANALYSES

The amount of radioactive material in a sample of air, water, soil, or other material can be assessed using several analyses, the most common of which are described below.

Gross alpha – Alpha particles are emitted from radioactive material in a range of different energies. An analysis that 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 total amount but not the type of alpha-emitting radionuclides that may be present in a sample.

Gross beta – This is the same concept as that for gross alpha analysis, except that it applies to the measurement of gross beta particle activity.

Tritium – Tritium radiation consists of low-energy beta particles. It is detected and quantified by liquid scintillation counting. More information on tritium is presented in the section Radionuclides of Environmental Interest, later in this appendix.

Strontium-90 – Due to the properties of the radiation emitted by strontium-90 (Sr-90), a special analysis is required. Samples are chemically processed to separate and collect any strontium atoms that may be present. The collected atoms are then analyzed separately. More information on Sr-90 is presented in the section Radionuclides of Environmental Interest.

Gamma – This analysis technique identifies specific radionuclides. It measures the particular energy of a radionuclide's gamma radiation emission. The energy of these emissions is unique for each radionuclide, acting as a "fingerprint" to identify it.

STATISTICS

Two important statistical aspects of measuring radioactivity are uncertainty in results, and negative values.

Uncertainty – Because the emission of radiation from an atom is a random process, a sample counted several times usually yields a slightly different result each time; therefore, a single measurement is not definitive. To account for this variability, the concept of uncertainty is applied to radiological data. In the SER, analysis results are presented in an x ± y format, where "x" is the analysis result and "± y" is the 95 percent "confidence interval" of that result. That means there is a 95 percent probability that the true value of x lies between (x + y) and (x – y).

Negative values – There is always a small amount of natural background radiation. The laboratory instruments used to measure radioactivity in samples are sensitive enough to measure the background radiation along with any contaminant radiation in the sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured. Due to the randomness of radioactive emissions and the very low concentrations of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported, even though doing so may seem illogical, but they are essential when conducting statistical evaluations of data.

Radiation events occur randomly; if a radioactive sample is counted multiple times, a spread, or distribution, of results will be obtained. This spread, known as a Poisson distribution, is centered about a mean (average) value. Similarly, if background activity (the number of radiation events observed when no sample is present) is counted multiple times, it also will have a Poisson distribution. The goal of a radiological analysis is to determine whether a sample contains activity greater than the background reading detected by the instrument. Because the sample activity and the background activity readings are both Poisson distributed, subtraction of background activity from the measured sample activity may result in values that vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) was established to determine the statistical likelihood that a sample's activity is greater than the background reading recorded by the instrument.

Identifying a sample as containing activity greater than background, when it actually does not have activity present, is known as a Type I error. Most laboratories set their acceptance of a Type I error at 5 percent when calculating the MDL for a given analysis. That is, for any value that is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity. Values that are less than the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all radiological data are reported, regardless of whether they are positive or negative

At very low sample activity levels that are close to the instrument's background reading, it is possible to obtain a sample result that is less than zero. This occurs when the background activity is subtracted from the sample activity to obtain a net value, and a negative value results. Due to this situation, a single radiation event observed during a counting period could have a significant effect on the mean (average) value result. Subsequent analysis may produce a sample result that is positive. When the annual data for the SER are compiled, results may be averaged; therefore, all negative values are retained for reporting as well. This data handling practice is consistent with the guidance provided in the Handbook of

Radioactivity Measurements Procedures (NCRP 1985) and the Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE 1991). Average values are calculated using actual analytical results, regardless of whether they are above or below the MDL, or even equal to zero. The uncertainty of the mean, or the 95 percent confidence interval, is determined by multiplying the population standard deviation of the mean by the $t_{(0.05)}$ statistic.

RADIONUCLIDES OF ENVIRONMENTAL INTEREST

Several types of radionuclides are found in the environment at BNL due to historical operations.

***Cesium-137* –** Cs-137 is a fission-produced radionuclide with a half-life of 30 years (after 30 years, only one half of the original activity level remains). It is found in the worldwide environment as a result of past aboveground nuclear weapons testing and can be observed in near-surface soils at very low concentrations, usually less than 1 pCi/g (0.004 Bq/g). Cs-137 is a beta-emitting radionuclide, but it can be detected by gamma spectroscopy because its decay product, barium-137m, emits gamma radiation.

Cs-137 is found in the environment at BNL mainly as a soil contaminant, from two main sources. The first source is the worldwide deposition from nuclear accidents and fallout from weapons testing programs. The second source is deposition from spills or releases from BNL operations. Nuclear reactor operations produce Cs-137 as a byproduct. In the past, wastewater containing small amounts of Cs-137 generated at the reactor facilities was routinely discharged to the Sewage Treatment Plant (STP), resulting in low-level contamination of the STP and the Peconic River. In 2002/2003, under the Environmental Restoration Program, sand and its debris containing low levels of Cs-137, Sr-90, and heavy metals were removed, assuring that future discharges from the STP are free of these contaminants. Soil contaminated with Cs-137 is associated with the following areas that have been, or are being, addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, and the Brookhaven Graphite Research Reactor (BGRR).

***Strontium-90* –** Sr-90 is a beta-emitting radionuclide with a half-life of 28 years. Sr-90 is found in the environment principally as a result of fallout from aboveground nuclear weapons testing. Sr-90 released by weapons testing in the 1950s and early 1960s is still present in the environment today. Additionally, nations that were not signatories of the Nuclear Test Ban Treaty of 1963 have contributed to the global inventory of fission products (Sr-90 and Cs-137). This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

Sr-90 is present at BNL in the soil and groundwater. As in the case of Cs-137, some Sr-90 at BNL results from worldwide nuclear testing; the remaining contamination is a byproduct of reactor operations. The following areas with Sr-90 contamination have been or are being addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, the BGRR, Former and Interim Landfills, Chemical and Glass Holes Area, and the STP.

The information in SER tables is arranged by method of analysis. Because Sr-90 requires a unique method of analysis, it is reported as a separate entry. Methods for detecting Sr-90 using state-of-the-art equipment are quite sensitive (detecting concentrations less than 1 pCi/L), which makes it possible to detect background levels of Sr-90.

***Tritium* –** Among the radioactive materials that are used or produced at BNL, tritium has received the most public attention. Approximately 4 million Ci (1.5E+5 TBq) per year are produced in the atmosphere naturally (NCRP 1979). As a result of aboveground weapons testing in the 1950s and early 1960s in the United States, the global atmospheric tritium inventory was increased by a factor of approximately 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 products such as self-illuminating wristwatches and exit signs (the signs may each contain as much as 25 Ci [925 GBq] of tritium). Tritium 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 such as BNL and other national laboratories.

Of the sources mentioned above, the most significant contributor to tritium in the environment has been aboveground nuclear weapons testing. In the early 1960s, the average tritium concentration in surface streams in the United States reached a value of 4,000 pCi/L (148 Bq/L; NCRP 1979). Approximately the same concentration was measured in precipitation. Today, the level of tritium in surface waters in New York State is less than one-twentieth of that amount, below 200 pCi/L (7.4 Bq/L; NYSDOH 1993). This is 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 (nonradioactive) helium. The beta radiation that tritium releases has a very low energy, compared to the emissions of most other radioactive elements. In humans, the outer layer of dead skin cells easily stops the beta radiation from tritium; therefore, only when tritium is taken into the body can it cause an exposure. Tritium may be taken into the body by inhalation, ingestion, or absorption of tritiated water through the skin. Because of its low energy radiation and short residence time in the body, the health threat posed by tritium is very small for most 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 shorthand notation, HTO). Most of the tritium released from BNL sources is in the form of HTO, none as elemental tritium. Sources of tritium at BNL include the reactor facilities (all now non-operational), where residual water (either heavy or light) is converted to tritium via neutron bombardment; the accelerator facilities, where tritium is produced by secondary radiation interactions with soil and water; and facilities like the Brookhaven Linac Isotope Producer, where tritium is formed from secondary radiation interaction with cooling water. Tritium has been found in the environment at BNL as a groundwater contaminant from operations in the following areas: Current Landfill, BLIP, Alternating Gradient Synchrotron, and the High Flux Beam Reactor. Although small quantities of tritium are still being released to the environment through BNL emissions and effluents, the concentrations and total quantity have been drastically reduced, compared with historical operational releases as discussed in Chapters 4 and 5.

REFERENCES AND BIBLIOGRAPHY

DOE Order 5400.5. 1993. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Washington, DC. Change 2: 1-7-93.

DOE. 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. DOE/EH-0173T. U.S. Department of Energy, Washington, DC.

NCRP. 1979. *Tritium in the Environment. NCRP Report No. 62.* National Council on Radiation Protection and Measurements. Bethesda, MD.

NCRP. 1985. *Handbook of Radioactivity Measurements Procedures, NCRP Report No. 58.* National Council on Radiation Protection and Measurements, Bethesda, MD.

NCRP. 1987. *Ionizing Radiation Exposure of the Population of the United States.* NCRP Report No. 93. National Council on Radiation Protection and Measurements. Bethesda, MD.

NYSDOH. 1996. *Radioactive Contamination in the Peconic River.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

NYSDOH. 1993. *Environmental Radiation in New York State*. Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, NY.

Radiochemistry Society Online. www.radiochemistry.org/nomenclature/index/html, accessed 3-25-04.

Units of Measure and Half-Life Periods

UNITS OF RADIATION MEASUREMENT AND CONVERSIONS

U.S. System	International System	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad	gray (Gy)	1 rad = 0.01 Gy
rem	sievert (Sv)	1 rem = 0.01 Sv

APPROXIMATE METRIC CONVERSIONS

When you know	multiply by	to obtain	When you know	multiply by	to obtain
centimeters (cm)	0.39	inches (in.)	in.	2.54	cm
meters (m)	3.28	feet (ft)	ft	0.305	m
kilometers (km)	0.62	miles (mi)	mi	1.61	km
kilograms (kg)	2.20	pounds (lb)	lb	0.45	kg
liters (L)	0.264	gallons (gal)	gal	3.785	L
cubic meters (m^3)	35.32	cubic feet (ft^3)	ft^3	0.03	m^3
hectares (ha)	2.47	acres	acres	0.40	ha
square kilometers (km^2)	0.39	square miles (mi^2)	mi^2	2.59	km^2
degrees Celcius (°C)	1.8 (°C) + 32	degrees Fahrenheit (°F)	°F	(°F - 32) / 1.8	°C

SCIENTIFIC NOTATION USED FOR MEASUREMENTS

Multiple	Decimal Equivalent	Notation	Prefix	Symbol
1×10^{12}	1,000,000,000,000	E+12	Tera-	T
1×10^{9}	1,000,000,000	E+9	giga-	G
1×10^{3}	1,000	E+03	kilo-	k
1×10^{-2}	0.01	E-02	centi-	c
1×10^{-3}	0.001	E-03	milli-	m
1×10^{-6}	0.000001	E-06	micro-	μ
1×10^{-9}	0.000000001	E-09	nano-	n
1×10^{-12}	0.000000000001	E-12	pico-	p

CONCENTRATION CONVERSIONS

1 ppm	=	1,000 ppb		
1 ppb	=	0.001 ppm	=	1μg/L*
1 ppm	=	1 mg/L	=	1000 μg/L*

* For aqueous fractions only.

HALF-LIFE PERIODS	
Am-241	432.7 yrs
C-11	~20 min
Co-60	5.3 yrs
Cs-137	30.2 yrs
N-13	~10 min
N-22	2.6 yrs
O-15	~2 min
PU-238	87.7 yrs
Pu-239	24,100.0 yrs
Pu-240	6,560.0 yrs
Sr-90	29.1 yrs
tritium	12.3 yrs
U-234	247,000.0 yrs
U-235	~700 million yrs (7.0004E8)
U-238	87.7 yrs

APPENDIX D

Federal, State, and Local Laws and Regulations Pertinent to BNL

DOE DIRECTIVES, REGULATIONS, AND STANDARDS

DOE O 231.1-A	Order: Environment, Safety and Health Reporting 08/19/03
DOE O 414.1	Order: Management Assessment and Independent Assessor's Guide 05/31/2001
DOE O 430.2B	Departmental Energy, Utilities, and Transportation 02/27/2008
DOE O 435.1	Order, Change 1: Radioactive Waste Management 08/28/2001
DOE O 450.1A	Order: Environmental Protection Program 06/04/2008
DOE P 450.5	Policy: Line Environment, Safety, and Health Oversight 06/26/1997
DOE O 5400.5	Order: Change 2, Radiological Protection of the Public and the Environment 01/07/1993

FEDERAL LAWS AND REGULATIONS

Executive Order 13148	Greening of the Government Through Leadership in Environmental Management
10 CFR 1021	National Environmental Protection Act, Implementing and Procedures
10 CFR 1022	Compliance with Floodplain/Wetlands Environmental Review Requirements
10 CFR 830	Subpart A: Quality Assurance Requirements
10 CFR 834	Radiation Protection of the Public and the Environment
16 USC 470	National Historic Preservation Act
36 CFR 60	National Register of Historic Places
36 CFR 63	Determination of Eligibility for Inclusion in the National Register of Historic Places
36 CFR 79	Curation of Federally Owned and Administered Archaeological Collections
36 CFR 800	Protection of Historic Properties
40 CFR 50-0	National Primary and Secondary Ambient Air Quality Standards
40 CFR 82	Protection of Stratospheric Ozone
40 CFR 109	Criteria for State, Local and Regional Oil Removal Contingency Plans
40 CFR 110	Discharge of Oil
40 CFR 112	Oil Pollution Prevention Act
40 CFR 113	Liability Limits for Small Onshore Storage Facilities
40 CFR 116	Designation of Hazardous Substances
40 CFR 117	Determination of Reportable Quantities for Hazardous Substances

40 CFR 121	State Certification of Activities Requiring a Federal License or Permit
40 CFR 122	National Pollution Discharge Elimination System (NPDES)
40 CFR 123	State Program Requirements
40 CFR 124	Procedures for Decision-making
40 CFR 125	Criteria and Standards for the National Pollutant Discharge Elimination System
40 CFR 129	Toxic Pollutant Effluent Standards
40 CFR 130	Water Quality Planning and Management
40 CFR 131	Water Quality Standards
40 CFR 132	Water Quality Guidance for the Great Lakes System
40 CFR 133	Secondary Treatment Regulation
40 CFR 135	Prior Notice of Citizen Suits
40 CFR 136	Guidelines Establishing Test Procedures for the Analysis of Pollutants
40 CFR 141	National Primary Drinking Water Regulations
40 CFR 142	National Primary Drinking Water Regulations Implementation
40 CFR 143	National Secondary Drinking Water Regulations
40 CFR 144	Underground Injection Control (UIC) Program
40 CFR 146	Underground Injection Control (UIC) Program: Criteria and Standards
40 CFR 148	Hazardous Waste Injection Restrictions
40 CFR 149	Sole Source Aquifers
40 CFR 167	Submissions of Pesticide Reports
40 CFR 168	Statements of Enforcement Policies and Interpretations
40 CFR 169	Books and Records of Pesticide Production and Distribution
40 CFR 170	Worker Protection Standard
40 CFR 171	Certification of Pesticide Applicators
40 CFR 260	Hazardous Waste Management Systems: General
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Special Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities

40 CFR 268	Land Disposal Restrictions
40 CFR 270	EPA Administered Permit Program: The Hazardous Waste Permit Program
40 CFR 271	Requirements for Authorization of State Hazardous Waste Mgmt Programs
40 CFR 272	Approved State Hazardous Waste Management Programs
40 CFR 273	Standards for Universal Waste Management
40 CFR 279	Standards for the Management of Used Oil
40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 355	Emergency Planning and Notification
40 CFR 370	Hazardous Chemical Report: Community Right-to-Know
40 CFR 372	Toxic Chemical Release Report: Community Right-to-Know
40 CFR 700	Toxic Substances Control Act [TSCA]
40 CFR 702	Toxic Substances Control Act: General Practices and Procedures
40 CFR 704	Toxic Substances Control Act: Reporting and Recordkeeping Requirements
40 CFR 707	Chemical Imports and Exports
40 CFR 710	Inventory Reporting Regulations
40 CFR 712	Chemical Information Rules
40 CFR 716	Health and Safety Data Reporting
40 CFR 717	Records and Reports of Allegations that Chemical Substances Cause Significant Adverse Reactions to Health or the Environment
40 CFR 720	Premanufacture Notification
40 CFR 721	Significant New Users of Chemical Substances
40 CFR 723	Premanufacture Notification Exemptions
40 CFR 725	Reporting Requirements and Review Processes for Microorganisms
40 CFR 745	Lead-Based Paint Poisoning Prevention in Certain Residential Structures
40 CFR 747	Metalworking Fluids
40 CFR 749	Water Treatment Chemicals
40 CFR 750	Procedures for Rulemaking Under Section 6 of TSCA
40 CFR 761	PCBs Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
40 CFR 763	Asbestos
40 CFR 1500	Council on Environmental Quality: Purpose, Policy, and Mandate

40 CFR 1501	NEPA and Agency Planning
40 CFR 1502	Environmental Impact Statement
40 CFR 1503	Commenting
40 CFR 1504	Predecision Referrals to the Council of Proposed Federal Actions
40 CFR 1505	NEPA and Agency Decision-making
40 CFR 1506	Other Requirements of NEPA
40 CFR 1507	Agency Compliance
40 CFR 1508	Terminology and Index
50 CFR 17	Endangered and Threatened Wildlife and Plants

NEW YORK STATE LAWS, REGULATIONS, AND STANDARDS

6 NYCRR 182	Endangered and Threatened Species of Fish and Wildlife, Species of Special Concern
6 NYCRR 200	Environmental Conservation Law
6 NYCRR 201	Subpart 201-1: General Provisions
6 NYCRR 202	Subpart 202: Emissions Verification
6 NYCRR 203	Indirect Sources of Air Contamination
6 NYCRR 204	NO_x Budget Training Program
6 NYCRR 205	Architectural and Maintenance (AIM) Coatings
6 NYCRR 207	Control Measures for an Air Pollution Episide
6 NYCRR 208	Landfill Gas Collection and Control System for Certain Municipal Solid Waste Landfills
6 NYCRR 211	General Prohibitions
6 NYCRR 212	General Process Emission Sources
6 NYCRR 215	Open Fires
6 NYCRR 217	Environmental Conservation Rules and Regulations [Exhaust and Emission Standards]
6 NYCRR 218	Subpart 218-1 [More on Vehicle Exhaust]
6 NYCRR 221	Asbestos-Containing Surface Coating Material
6 NYCRR 225	Subpart 225-1: Fuel Composition and Use – Sulfur Limitations
6 NYCRR 227	Solvent Metal Cleaning Processes
6 NYCRR 228	Surface Coating Processes
6 NYCRR 229	Petroleum and Volatile Organic Liquid Storage and Transfer
6 NYCRR 230	Gasoline Dispensing Sites and Transport Vehicles
6 NYCRR 231	New Source Review in Nonattainment Areas and Ozone Transport Regions
6 NYCRR 234	Graphic Arts

6 NYCRR 237	Acid Deposition Reduction NO_x Budget Training Program
6 NYCRR 238	Acid Deposition Reduction SO_2 Budget Training Program
6 NYCRR 239	Portable Fuel Container Spillage Control
6 NYCRR 240	Conformity to State or Federal Implementation Plans
6 NYCRR 250	Miscellaneous Orders
6 NYCRR 256	Air Quality Classification System
6 NYCRR 257	Air Quality Standards
6 NYCRR 307	[Air Quality in] Suffolk County
6 NYCRR 320	Pesticides - General
6 NYCRR 325	Application of Pesticides
6 NYCRR 326	Registration and Certification of Pesticides
6 NYCRR 327	Use of Chemicals for the Control or Elimination of Aquatic Vegetation
6 NYCRR 328	Use of Chemicals for the Extermination of Undesirable Fish
6 NYCRR 329	Use of Chemicals for the Control or Elimination of Aquatic Insects
6 NYCRR 360-1	General Provisions: Solid Waste Management Facilities
6 NYCRR 361	Siting of Industrial Hazardous Waste Facilities
6 NYCRR 364	Waste Transporter Permits
6 NYCRR 370	Hazardous Waste Management Regulations
6 NYCRR 371	Identification and Listing of Hazardous Waste
6 NYCRR 372	Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities
6 NYCRR 373	Hazardous Waste Management Facilities
6 NYCRR 374	Standards for the Management of Specific Hazardous Wastes
6 NYCRR 376	Land Disposal Restrictions
6 NYCRR 595	Release of Hazardous Substances
6 NYCRR 596	Hazardous Substance Bulk Storage Regulations
6 NYCRR 597	List of Hazardous Substances
6 NYCRR 611	Environmental Priorities and Procedures in Petroleum Cleanup and Removal
6 NYCRR 612	Registration of Petroleum Storage Facilities
6 NYCRR 613	Handling and Storage of Petroleum
6 NYCRR 663	Freshwater Wetlands Permit Requirements
6 NYCRR 666	Regulation for Administration and Management of the Wild, Scenic, and Recreational Rivers System in New York State Excepting Private Land in the Adirondack Park

6 NYCRR 700	Part 700 Water Quality Regulations
6 NYCRR 701	Classification – Surface Waters and Groundwaters
6 NYCRR 702	Derivation and Use of Standards and Guidance Values
6 NYCRR 703	Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations
6 NYCRR 750	Obtaining a SPDES Permit
10 NYCRR 5	State Sanitary Code – Part 5

SUFFOLK COUNTY RULES, REGULATIONS, AND STANDARDS

SCSC Art. 12	Toxic and Hazardous Material Storage, Handling and Control

2008 Site Environmental Report Reader Response Form

The 2008 Site Environmental Report (SER) was written to inform outside regulators, the public, and BNL employees of the Laboratory's environmental performance for the calendar year. The report summarizes BNL's on-site environmental data; environmental management performance; compliance with applicable regulations; and environmental, restoration, and surveillance monitoring programs.

BNL welcomes your comments, suggestions for improvements, or any questions you may have. Please fill in the information below, and mail your response form to:

Brookhaven National Laboratory
Environmental Protection Division
Attention: SER Project Coordinator
Building 120
P.O. Box 5000
Upton, NY 11973-5000

Name ____________________

Address ____________________

____

Phone ____________________

Email ____________________

Comments, Suggestions, or Questions

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____

____

____

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☐ I would like to be added to your Environmental Issues mailing list.

BROOKHAVEN NATIONAL LABORATORY

SER Project Coordinator
Environmental Protection Division
Building 120
Brookhaven National Laboratory
PO Box 5000
Upton, NY 11973-5000

FUTURE NSLS-II

Green Buildings

RESEARCH SUPPORT BUILDING

CENTER FOR FUNCTIONAL NANOMATERIALS

BROOKHAVEN NATIONAL LABORATORY

2008 Site Environmental Report

GROUNDWATER STATUS REPORT

Volume II

BNL-82388-2009

2008
SITE ENVIRONMENTAL REPORT
VOLUME II
GROUNDWATER STATUS REPORT

June 12, 2009

Environmental Protection Division
Groundwater Protection Group

Brookhaven National Laboratory
Operated by
Brookhaven Science Associates
Upton, NY 11973

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Report Contributors

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Environmental Protection Division

John Burke	William Dorsch	Brian Foley
George Goode	Robert Howe	Richard Lagattolla
Chris Ogeka	Doug Paquette	Vincent Racaniello
Andrew Rohkohl	Frank Tramontano	Susan Young

Facility and Operations Directorate
Eric Kramer

J.R. Holzmacher P.E., LLC

Diana Holzmacher	Lucas Robak	Kyle Sarich
Patricia Zalak	Anthony Zalak	

R&C Formations, LTD.

Robert Casson	Robert Heiss Jr.	Philip Hoffken Jr.
Melissa Yost	Arthur John Scheff	

D. B. Bennett Consulting Engineer
Drew Bennett

TERRA Editing, Inc.
Joanne Yeary

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Contents

List of Appendices

BGRR/WCF Sr-90 System

OU III Chemical/Animal Holes Sr-90 System

OU III HFBR Tritium System

OU VI EDB Pump and Treat System

G. Data Usability Reports

List of Figures

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List of Tables

Acronyms and Abbreviations

These acronyms and abbreviations reflect the typical manner in which terms are used in Volume II of this document, and may not apply to all situations.

AGS	Alternating Gradient Synchrotron
AOC	Area of Concern
AS/SVE	Air Sparge/Soil Vapor Extraction
AWQS	Ambient Water Quality Standards
BGD	Below Ground Ducts
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven Linac Isotope Producer
bls	below land surface
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
COC	Chain of Custody
Cr	chromium
Cr(VI)	hexavalent chromium
CRDL	Contract Required Detection Limit
CSF	Central Steam Facility
CY	calendar year
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG	Derived Concentration Guide
DNAPL	dense non-aqueous-phase liquid
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DTW	Depth to Water
DWS	Drinking Water Standards
EDB	ethylene dibromide
EDD	Electronic Data Deliverable
EE/CA	Engineering Evaluation/Cost Analysis
EIMS	Environmental Information Management System
EM	Environmental Management
EMS	Environmental Management System
EPA	United States Environmental Protection Agency
EPD	Environmental Protection Division
ERP	Emissions Rate Potential
ES	Environmental Surveillance
ESD	Explanation of Significant Differences
EW	extraction well
FFA	Federal Facility Agreement
ft	feet
ft msl	feet relative to mean sea level
GAC	granular activated carbon
gal/hr	gallons per hour
gpm	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Inter Agency Agreement
ID	identification
lb/gal	pounds per gallon
lb/hr	pounds per hour
lbs	pounds
LIE	Long Island Expressway
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LTRA	Long Term Response Actions
mCi	milli Curies
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDL	Minimum Detection Limit
mg/kg	milligrams per kiolgram
mg/L	milligrams per liter
MGD	millions of gallons per day
MNA	Monitored Natural Attenuation
MPF	Major Petroleum Facility
mrem/yr	millirems per year
MS/MSD	Matrix Spike/Matrix Spike Duplicate
msl	mean sea level
MTBE	methyl tertiary-butyl ether
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NSE	North Street East
NSLS-II	National Synchrotron Light Source II
NSRL	NASA Space Radiation Laboratory
NYCRR	New York Code of Rules and Regulations
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance

OU	Operable Unit
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
pCi/L	pico Curies per liter
PFS	Pile Fan sump
PLC	programmable logic controller
QA/QC	Quality Assurance and Quality Control
RA V	Removal Action V
RCRA	Resource Conservation and Recovery Act
RHIC	Relativistic Heavy Ion Collider
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPD	Relative Percent Difference
RTW	Recirculating Treatment Well
RW	remediation well
SBMS	Standards Based Management System
SCDHS	Suffolk County Department of Health Services
SCWA	Suffolk County Water Authority
SDG	Sample Delivery Group
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
STP	Sewage Treatment Plant
SU	standard unit
SVOC	semivolatile organic compound
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TVOC	total volatile organic compound
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
µg/L	micrograms per liter
WCF	Waste Concentration Facility
WLA	Waste Loading Area
WMF	Waste Management Facility

2008 BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER STATUS REPORT

Executive Summary

The mission of the Laboratory's Groundwater Protection Program is to protect and restore the aquifer system at Brookhaven National Laboratory (BNL). Four key elements make up the program:

- **Pollution prevention** – preventing the potential pollution of groundwater at the source
- **Monitoring** – monitoring the effectiveness of pollution-prevention efforts, as well as progress in restoring contaminated groundwater
- **Restoration** – maintaining groundwater treatment systems and restoring groundwater quality that BNL has impacted
- **Communication** – communicating the findings and the results of the program to regulators and other stakeholders

The *2008 BNL Groundwater Status Report* is a comprehensive summary of data collected during the calendar year, and an evaluation of Groundwater Protection Program performance. This is the thirteenth annual groundwater status report issued by BNL. This document examines the performance of the program on a project-by-project basis.

How to Use This Document. This detailed technical document includes summaries of laboratory data, as well as data interpretations. Area summary level review of this information is presented as Chapter 7 of Volume I of the *Site Environmental Report*. Groundwater restoration is performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) by the Groundwater Protection Group, and includes measuring and monitoring of groundwater remediation performance, and efforts in achieving cleanup goals. Facility Monitoring refers to the monitoring of groundwater quality at active research and support facilities, primarily in response to Department of Energy (DOE) Order 450.1, Environmental Protection. Data are presented in five key areas:

- Improvements to the understanding of the hydrogeologic environment beneath BNL and surrounding areas
- Identification of any new impacts on groundwater quality due to BNL's active operations
- Progress in cleaning up the groundwater contamination
- Performance of individual groundwater remediation systems
- Recommended changes to the groundwater protection program

This document satisfies BNL's requirement to report groundwater data under the Federal Facility Agreement (FFA), and partially fulfills the commitment of BNL's Groundwater Protection Program to communicate the findings and progress of the program to regulators and stakeholders.

Section 1 summarizes the regulatory requirements of the data collection work in 2008, the site's groundwater classification, and the objectives of the groundwater monitoring efforts. **Section 2** discusses improvements to our understanding of the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2008. **Section 3** summarizes the groundwater cleanup data, progress towards achieving the site's cleanup goals, and recommended modifications to the remediation systems or monitoring programs. **Section 4** summarizes the facility monitoring data used to verify that operational and engineering controls are preventing further contamination from the site's active experimental and support facilities. The recommended changes to the Groundwater Protection Program are summarized in **Section 5**.

HYDROGEOLOGIC DATA

The following were important hydrogeologic findings in 2008:

- The desired flow conditions continued to be maintained in the central portion of the site during 2008, with 90 percent of the total site-wide potable and process water pumpage being derived from the western supply-well field. No shifting of contaminant plumes outside of the established monitoring networks was observed on site in 2008.
- Total annual precipitation in 2008 was 51.1 inches, which is above the yearly average of 48 inches. Seven of the past 10 years have featured above-normal average precipitation at BNL.

GROUNDWATER RESTORATION PROGRESS AND ISSUES (CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of CERCLA. During 2008, 12 volatile organic compound (VOC) groundwater remediation systems were in operation, along with two Strontium-90 (Sr-90) treatment systems, and a tritium pump and recharge system. In 2008, 220 pounds of VOCs were removed from the aquifers by the treatment systems. To date, 6,117 pounds of VOCs have been removed from the aquifer. The Operable Unit (OU) III Chemical/Animal Holes Sr-90 System removed 0.74 milli Curies (mCi) of Sr-90 from the Upper Glacial aquifer in 2008, for a total of 3.33 mCi since operations began in 2003. The OU III Brookhaven Graphite Research Reactor (BGRR) Sr-90 System removed 2.7 mCi of Sr-90 during the year, for a total of 16.85 mCi since operations began in 2005.

Groundwater remediation is expected to be a long-term process for most of the plumes. Noticeable improvements in groundwater quality are evident in most of the plumes. The OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) system was decommissioned in 2003, and the OU III Carbon Tetrachloride System has remained in standby since 2004. A number of individual extraction wells have been placed on standby. A petition for closure for the Carbon Tetrachloride System will be prepared and submitted to the regulators in 2009. In 2009 a petition for shutdown will be prepared for the Industrial Park East System. Groundwater remediation activities are expected to continue until the cleanup objectives for the plumes have been met. The specific goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve the MCL of 8 pico Curies per liter (pCi/L) for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070
- Achieve the MCL of 8 pCi/L for Sr-90 at the Chemical/Animal Holes in the Upper Glacial aquifer by 2040

The cleanup objectives will be met by a combination of active treatment and natural attenuation. The comprehensive groundwater monitoring program will measure the remediation progress.

The locations and extent of the primary VOC and radionuclide plumes at BNL, as of December 2008, are summarized on **Figures E-1** and **E-2**, respectively. Significant items of interest during 2008 were the following:

- A total of 735 monitoring wells were sampled as part of the CERCLA Groundwater Monitoring Program, comprising a total of 1,815 groundwater samples. In 2008, 86 temporary wells were also installed under the CERCLA program. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site.
- During 2008, 1.5 billion gallons of groundwater were treated, and 220 pounds of VOCs and 3.4 mCi of Sr-90 were removed from the aquifer. (**Table E-1**).

Table E-1.
BNL Groundwater Remediation System Treatment Summary for 1997 – 2008.

	1997 – 2007		2008	
VOCs Remediation (start date)	Water Treated (gallons)	VOCs Removed (pounds)(c)	Water Treated (gallons)	VOCs Removed (pounds)(c)
OU III South Boundary (June 1997)	3,184,952,850	2,569	135,000,000	60
OU III Industrial Park (Sept. 1999)	1,364,478,330	1010	128,000,000	24
OU III W. South Boundary (Sept. 2002)	602,647,000	49	65,000,000	5
OU III Carbon Tetrachloride (Oct. 1999)	153,538,075	349	0	0
OU I South Boundary (Dec. 1996)	3,184,314,000	337	258,000,000	10
OU III HFBR Tritium Plume (May 1997) (a)	248,978,000	180	86,000,000	0
OU IV AS/SVE (Nov. 1997) (b)	0	35	0	0
OU III Building 96 (Feb. 2001)	138,297,416	71	34,000,000	13
OU III Middle Road (Oct. 2001)	1,267,411,550	741	150,000,000	56
OU III Industrial Park East (May 2004)	287,172,000	33	33,000,000	3
OU III North Street (June 2004)	689,122,000	268	180,000,000	21
OU III North Street East (June 2004)	428,976,000	20	64,000,000	5
OU III LIPA/Airport (June 2004)	846,887,000	235	226,000,000	23
OU VI EDB (August 2004)	471,711,000	NA(d)	153,000,000	NA (d)
Totals	12,868,485,221	5,897	1,512,000,000	220

	2003 – 2007		2008	
Sr-90 Remediation (start date)	Water Treated (gallons)	Sr-90 Removed (mCi)	Water Treated (gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes (Feb 2003)	12,404,826	2.59	6,000,000	0.74
OU III BGRR (June 2005)	22,151,000	14.15	8,800,000	2.7
Totals	34,555,826	16.74	14,800,000	3.44

Notes:
(a) System was placed in standby mode on Sept. 29, 2000, but restarted November 2007.
(b) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance measured by pounds of volatile organic compounds (VOCs) removed. System was dismantled in December 2003.
(c) Values rounded to the nearest whole number.
(d) Ethylene dibromide (EDB) has been detected in the system influent at trace levels well below the standard since operations began. Therefore, no removal of VOCs is reported.
NA – Not applicable
mCi – milli Curies

- The High Flux Beam Reactor (HFBR) Pump and Recharge system was operational during 2008. Newly installed extraction well EW-16 is positioned to capture the downgradient high concentration tritium slug, as shown by 2008 temporary and permanent well data. The leading edge of this slug reached EW-16 during the first quarter of 2009. The system is expected to remain operational for several years until this slug has been completely captured, and tritium concentrations in the area decrease below the 20,000 pCi/L Drinking Water Standard (DWS).
- The source of the Building 96 tetrachloroethylene (PCE) plume was identified and delineated during 2008 following a combined soil boring and soil gas characterization effort. A small area of contaminated soils located in the unsaturated zone south of the former Building 96 is planned for excavation and off-site disposal of soils. It is expected that the removal of this source area will reduce groundwater plume PCE concentrations to below the capture goal of 50 micrograms per liter (μg/L) within three to five years, and allow for the Building 96 Air Stripping groundwater treatment system to be turned off and the OU III Record of Decision (ROD) cleanup goal to be achieved. The source area is presently being hydraulically controlled by the groundwater treatment system, and a temporary plastic cover was placed over the contaminated soils source area until excavation is initiated. A draft *Explanation of Significant Differences* (ESD) documenting the source area excavation was submitted to the regulators in April 2009. Following regulator comment, a Final ESD was prepared in July 2009.
- A groundwater characterization consisting of the installation and sampling of 29 temporary wells was performed during the late 2008/early 2009 time frame. The goal of this effort was to define the present location of both the downgradient g-2 tritium plume slug and the high concentration Sr-90 slug downgradient of the Waste Concentration Facility (WCF). Data obtained reveals that the core of the Sr-90 slug is just to the northwest of the HFBR building, while the area of highest tritium concentrations is located just south of the HFBR. The separation of these two areas will allow for the design of additional extraction wells to capture and treat the higher Sr-90 concentrations without entraining significant tritium. This newly acquired data will be used for pre-design groundwater modeling.
- TVOC concentrations up to 120 μg/L were observed in a temporary well installed along Middle Road in the Western South Boundary area in 2008. This was part of a groundwater characterization effort recommended in the *2007 Groundwater Status Report* in response to a comment from The United States Environmental Protection Agency (EPA). Dichlorodifluoromethane (a freon) and 1,1,1-trichloroethane (TCA) were the primary VOCs detected in several of the eight temporary wells installed to investigate this area. This contamination is projected to be captured at the southern site boundary by Western South Boundary System extraction well WSB-1, which has been reinstated to full-time operation. A permanent monitoring well will be installed in 2009 to monitor this contamination. The data will be evaluated for approximately one year to determine if additional actions are necessary.
- A small area of elevated Sr-90 concentrations has been monitored in the OU I area south of the former Hazardous Waste Management Facility (HWMF) over the past several years. In 2008, Sr-90 concentrations exceeded the DWS in the downgradient sentinel well for this plume. This report is recommending that the plume be further characterized and additional sentinel wells installed.
- No rebound of carbon tetrachloride concentrations has been observed since the system has been in standby mode. System standby began in 2004 following the approval of the petition for shutdown of the Carbon Tetrachloride System. A petition for closure of this system will be prepared and submitted to the regulators in 2009.
- VOC concentrations in Industrial Park East monitoring and extraction wells have decreased to levels well below the system capture goals. As a result, a petition for shutdown of this system

will be prepared and submitted to the regulators in 2009.

Progress of the groundwater restoration program is summarized on **Table E-2**.

INSTITUTIONAL CONTROLS

Institutional controls are in place at BNL to ensure effectiveness of all groundwater remedies. During 2008, the institutional controls continued to be effective in protecting human health and the environment. In accordance with the *BNL Land Use Controls Management Plan* (2007a), the following institutional controls continued to be implemented for the groundwater remediation program.

- Groundwater monitoring, including BNL potable supply systems and Suffolk County Department of Health Services (SCDHS) monitoring of Suffolk County Water Authority (SCWA) well fields closest to BNL
- Five-year reviews, as required by CERCLA, until cleanup goals are met and to determine the effectiveness of the groundwater monitoring program
- Controls on the installation of new supply wells and recharge basins on BNL property
- Public water service in plume areas south and east of BNL
- Prohibitions on the installation of new potable water-supply wells where public water service exists (Suffolk County Sanitary Code Article 4)
- Property access agreements for treatment systems off the BNL property.

An annual update on Institutional Controls summarizing noteworthy issues, changes, breaches, etc. was submitted to the regulatory agencies in February 2009 and approved in June 2009.

FACILITY MONITORING RESULTS

During 2008, the Facility Monitoring Program monitored groundwater quality at 10 active research and support facilities. Groundwater samples were collected from 125 wells, for a total of approximately 240 individual samples. BNL also installed 29 temporary wells to track the downgradient segment of the g-2 Tritium Plume. Although no new impacts to groundwater quality were discovered during 2008, groundwater quality continues to be impacted at two facilities: continued periodic high levels of tritium at the g-2 Tritium Source Area, and continued VOCs at the Upton Service Station.

Highlights for the Facility Monitoring Program are as follow:

- Tritium continues to be detected in the g-2 source area monitoring wells, at concentrations above the 20,000 pCi/L DWS. A short-term spike in tritium levels was observed in January 2008, with a tritium concentration of 186,000 pCi/L detected in the source area. Tritium levels in the source area wells dropped to less than 50,000 pCi/L by the fourth quarter of the year. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicate that the continued release of tritium appears to be related to the flushing of residual tritium from the vadose zone following significant natural periodic fluctuations in the local water table.
- During 2008 through early 2009, monitoring of the downgradient areas of the g-2 tritium plume was accomplished using a combination of permanent and temporary wells. The highest tritium

concentration in the downgradient segment of the plume was 80,700 pCi/L, observed immediately south of the HFBR. The southern extent of the plume was tracked to the Temple Place area, where a maximum tritium concentration of 33,300 pCi/L was detected. As a result of natural radioactive decay and dispersion in the aquifer, the tritium plume appears to be breaking up into discrete segments.

- At the Brookhaven Linac Isotope Producer (BLIP) facility, tritium concentrations in groundwater have been less than the 20,000 pCi/L since April 2006. The maximum tritium concentration during 2008 was 5,630 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding, and that the amount of residual tritium in the deep vadose zone is diminishing.
- At the BNL Onsite Service Station, VOCs associated with petroleum products and the solvent PCE continue to be detected in the groundwater directly downgradient of the facility. Total volatile organic compound (TVOC) concentrations in one well reached a maximum of 1,575 μg/L, with the contamination consisting mostly of xylenes, ethylbenzene, and trimethylbenzenes. Monitoring of the leak detection systems at the Service Station indicates that the gasoline storage tanks and associated distribution lines are not leaking, and that the waste oils and used solvents are being properly stored and recycled. It is believed that the contaminants detected in groundwater originate from historical vehicle maintenance activities and are not related to current operations. The petroleum-related compounds detected in the groundwater at the Motor Pool are not detected in downgradient Carbon Tetrachloride Pump and Treat System wells, indicating that these compounds breakdown within a short distance from the facility.

PROPOSED CHANGES TO THE GROUNDWATER PROTECTION PROGRAM

The data summarized in this report are the basis for several significant operational and groundwater monitoring changes to the groundwater protection program. A summary of the changes follows (specific details of which are provided in **Section 5**):

- **OU I South Boundary System** – Install up to nine shallow temporary wells to characterize the current extent of the elevated Sr-90 contamination.
- **Carbon Tetrachloride System** – Submit a petition for closure of this system based on the continued low concentrations observed in the monitoring and extraction wells over the previous five years.
- **Building 96 System** – Following regulator approval of the OU III ESD, excavate the PCE-contaminated soils from the vadose zone source area and install three additional monitoring wells to monitor the effectiveness of the excavation.
- **Middle Road System** – Install a temporary well west of well RW-1 to identify the vertical distribution of contaminants in this area. Based on the results of this temporary well, evaluate the pumping rates and pump locations in extraction wells RW-1, RW-2 and RW-3.
- **OU III Western South Boundary System** – A permanent monitoring well will be installed in 2009 to monitor the elevated dichlorodifluoromethane detected between Middle Road and Princeton Avenue. Analytical results from this well will be evaluated for approximately one year and the need for additional actions evaluated.
- **Industrial Park East System** – Because the operation and maintenance manual shutdown criteria of achieving less than 50 μg/L TVOCs for at least four consecutive sampling rounds has

been met in the core monitoring and extraction wells, a Petition for Shutdown of the system will be prepared and submitted to the regulators for review and approval.

- **BGRR/WCF Sr-90 System –** Perform groundwater modeling to determine the number and placement of additional extraction wells necessary to reduce Sr-90 concentrations to levels that will allow for achievement of OU III ROD cleanup goals. Several new extraction wells will be installed. Several temporary wells will also be installed for additional plume characterization.
- **Chemical/Animal Holes Sr-90 System –** Install temporary wells to determine the extent of the Sr-90 contamination detected in well 106-48.
- **Building 650 Sr-90 Plume** – Install two to three temporary wells to characterize the leading edge and width of the plume in this area. A permanent monitoring well may be installed if needed, pending the results.
- **CERCLA Groundwater Monitoring Program** – Sampling frequencies were modified for 143 monitoring wells, the details for which are summarized on **Table 5-1**. This table also recommends a number of wells for abandonment.

Table E-2.
Groundwater Restoration Progress.

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU I					
OU I South Boundary (RA V)	VOCs	Operational	P&T with AS	2011	Continue to monitor an area of elevated VOCs slowly migrating towards treatment system.
Current Landfill	VOCs tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	Groundwater quality slowly improving. VOCs and tritium stable or slightly decreasing.
Former Landfill	VOCs Sr-90 tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	No longer a continuing source of contaminants to groundwater.
Former HWMF	Sr-90	Long Term Response Action	Monitoring	NA	Area of elevated Sr-90 detected above DWS in sentinel well in 2008. Additional characterization recommended.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-1 pulse pumping)	P&T with ion exchange (IE)	2014	Characterized Sr-90 remaining in source area in 2008. System performing as expected.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Standby	P&T with carbon	Complete	No rebound of VOCs observed in monitoring wells during 2008. Preparing Petition for Closure.
Building 96 source control	VOCs	Operational	Recirculation wells with AS for 3 of 4 wells. RTW-1 is P&T with AS.	2014	Treatment well RTW-1 modified for surface discharge in May 2008. Identified high concentration of PCE in soil in 2008. Soil excavation is recommended.
South Boundary	VOCs	Operational (EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2013	Continued decline in monitoring well VOC concentrations at the site boundary with the exception of several wells in the vicinity of EW-4 and EW-5.
Middle Road	VOCs	Operational (RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	Extraction wells RW-1 and RW-2 continue to show moderate VOC levels. Eastern extraction wells showing low VOC concentrations.

continued

Table E-2 *(continued)*.
Groundwater Restoration Progress.

Project	Target	Mode	Treatment Type	Treatment Progress	Expected System Shutdown	Groundwater Quality Highlights
OU III (cont.)						
Western South Boundary	VOCs	Operational (Pulse)	P&T with AS	54 lbs of VOCs treated to date	2019	Extraction well WSB-1 put back into full-time operation due to increasing VOCs in nearby well. WSB-2 continued pulse pumping. Temporary wells were installed in 2008 to characterize upgradient extent of VOC contamination. Additional characterization planned.
Industrial Park	VOCs	Operational (UVB-1 on standby)	In-well stripping	1,033 lbs. of VOCs treated to date.	2012	VOC concentrations continued to decline. Place UVB-7 on standby.
Industrial Park East	VOCs	Operational (Pulse)	P&T with carbon t	35 lbs. of VOCs treated to date.	2009	Concentrations in plume core wells at very low levels in 2008. Preparing Petition for Shutdown.
North Street	VOCs	Operational	P&T with carbon	290 lbs. of VOCs treated to date.	2012	High concentration segment of plume continues to be located in the capture zone of NS-1 and NS-2. Leading edge of plume beyond the capture zone prior to system start-up, migrating towards the Airport system.
North Street East	VOCs	Operational (Pulse)	P&T with carbon	24 lbs. of VOCs treated to date.	2010	Concentrations in plume core wells at very low levels in 2008.
Long Island Power Authority (LIPA) Right of Way/ Airport	VOCs	Operational	P&T and recirculation wells with carbon	260 lbs. of VOCs treated to date.	2014 (LIPA) 2019 (Airport)	Airport wells continued pulse pumping in 2008. A temporary and permanent monitoring well were installed east of RTW-3A.
HFBR Tritium	Tritium	Operational	Pump and recharge	0.2 Curies removed for off-site disposal.* 180 lbs. of VOCs also removed from aquifer & treated.	2012	Leading edge of high concentration slug reaching EW-16.
BGRR/WCF	Sr-90	Operational	P&T with IE	16.9 mCi to date	2019	Continued characterization of area of higher than expected Sr-90 concentrations in downgradient portion of plume that will require system modification to achieve cleanup goal.
OU IV						

Table E-2 *(continued)*.
Groundwater Restoration Progress.

Project	Target	Mode	Treatment Type	Treatment Progress	Expected System Shutdown	Groundwater Quality Highlights
OU IV AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	35 lbs. of VOCs removed.	Complete	VOC concentrations in monitoring wells remain low. System decommissioned in Dec. 2003.
Building 650 sump outfall	Sr-90	Long Term Response Action	Monitored Natural Attenuation (MNA)	Plume slowly migrating south within monitoring- well network.	NA	Sr-90 plume still migrating slowly southwest from Bldg. 650 sump outfall and attenuating.
OU V						
STP	VOCs, tritium	Long Term Response Action	MNA	NA	NA	Low-level VOC plume concentrations continued to slowly decline during 2008. Tritium continued to be detected in monitoring wells just above detection limits.
OU VI						
Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon	NA (due to minimal EDB in influent, no VOC removal is reported).	2015	The EDB plume continues to migrate as predicted. The extraction wells are capturing the plume.

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
HWMF = Hazardous Waste Management Facility (former)
IE = Ion Exchange
lbs. = pounds
MNA = Monitored Natural Attenuation
NA = Not Applicable
NYS AWQS = New York State Ambient Water Quality Standards
P&T = Pump and Treat
RA = Removal Action
STP = Sewage Treatment Plant

* Off-site removal of tritium was conducted during low-flow pumping events conducted in 2000 and 2001.

1.0 INTRODUCTION AND OBJECTIVES

The mission of Brookhaven National Laboratory's Groundwater Protection Program is to protect and restore the aquifer system at Brookhaven National Laboratory (BNL). The program is built on four key elements:

- Pollution prevention–preventing the potential pollution of groundwater at the source
- Restoration–restoring groundwater that BNL operations have impacted
- Monitoring–monitoring the effectiveness of pollution-prevention efforts, as well as progress in restoring the quality of affected groundwater
- Communication–communicating the findings and results of the program to regulators and stakeholders

The *BNL 2008 Groundwater Status Report* is a comprehensive summary of groundwater data collected in calendar year 2008 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the twelfth annual groundwater status report issued by BNL. This document examines performance of the program on a project-by-project (facility-by-facility) basis, as well as comprehensively.

How To Use This Document. This document is a detailed technical report that includes analytical laboratory data, as well as data interpretations conducted by BNL's Groundwater Protection Group. This document can also be obtained through BNL's website. Data are presented in four key subject areas:

- Improvements to the understanding of the hydrogeologic environment and surrounding areas
- Identification of any new impacts to groundwater quality due to BNL's active operations
- Progress in cleaning contaminated groundwater
- Proposed changes to the groundwater protection program

This document satisfies BNL's requirement to report groundwater data under the Interagency Agreement and partially fulfills the commitment of the Groundwater Protection Program to communicate the program's findings and progress to regulators and stakeholders.

Section 1 discusses the regulatory requirements of the data collection work in 2008, the site's groundwater classification, and the objectives of groundwater monitoring. **Section 2** discusses the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2008. In **Section 3**, the groundwater cleanup data and progress towards achieving the site's cleanup goals are described. **Section 4** outlines the groundwater surveillance data used to verify that operational and engineered controls are preventing further contamination from BNL's active experimental and support facilities. **Section 5** is a summary of the proposed recommendations to the Groundwater Protection Program identified in **Sections 3 and 4**.

Appendices A and **B** include hydrogeologic data that support the discussions in **Section 2**. **Appendix C** contains the analytical results for each sample obtained under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) program. **Appendix D** contains analytical results for each sample obtained under the Facility Monitoring program. Due to the volume of these data, all of the report appendices are included on a CD-ROM, which significantly reduces the size of this report in printed format. The CD-ROM has a contents table with active links; by selecting the specific project and analytical suite, the user will be directed to the associated table of results. The groundwater results are arranged by specific monitoring project and analytical group: volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, general chemistry, pesticides/polychlorinated biphenyls (PCBs), and radionuclides. The data are organized further by well identification (ID) and the date of sample collection. Chemical/radionuclide concentrations, detection limits, and uncertainties are reported, along with a data verification, validation, and/or usability qualifier (if assigned), and/or a laboratory data qualifier. If a data verification/validation qualifier was not assigned, the laboratory data qualifier is shown. Results exceeding the corresponding groundwater standard or guidance criteria (see **Section 1.1.2**) are identified by bold text. Including the complete results enables the reader to analyze the data in detail. **Appendix E** contains information on sample collection, analysis, and Quality Assurance/Quality Control (QA/QC). **Appendix F** consists of data supporting the remediation system discussions in **Section 3**, and **Appendix G** is a compilation of data usability report forms.

1.1 Groundwater Monitoring Program

1.1.1 Regulatory Requirements

Activities at BNL are driven by federal and state regulations as well as Department of Energy (DOE) Orders.

Comprehensive Environmental Response, Compensation and Liability Act

On December 21, 1989, BNL was included as a Superfund Site on the National Priorities List (NPL) of contaminated sites identified for priority cleanup. DOE, the United States Department of Environmental Protection (EPA), and the New York State Department of Environmental Conservation (NYSDEC) created a comprehensive Federal Facility Agreement (FFA) that integrated DOE's response obligations under CERCLA, the Resource Conservation and Recovery Act (RCRA), and New York State hazardous waste regulations. The FFA, also known as the interagency agreement, was finalized and signed by these parties in May 1992, and includes a requirement for groundwater monitoring (USEPA 1992).

New York State Regulations, Permits, and Licenses

The monitoring programs for the Current Landfill and Former Landfill are designed in accordance with post-closure Operation and Maintenance requirements specified in 6 NYCRR (New York Code of Rules and Regulations) Part 360, *Solid Waste Management Facilities*.

BNL's Major Petroleum Facility (MPF) is operated under NYSDEC Bulk Petroleum Storage License No. 01-1700. This license requires BNL to routinely monitor the groundwater. Together with approved engineering controls, the groundwater monitoring program verifies that storage operations for bulk fuel have not degraded the quality of the groundwater. The engineered controls and monitoring program for the MPF are described in the *BNL Spill Prevention, Control and Countermeasures Plan* (BNL 2001a).

BNL's Waste Management Facility (WMF) is a hazardous waste storage facility operated under NYSDEC RCRA Part B Permit No. 1-422-00032/00102-0. The permit requires groundwater monitoring as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls.

DOE Orders

DOE Order 450.1, Section 5-D-14, *Responsibilities*, states that DOE facilities are required to "Conduct environmental monitoring, as appropriate, to support the site's ISMS [Integrated Safety Management System], to detect, characterize, and respond to releases from DOE activities; assess impacts; estimate dispersal patterns in the environment; characterize the pathways of exposure to members of the public; characterize the exposures and doses to individuals, to the population; and to evaluate the potential impacts to the biota in the vicinity of the DOE activity" (DOE 2003).

1.1.2 Groundwater Quality and Classification

In Suffolk County, drinking water supplies are obtained exclusively from groundwater aquifers (e.g., the Upper Glacial aquifer, the Magothy aquifer, and, to a limited extent, the Lloyd aquifer). In 1978, EPA designated the Long Island aquifer system as a sole source aquifer pursuant to Section 1424(e) of the Safe Drinking Water Act (SDWA). Groundwater in the sole source aquifers underlying the BNL site is classified as "Class GA Fresh Groundwater" by the State of New York (6 NYCRR Parts 700–705); the best usage of Class GA groundwater is as a source of potable water. Accordingly, in establishing the goals for protecting and remediating groundwater, BNL followed federal Drinking Water Standards (DWS), New York State (NYS) DWS, and NYS Ambient Water Quality Standards (AWQS) for Class GA groundwater.

For drinking water supplies, the applicable federal maximum contaminant levels (MCLs) are set forth in 40 CFR (Code of Federal Regulations) 141 (for primary MCLs) and 40 CFR 143 (for secondary MCLs). In New York State, the SDWA requirements relating to the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code (10 NYCRR Part 5), enforced by the Suffolk County Department of Health Services (SCDHS) as an agent for the New York State Department of Health (NYSDOH). These regulations apply to any water supply that has at least five service connections or that regularly serves at least 25 individuals. BNL supplies water to approximately 3,500 employees and visitors, and therefore must comply with these regulations. In addition, DOE Order 5400.5, *Radiation Protection of the Public and Environment* (DOE 1993), establishes Derived Concentration Guides (DCGs) for radionuclides not covered by existing federal or state regulations.

BNL evaluates the potential impact of radiological and nonradiological levels of contamination by comparing analytical results to NYS and DOE reference levels. Nonradiological data from groundwater samples collected from surveillance wells usually are compared to NYS AWQS (6 NYCRR Part 703.5). Radiological data are compared to the NYS AWQS for tritium, strontium-90 (Sr-90), gross beta; gross alpha, radium-226, and radium-228; and the 40 CFR 141/DOE DCGs for determining the 4 millirems per year (mrem/yr) dose for other beta- or gamma-emitting radionuclides.

Tables 1-1, 1-2, 1-3, and **1-4** show the regulatory and DOE "standards, criteria, and guidance" used for comparisons to BNL's groundwater data.

1.1.3 Monitoring Objectives

Groundwater monitoring is driven by regulatory requirements, DOE Orders, best management practice, and BNL's commitment to environmental stewardship. BNL monitors its groundwater resources for the following reasons:

Groundwater Resource Management

- To support initiatives in protecting, managing, and remediating groundwater by refining the conceptual hydrogeologic model of the site and maintaining a current assessment of the dynamic patterns of groundwater flow and water-table fluctuations.
- To determine the natural background concentrations for comparative purposes. The site's background wells provide information on the chemical composition of groundwater that has not been affected by BNL's activities. These data are a valuable reference for comparison with the groundwater quality data from affected areas. The network of wells also can warn of any contaminants originating from potential sources that may be located upgradient of the BNL site.
- To ensure that potable water supplies meet all regulatory requirements.

Groundwater Facility Monitoring

- To verify that operational and engineered controls effectively prevent groundwater contamination.

- To trigger early action and communication, should the unexpected happen (e.g., control failure).
- To determine the efficacy of the operational and engineered control measures designed to protect the groundwater.
- To demonstrate compliance with applicable requirements for protecting and remediating groundwater.

Groundwater -CERCLA Monitoring

- To track a dynamic groundwater cleanup problem when designing, constructing, and operating treatment systems.
- To measure the performance of the groundwater remediation efforts in achieving cleanup goals.
- To protect public health and the environment during the cleanup period.
- To define the extent and degree of groundwater contamination.
- To provide early warning of the arrival of a leading edge of a plume, which could trigger contingency remedies to protect public health and the environment.

The details of the monitoring are described in the BNL *2008 Environmental Monitoring Plan* (BNL 2008a). This plan includes a description of the source area, description of groundwater quality, criteria for selecting locations for groundwater monitoring, and the frequency of sampling and analysis. **Figure 1-1** highlights BNL's operable unit (OU) locations designated as part of the CERCLA program, and key site features. Details on the sampling parameters, frequency, and analysis by well are listed on **Tables 1-5** and **1-6**. Screen zone, total depth, and ground surface elevations have been summarized on **Table 1-7**. **Figure 1-2** shows the locations of wells monitored as part of the Laboratory's groundwater protection program. Detailed groundwater monitoring rationale can be found in the *BNL Environmental Monitoring Plan*. BNL's CERCLA groundwater monitoring has been streamlined into five general phases **(Table 1-8)**:

<u>Start-up Monitoring</u>

A quarterly sampling frequency is implemented on all wells for a period of two years. This increased sampling frequency provides sufficient data while the system operation is in its early stages.

<u>Operations and Maintenance (O&M) Monitoring</u>

This is a period of reduced monitoring during the time when the system is in a routine operational state. The timeframe for each system varies. This phase is also utilized for several plume monitoring programs not requiring active remediation.

<u>Shutdown Monitoring</u>

This is a two-year period of monitoring implemented just prior to petitioning for system shut down. The increased sampling frequency provides the necessary data to support the shutdown petition.

<u>Standby Monitoring</u>

This is a period of reduced monitoring up to a five-year duration to identify any potential rebounding of contaminant concentrations. If concentrations remain below MCLs, the petition for closure and decommissioning of the system is recommended.

<u>Post Closure Monitoring</u>

This is a monitoring period of varying length for approximately 20% of the key wells in a given project following system closure. Monitoring continues until the Record of Decision (ROD) goal of meeting MCLs in the Upper Glacial aquifer is reached. This is expected to occur by 2030. This phase is considerably longer for the Magothy and Sr-90 cleanups due to greater length of the time to reach MCLs required for those projects.

Since 2001, BNL uses a structured Data Quality Objective (DQO) process to continually review and refine the groundwater monitoring and remediation projects. The results of the DQO reviews are documented annually in updates to the *BNL Environmental Monitoring Plan*.

Table 1-8. CERCLA Groundwater Monitoring Program – Well Sampling Frequency.

Project Activity Phase	Well Type	Phase Duration (yrs.)	Sampling Freq. (events/yr.)****
Start-up Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel/Bypass	2	4x
Operations & Maintenance (O&M) Monitoring	Plume Core	End Start-up to Shutdown*	2x
	Plume Perimeter	End Start-up to Shutdown*	2x
	Sentinel/Bypass	End Start-up to Shutdown*	4x
Shutdown Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel/Bypass	2	4x
Standby Monitoring	Key Plume Core	5	2x
	Plume Perimeter	5	1x
	Sentinel/Bypass	5	2x
Post Closure Monitoring***	20% of key wells	Up To 2030**	1x

Notes:
*- Varies by project, see Table 1-5.
** - Magothy: 2065, BGRR Sr-90: 2070, S. Boundary Rad: 2038, Chem Holes Sr-90: 2045
*** - Verification monitoring for achieving MCLs.
****- Sr-90 monitoring projects use approximately half the defined sampling frequency.

The groundwater monitoring well networks for each program are organized into background, core, perimeter, bypass, and sentinel wells. The wells are designated as follows:

- Background –water quality results will be used to determine upgradient water quality
- Plume Core – utilized to monitor the high concentration or core area of the plume
- Perimeter – used to define the outer edge of the plume both horizontally and vertically
- Bypass – used to determine whether plume capture performance is being met
- Sentinel – An early warning well to detect the leading edge of a plume.

1.2 Private Well Sampling

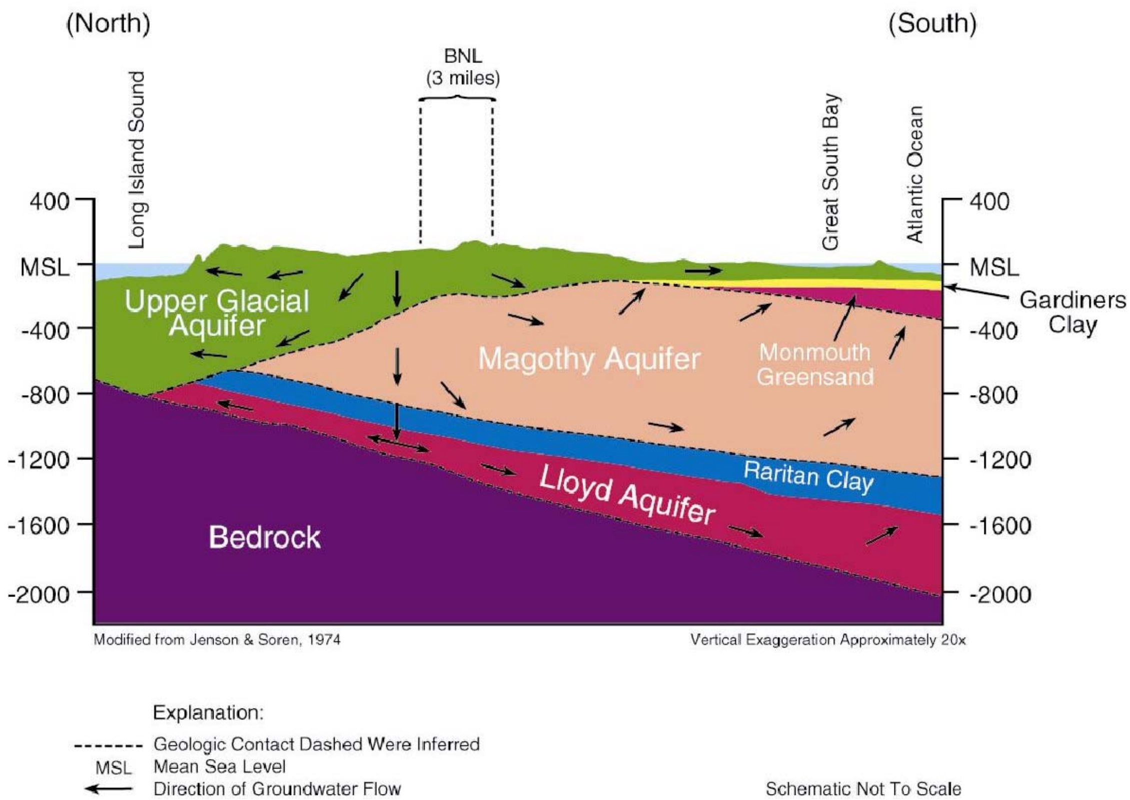
During 2008, there were eight known homeowners in the residential area overlying the plume who continue to use their private wells for drinking water purposes. In accordance with the OU III and OU VI RODs, DOE formally offers these homeowners free testing of their private drinking water wells on an annual basis. SCDHS coordinates and performs the sampling and analysis. During 2008, three of the eight homeowners who were offered the free testing requested the sampling. The results from SCDHS indicate that there were no VOCs detected.

2.0 HYDROGEOLOGY

This section briefly describes the hydrogeologic environment at BNL and the surrounding area. It also summarizes the dynamics of the groundwater flow system in 2008, along with on-site pumping rates and rainfall recharge.

Detailed descriptions of the aquifer system underlying BNL and the surrounding areas are found in the U.S. Geological Survey (USGS) report by Scorca and others (1999), *Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, New York, 1994–97,* and the USGS report by Wallace deLaguna (1963), *Geology of Brookhaven National Laboratory and Vicinity, Suffolk County, New York.* The stratigraphy below BNL consists of approximately 1,300 feet of unconsolidated deposits overlying bedrock (**Figure 2-1**). The current groundwater monitoring program focuses on groundwater quality within the Upper Pleistocene deposits (Upper Glacial aquifer), and the upper portions of the Matawan Group-Magothy Formation (Magothy aquifer).

Figure 2-1.
Generalized Geologic Cross Section in the Vicinity of Brookhaven National Laboratory.



The Pleistocene deposits are about 100–200 feet thick and are divided into two primary hydrogeologic units: undifferentiated sand and gravel outwash and moraine deposits, and the finer-grained, more poorly sorted Upton Unit. The Upton Unit makes up the lower portion of the Upper Glacial aquifer beneath several areas of the site. It generally consists of fine- to medium-grained white to greenish sand with interstitial clay. In addition to these two major hydrogeologic units, there are several other distinct hydrogeologic units within the Upper Glacial aquifer. They include localized, near-surface clay layers in the vicinity of the Peconic River (including the Sewage Treatment Plant [STP] area), and reworked Magothy deposits that characterize the base of the aquifer in several areas. The Gardiners Clay is a regionally defined geologic unit that is discontinuous beneath BNL and areas to the south. Typically, it is characterized by variable amounts of green silty clay, sandy and gravelly green clay, and clayey silt.

Where it exists, the Gardiners Clay acts as a confining or semi-confining unit that impedes the vertical flow and migration of groundwater between the Upper Glacial aquifer and the underlying Magothy aquifer.

The Magothy aquifer is composed of the continental deltaic deposits of the Cretaceous Age that unconformably underlie the Pleistocene deposits. The Magothy aquifer at BNL is approximately 800 feet thick, and because it is composed of fine sand interbedded with silt and clay, it is generally less permeable than the Upper Glacial aquifer. The Magothy aquifer is highly stratified. Of particular importance at BNL is that the upper portion of the Magothy contains extensive, locally continuous layers of grey-brown clay (referred to herein as the Magothy Brown Clay). Regionally, the Magothy Brown Clay is not interpreted as being continuous; however, beneath BNL and adjacent off-site areas, it acts as a confining unit (where it exists), impeding the vertical flow and movement of groundwater between the Upper Glacial and Magothy aquifers.

Regional patterns of groundwater flow near BNL are influenced by natural and artificial factors. **Figures 2-2 and 2-3** show the locations of pumping wells and recharge basins. Under natural conditions, recharge to the regional aquifer system is derived solely from precipitation. A regional groundwater divide exists immediately north of BNL near Route 25. It is oriented roughly east–west, and appears to coincide with the centerline of a regional recharge area. Groundwater north of this divide flows northward, ultimately discharging to the Long Island Sound (**Figure 2-1**). Shallow groundwater in the BNL area generally flows to the south and east. During high water-table conditions, that groundwater can discharge into local surface water bodies such as the Peconic River and adjacent ponds. The BNL site is within a regional deep-flow recharge area, where downward flow helps to replenish the deep sections of the Upper Glacial aquifer, the Magothy aquifer, and the Lloyd aquifer. South of BNL, groundwater flow becomes more horizontal and ultimately flows upward as it moves toward regional discharge areas such as Carmans River and Great South Bay. Superimposed on the natural regional field of groundwater flow are the artificial influences due to pumping and recharge operations.

2.1 Hydrogeologic Data

Various hydrogeologic data collection and summary activities were undertaken as part of the 2008 Groundwater Protection Program to evaluate groundwater flow patterns and conditions. This work is described in the following sections and includes the results of groundwater elevation monitoring, information on pumping and recharging activities on and off site, and precipitation data.

2.1.1 Groundwater Elevation Monitoring

Synoptic water levels are obtained quarterly from a network of on-site and off-site wells screened at various depths within the Upper Glacial aquifer and upper portions of the Magothy aquifer. These data are used to characterize the groundwater flow-field (direction and rate) and to evaluate seasonal and artificial variations in its flow patterns. Additional water-level data from off-site wells are obtained from the USGS.

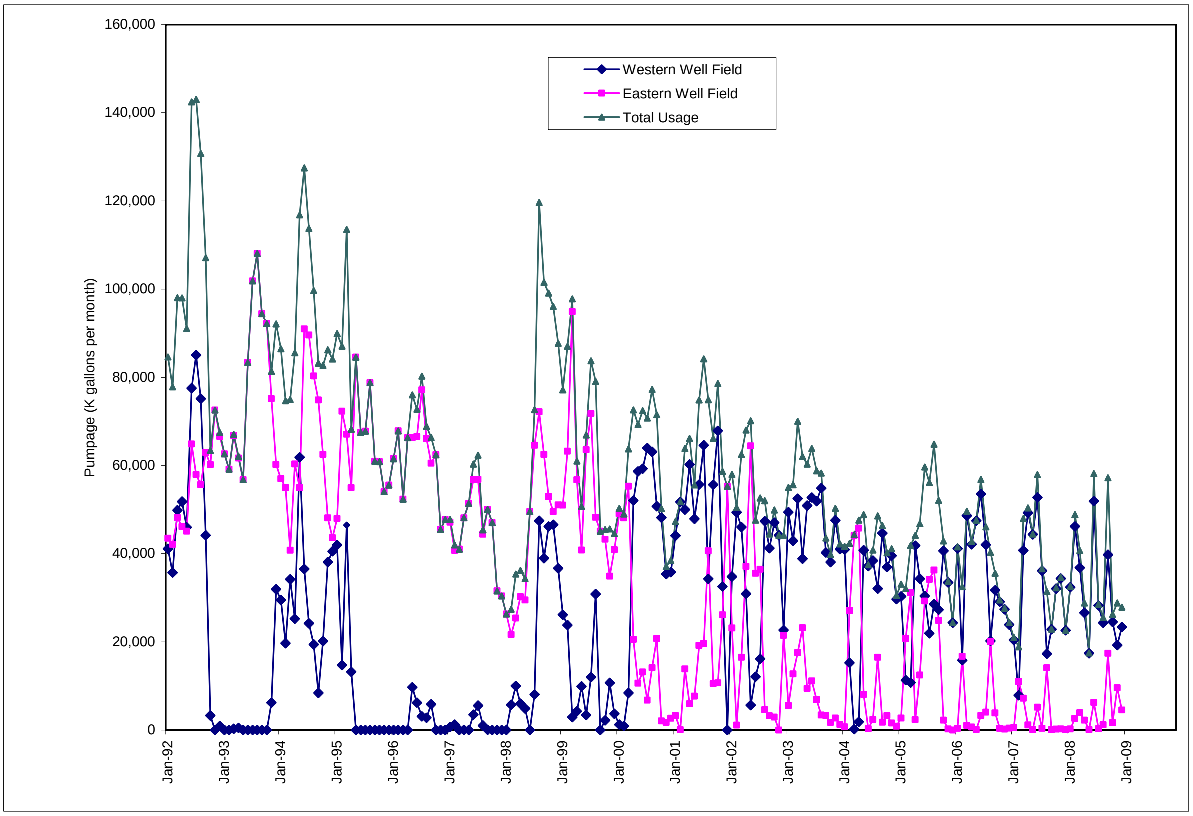
The quarterly synoptic water-level measurement events comprising the complete network of on-site and off-site wells were conducted in June and November 2008, with data collected from approximately 775 wells. Smaller scale synoptic measurement using wells located only in the central part of the BNL site were conducted in April and September 2008, with data collected from approximately 100 shallow glacial wells. Water levels were measured with electronic water-level indicators following the BNL *Environmental Monitoring Standard Operating Procedure* EM-SOP-300. **Appendix A** provides the depth-to-water (DTW) measurements and the calculated groundwater elevations for these measurements. Monitoring results for long-term and short-term hydrographs for select wells are discussed in **Section 2.2**.

2.1.2 Pumpage of On-Site Water Supply and Remediation Wells

BNL operates six water supply wells to provide potable and process cooling water, and 61 treatment wells. All six water supply wells are screened entirely within the Upper Glacial aquifer. During 2008, 14 of the 61 treatment wells were in standby mode. **Figures 2-2** and **2-3** show the locations of the water supply and remediation wells. The effects the groundwater withdrawals have on the aquifer system are discussed in **Section 2.2**.

Table 2-1 provides the monthly and total water usage for 2008 for the six on-site potable supply wells (4, 6, 7, 10, 11, and 12). It includes information on each well's screened interval and pumping capacity. These wells primarily withdraw groundwater from the middle to deep sections of the Upper Glacial aquifer. The variation in monthly pumpage primarily reflects changes in water demand, and maintenance schedules for the water supply system. The western potable well field includes wells 4, 6, and 7; the eastern field contains wells 10, 11, and 12. The water supply operating protocols, which have been established by the BNL Water and Sanitary Planning Committee, currently require that the western well field be used as the primary source of water, with a goal of obtaining 75 percent or more of the site-wide water supply from that well field. Using the western well field minimizes the groundwater flow direction effects of supply well pumping on several segments of the groundwater contaminant plumes located in the center of the BNL site. **Figure 2-4** below summarizes monthly pumpage for the eastern and western well fields. Supply well 12 has been out of service since October 2008, when a propane gas explosion destroyed the pump house and associated pump controls.

Figure 2-4.
Summary of BNL Supply Well Pumpage 1992 through 2008.



Since 1999, the implementation of effective water conservation measures has resulted in a significant reduction in the amount of water pumped from the aquifer. During 2008, a total of 421 million gallons of water were withdrawn from the aquifer, and BNL met its goal of obtaining more than 75 percent of its total water supply from the western well field. The western well field provided approximately 90 percent of the water supply, with most of the pumpage obtained from wells 6 and 7. Supply well 10 has been maintained in standby mode since 2000 due to the impacts it might have on contaminant plume flow directions in the central portion of the site (especially on the g-2 tritium plume and the Waste Concentration Facility Sr-90 plume). However, with the loss of well 12 following the October 2008 propane gas explosion, in early 2009 BNL started to use well 10 for short periods of time. **Table 2-2** summarizes the 2008 BNL process water usage. **Table 2-3** summarizes the 2008 monthly water pumpage for the groundwater remediation systems. Additional details on groundwater remediation system pumping are provided in **Section 3** of this report.

2.1.3 Off-Site Water Supply Wells

Several Suffolk County Water Authority (SCWA) well fields are located near BNL. The William Floyd Well Field is west/southwest of BNL (**Figures 2-2 and 2-3**), and consists of three water supply wells that withdraw groundwater from the mid Upper Glacial aquifer and the upper portion of the Magothy aquifer. The Country Club Drive Well Field is south/southeast of BNL, and consists of three water supply wells that withdraw groundwater from the mid section of the Upper Glacial aquifer. Pumpage information for 1989 through 2008 is provided as **Figure 2-5.** In 2008, the William Floyd (Parr Village) and Country Club Drive Well Fields produced 598 and 564 million gallons for the year, respectively. The Lambert Avenue Well Field, located south of BNL, produced 229 million gallons for the year.

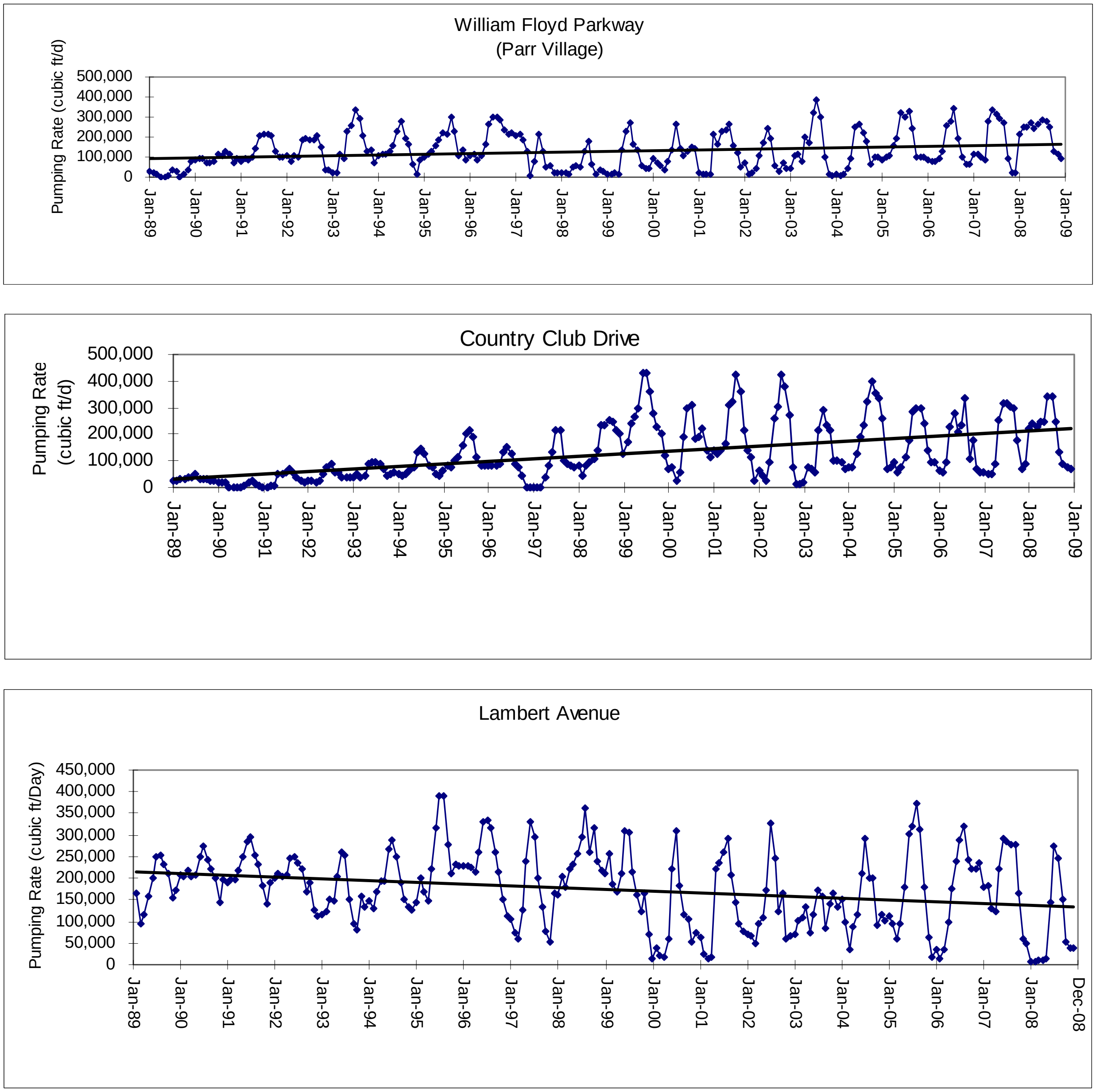
2.1.4 Summary of On-Site Recharge and Precipitation Data

This section summarizes artificial (i.e., on-site recharge basins) and natural recharge from precipitation. **Table 2-4** summarizes the monthly and total flow of water through 10 on-site recharge basins during 2008. Their locations are shown on **Figures 2-2 and 2-3**. **Section 2.2** (Groundwater Flow) provides a discussion on the effects associated with recharge. Seven of the basins (HN, HO, HS, HT-W, HT-E, HX, and HZ) receive stormwater runoff and cooling water discharges. Flow into these basins is monitored monthly per NYSDEC State Pollutant Discharge Elimination System (SPDES) permit requirements. Generally, the amount of water recharging through the groundwater system to these basins reflects supply well pumpage. Annual water supply flow diagrams show the general relationships between recharge basins and the supply wells, and are published in Volume I of the annual *Site Environmental Report (Chapter 5, Water Quality)*.

The remaining three basins (Removal Action V [RA V], OU III, and Western South Boundary) were constructed to recharge water processed through several of the groundwater remediation systems. Until September 2001, treated groundwater from the OU III South Boundary Pump and Treat System was discharged solely to the OU III basin, adjacent to former recharge basin HP along Princeton Avenue. After September 2001, groundwater from that system and the OU III Middle Road and High Flux Beam Reactor (HFBR) systems was discharged equally to the OU III and RA V basins. Treated groundwater from the OU I South Boundary is discharged to the RA V basin. **Table 2-4** gives estimates of flow to these basins. The discharge to these basins for 2008 (14 and 9 million gallons per month, average, for the OU III and RA V basins, respectively) is significantly greater than that from other individual on-site basins. Pulse pumping and the placement of several groundwater remediation extraction wells on standby resulted in an overall decrease of discharge totals.

Other important sources of artificial recharge, not included on **Table 2-4**, include a stormwater retention basin referred to as HW (on Weaver Drive), and the sand filter beds at the STP. Basin HW causes localized mounding of the water table. At the sand filter beds, approximately 10 to 15 percent of the treated effluent (approximately 15 million gallons annually) seeps directly to the underlying water table beneath the underlying tile-drain collection system. The remaining treated effluent (approximately 130 million gallons annually) is discharged to the Peconic River. Most of the water released to the Peconic River recharges to the aquifer before it reaches the BNL site boundary, except during times of seasonally high water levels.

Figure 2-5.
Suffolk County Water Authority Pumping Near BNL.



Precipitation provides the primary recharge of water to the aquifer system at BNL. In an average year, approximately 24 inches of rainfall recharges the Upper Glacial aquifer. Under long-term conditions in undeveloped areas of Long Island, about 50 percent of precipitation is lost through evapotranspiration and direct runoff to streams; the other 50 percent infiltrates the soil and recharges the groundwater system (Aronson and Seaburn 1974; Franke and McClymonds 1972). In 2008, it is estimated that the recharge at BNL was approximately 25 inches. **Table 2-5** summarizes monthly and annual precipitation results from 1949 to 2008 collected on site by BNL Meteorology Services. Variations in the water table generally can be correlated with seasonal precipitation patterns. As depicted on **Table 2-5**, total annual precipitation in

2008 was 51.17 inches, which was above the long-term yearly average of 48.76 inches. Seven of the past 10 years have featured above-normal annual average precipitation at BNL.

2.2 Groundwater Flow

BNL routinely monitors horizontal and vertical groundwater flow directions and magnitudes within the Upper Glacial aquifer and uppermost Magothy aquifer by using water-level data collected from a large network of on-site and off-site monitoring wells. Short-term and long-term seasonal fluctuations of water levels are also evaluated using hydrographs for select wells, and trends in precipitation.

2.2.1 Water-Table Contour Map

Figure 2-2 is a groundwater elevation contour map representing the configuration of the water table for November 2008. The contours were generated from the water-level data from shallow Upper Glacial aquifer wells, assisted by a contouring package (Quick SURF). Localized hydrogeologic influences on groundwater flow were considered, including on-site and off-site pumping wells, and on-site recharge basins (summarized in **Section 2.1**).

Groundwater flow in the shallow Upper Glacial aquifer is generally characterized by a southeasterly component of flow in the northern portion of the site, with a gradual transition to a more southerly direction at the southern boundary and beyond. Flow directions in the eastern portion of BNL are predominately to the east and southeast (**Figure 2-2**). The general groundwater flow pattern for 2008 was consistent with historical flow patterns. As described in **Section 2.1.2**, the water supply operating protocols established by BNL in late 2005 require that the western well field be used as the primary source of water, with a goal of obtaining 75 percent or more of the site's water supply from these wells. This protocol has resulted in a more stable south-southeast groundwater flow direction in the central portion of the site.

Localized man-made disturbances to groundwater flow patterns are evident on the groundwater contour maps. They result primarily from active on-site and off-site well pumpage and the discharge of water to on-site recharge basins. Influences from the pumping wells can be seen as cones of depressions, most notably near potable supply wells 4 and 7, and near the groundwater treatment wells along the southern boundary (**Figure 2-2**).

Influences from water recharge activities can be observed as localized mounding of the water table, particularly around recharge basin OU III and the RA V basin (in the center of the site), and the STP. The degree of mounding is generally consistent with the monthly flows to recharge basins summarized in **Section 2.1**. However, the extent of some of the mounding also reflects the ability of the underlying deposits to transmit water, which varies across the site. For example, the volume of recharged water at the STP sand filter beds typically is not as great as that at recharge basin OU III or the RA V basin. However, the presence of near-surface clay layers underlying portions of the STP sand filter beds results in an extensive groundwater mound.

Other noteworthy features are the influence that surface water bodies have on groundwater flow directions. **Figure 2-2** shows groundwater flowing towards the Carmans River in areas south/southwest of BNL. This pattern is consistent with the fact that the Carmans River is a significant discharge boundary.

2.2.2 Deep Glacial Contour Map

Figure 2-3 shows the potentiometric surface contour map of the deep zone of the Upper Glacial aquifer for November 2008. The contours were generated in the same manner as the water-table contours, but using water-level data from wells screened only within the deep sections of the Upper Glacial aquifer.

The 2008 patterns for groundwater flow in the deep Upper Glacial are similar to those in the shallow (or water-table) zone. They are characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly flow at the southern site boundary and beyond. In areas south/southwest of BNL, the deep glacial contour map also indicates flow toward the Carmans River. The localized influences of pumping on the potentiometric surface configurations are evident as cones of depression. As with the water-table configurations, variations in these localized hydrogeologic effects are attributed to the monthly variations in pumpage.

Although the localized influences of recharging on the potentiometric surface configurations are evident for the deep Upper Glacial aquifer, they are not as pronounced as those observed at the water table. Such hydrogeologic effects generally decrease with depth in the aquifer. Furthermore, mounding is not present beneath the STP sand filter beds because mounding is controlled by shallow, near-surface clay layers. Finally, the surface water/groundwater interactions that take place along the Peconic River in the vicinity of BNL do not influence the deep glacial zone.

2.2.3 Well Hydrographs

Groundwater hydrographs are useful in estimating recharge rates and the location of the water table relative to contaminant sources. Long-term (typically 1950–2008) and short-term (1997–2008) well hydrographs were constructed from water-level data that were obtained for select USGS and BNL wells, respectively. These hydrographs track fluctuations in water level over time. Precipitation data also were compared to natural fluctuations in water levels. **Appendix B** contains the well hydrographs, together with a map depicting the locations of these wells.

A long-term hydrograph was constructed from historical water-level data from BNL well 065-14 (NYSDEC # S-5517.1; USGS Site Number 405149072532201). This well was installed by the USGS for the DOE in the late 1940s. The well is located near the BNL Brookhaven Center building, and is screened in the Upper Glacial aquifer close to the water table. The USGS has collected monthly water-level information from this well from 1953 through 2005. In 2006, the USGS installed a real time continuous water-level recorder in the well. Data from this monitoring station can be accessed on the World Wide Web at: http://groundwaterwatch.usgs.gov/AWLSites.asp?S=405149072532201&ncd=rtn.

The long-term hydrographs indicate that typical seasonal water-table elevation fluctuations are on the order of 4 to 5 feet. Some of the water-table elevation changes have occurred during prolonged periods of low precipitation, where a maximum fluctuation of nearly 14 feet was observed during the regional drought of the early 1960s.

Short-term hydrographs from three well clusters (well cluster 075-39/075-40/075-41, 105-05/105-07/105-24, and 122-01/122-04/122-05) are used to evaluate water-table fluctuations and fluctuations in vertical gradients from 1999 through 2008. Generally, the highest groundwater elevations can be observed during the March-May time period in response to snow melt and spring rains. Normally, the position of the water table drops through the summer and into the fall. Water-table elevations during 2007 and 2008 showed a relatively steady decline from 2006, when precipitation values of nearly 12 inches above average resulted in water levels that were the highest observed since 1997 and just below some of the highest recorded water elevations observed since record keeping began in the early 1950s (**Table 2-5)**.

2.2.4 Groundwater Gradients and Flow Rates

Evaluation of the horizontal hydraulic gradients provides information on the driving force behind groundwater flow. These gradients can be used with estimates of aquifer parameters such as hydraulic conductivity (175 feet per day [ft/day]) and effective porosity (0.24) to assess the velocities of groundwater flow. The horizontal hydraulic gradient at the BNL site is typically 0.001 feet per foot (ft/ft), but in recharge and pumping areas it can steepen to 0.0024 ft/ft or greater. The natural groundwater flow velocity in most parts of the site is estimated to be approximately 0.75 ft/day, but flow velocities in recharge areas can be as high as 1.45 ft/day, and those in areas near BNL supply wells can be as high as 28 ft/day (Scorca et al. 1999).

2.3 New Geologic Data

Although a number of new wells were drilled in the central and southern portions of the BNL site during 2008, most of the geologic information obtained during their installation was consistent with previous investigations. However, data obtained during the installation of OU I vertical profile well 107-38 indicated that the Gardiners Clay is present approximately 300 feet further to the south than previously known. Based upon this information, the geologic map and model layer of the extent of the Gardiners Clay in this area has been modified.

2.4 Monitoring Well Abandonment Program

BNL has a program to abandon groundwater monitoring wells and water supply wells that are no longer needed for routine monitoring or water supply. During 2008, 64 groundwater monitoring wells were abandoned under this program. Eleven of these wells were abandoned because they were located in the construction foot print of the new National Synchrotron Light Source II (NSLS-II). These wells were actively used for collecting water-table elevation data or for surveillance of the HFBR tritium plume. At the conclusion of NSLS-II construction, several new wells will be installed to provide needed piezometric data. Rather than install permanent replacement wells for the HFBR tritium plume, temporary wells will be periodically installed to monitor the migration of the plume in this area. The wells were abandoned using the protocols defined in BNL standard operating procedure EM-SOP-104, *Abandonment of Monitoring Wells, Supply Wells and Remediation Wells*. This procedure conforms to NYSDEC Region II well abandonment guidelines. **Table 5-1** provides a list of the next set of monitoring wells that will be abandoned.

3.0 CERCLA GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during 2008. The chapter is organized first by Operable Unit, and then by the specific groundwater remediation system and/or monitoring program. **Figure 1-2** shows the locations of monitoring wells throughout the site by project. Monitoring well location maps specific to particular monitoring programs are included throughout **Section 3**.

Report and Data on CD

Appendices C and D contain the analytical results for each sample. Due to the large volume of data, these appendices are included on a CD-ROM; this significantly reduces the size of the hardcopy of this report. The CD-ROM has a table of contents with active links, such that, by selecting the specific project and analytical suite, the user will be directed to the associated table of results. The groundwater results are arranged by specific monitoring project and then by analytical group (e.g., VOCs, SVOCs, metals, chemistry, pesticides/PCBs, and radionuclides). The data are further organized by well ID and the collection date of the sample. Chemical/radionuclide concentrations, detection limits, and uncertainties are reported, along with a data verification, validation, and/or usability qualifier (if assigned), and/or a laboratory data qualifier. If a data verification/validation qualifier was not assigned, the laboratory data qualifier is presented. Results that exceed the corresponding groundwater standard or guidance criteria (**Section 1.1.1** [Regulatory Requirements]) are in bold text. The complete analytical results are included to allow the reader the opportunity for detailed analysis. In addition, this entire report is included on the CD-ROM with active links to tables and figures.

About the Plume Maps

Maps are provided that depict the areal extent and magnitude of the contaminant plumes. In most cases, the VOC plumes were simplified by using the total VOC (TVOC) values for drawing the contours, except for those plumes that consist almost exclusively of one chemical, such as the OU III Carbon Tetrachloride plume and the OU VI Ethylene Dibromide (EDB) plume. TVOC concentrations are a summation of the individual concentrations of VOCs analyzed by EPA Method 524.2.

The extent of plumes containing VOC contamination was contoured to represent concentrations that were greater than the typical NYS AWQS of 5 micrograms per liter (µg/L) for most compounds. Radionuclide plumes were contoured to their appropriate drinking water standard (DWS). **Figure 3.0-1** shows the VOC and radionuclide plumes as well as the locations and groundwater capture zones for each of the treatment systems.

Following the capping of the landfill areas and the beginning of active groundwater remediation systems in 1997, there have been significant changes in the size and concentrations of several of the VOC plumes. These changes can be attributed to the following:

- The beneficial effects of active remediation systems
- Source control and removal actions
- The impacts of BNL pumping and recharge on the groundwater flow system
- Radioactive decay, biological degradation, and natural attenuation

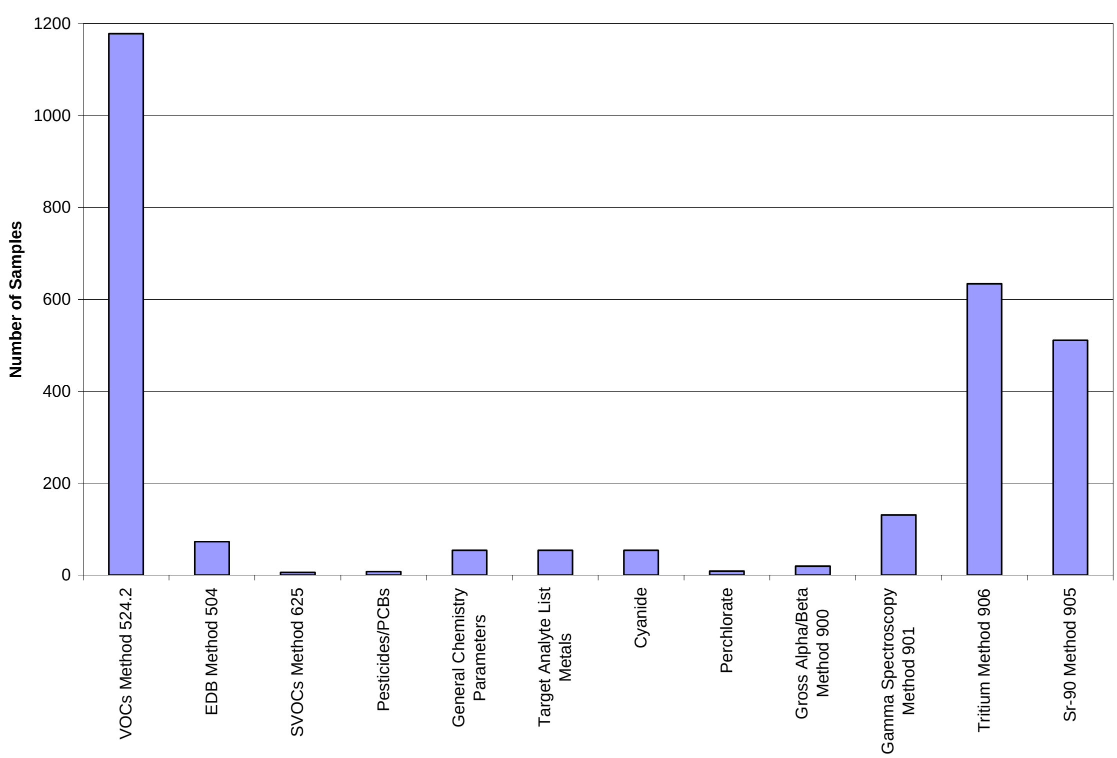
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by the:

- installation of additional permanent monitoring wells to the existing well networks
- installation of temporary wells that helped to fill in data gaps

During 2008, the contaminant plumes were tracked by collecting 1,815 groundwater samples obtained from 735 on-site and off-site monitoring wells. **Figure 3.0-2** below provides a summary of the number of analyses performed, arranged by analytical method. Unless otherwise noted, the extent of contamination for a given plume is depicted by primarily using 2008 data from permanent monitoring wells. In several cases, data from temporary wells installed during the first three months of 2009 were utilized. Contaminant plumes associated with OU I South Boundary, HFBR Tritium, Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) Sr-90, Chemical Holes Sr-90, Building 96, Western South Boundary, Carbon Tetrachloride, Middle Road, and g-2 Tritium Plume projects were further defined in 2008 or the first three months of 2009 using temporary wells (i.e., direct push Geoprobes® or vertical profiles).

A single representative round of monitoring data was usually chosen for each plume, typically from the last quarter of the year because it includes the most comprehensive sampling round for the year. This report also serves as the fourth quarter operations report for the remediation systems. Contaminant concentration trend plots for key monitoring wells in each plume are provided to identify significant changes. Data from monitoring wells sampled under BNL's Facility Monitoring Program are evaluated in **Section 4.0**.

Figure 3.0-2.
Summary of Laboratory Analyses Performed for the CERCLA Monitoring Program in 2008.



History and Status of Groundwater Remediation at BNL

Groundwater remediation systems have operated at BNL since 1997 beginning with the OU I South Boundary Pump and Treat System. The goal of groundwater remediation, as defined by the OU III Record of Decision, is to prevent or minimize plume growth and not to exceed MCLs in the Upper Glacial aquifer within 30 years or less (by 2030). Based on additional information obtained during the Strontium-90 Pilot Study, the *OU III Explanation of Significant Differences* (BNL 2005a) identified changes to the cleanup goal timeframes for the Sr-90 plumes. For the BGRR/WCF and Chemical Holes Sr-90 plumes, MCLs must be reached by 2070 and by 2040, respectively. In addition, cleanup of the Magothy aquifer VOC contamination must meet MCLs by 2065.

There are currently 14 groundwater remediation systems in operation. One system remains in standby mode (the Carbon Tetrachloride Pump and Treat System) and a Petition for Closure is being prepared. Another system has met its cleanup goals and has been decommissioned: the OU IV, Area of Concern (AOC) 5, Air Sparge/Soil Vapor Extraction System (OU IV AS/SVE). **Figure 3.0-1** shows the locations and groundwater capture zones for each of the treatment systems. In addition to the groundwater treatment systems, two landfill areas (Current and Former) were capped, which minimizes the potential for groundwater contamination.

BNL's Facilities and Operations personnel perform routine maintenance checks on the treatment systems in addition to their routine and non-routine maintenance. BNL's Environmental Protection Division (EPD) collects the treatment system performance samples. In 2008, 1,023 treatment system samples were obtained from 302 sampling points. The data from the treatment system sampling is available in **Appendix F** tables. Full details of the maintenance checks are recorded in the system's operation and maintenance daily inspection logs. The daily logs are available at the treatment facility, or in the project files.

In general, BNL uses two types of groundwater remediation systems to treat VOC contamination: pump and treat with air stripping or carbon treatment, or recirculation wells with air stripping or carbon treatment. Pump and treat remediation consists of pumping groundwater from the plume up to the surface and piping it to a treatment system, where the contaminants are removed by either air stripping or granular activated carbon. Treated water is then introduced back into the aquifer via recharge basins, injection wells, or dry wells. BNL utilizes pump and treat using ion-exchange resin for remediating Sr-90. Pump and recharge (without treatment) is utilized to hydraulically contain the HFBR tritium plume. Starting in 2008, BNL also used ion-exchange treatment for localized hexavalent chromium groundwater contamination at Building 96.

Table 3.0-1 summarizes the operating remediation systems. Groundwater remediation at BNL is proceeding as projected. As discussed in the following sections, groundwater modeling is also used as a tool to help determine if remediation of the plumes is proceeding as planned to meet the overall groundwater cleanup goals. When modifications to the remediation systems are necessary, the groundwater model is also used as a tool to aid in the design.

Table 3.0-1. 2008 Summary of Groundwater Remediation Systems at BNL.

Operable Unit System	Type	Target Contaminant	No. of Wells	Years in Operation	Recharge Method	Pounds VOCs Removed in 2008/Cumulative
Operable Unit I						
South Boundary	P&T, AS	VOC	2	11	Basin	10/347
Operable Unit III						
South Boundary	P&T, (AS)	VOC	7	11	Basin	60/2630
HFBR Pump and Recharge	Pump and Recirculate	Tritium	4	Operate: 4.5 Standby: 6.5	Basin	0/180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	7	9	Recirculation Well	24/1033
*Carbon Tet	P&T (Carbon)	VOC	3	Operate: 5 Standby: 4	Basin	NA/349
****Building 96	Recirculation Well (AS/Carbon)	VOC	4	Operate: 5 Standby: 3	Recirculation Well	13/84
Middle Road	P&T (AS)	VOC	6	7	Basin	56/798
Western South Boundary	P&T (AS)	VOC	2	6	Basin	5/54
Chemical Holes	P&T (IE)	Sr-90	3	6	Dry Well	0.74**/3.3
North Street	P&T (Carbon)	VOC	2	4	Wells	21/290
North Street East	P&T (Carbon)	VOC	2	4	Wells	5/24
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	10	4	Wells and Recirculation Well	23/260
Industrial Park East	P&T (Carbon)	VOC	2	4	Wells	3/35
BGRR/WCF	P&T (IE)	Sr-90	5	3	Dry Wells	2.7**/16.9
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	4	Wells	NA***

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
EDB = ethylene dibromide
IE = Ion Exchange
LIPA = Long Island Power Authority
NA = Not Applicable
* This system was shut down August 1, 2004 and put in standby mode.
P&T = Pump and Treat
Recirculation = Double screened well with discharge of treated water back to the same well in a shallow recharge screen
In-Well = The air stripper in these wells is located in the well vault.

** Sr-90 removal is expressed in mCi.
*** EDB was only detected in the system influent in 2008 below the standard. Therefore, no removal of VOCs is reported.

**** Well RTW-1 was modified from a recirculation well to surface discharge in May 2008. At the same time, hexavalent chromium treatment via ion-exchange resin was also added to RTW-1.

3.1 OPERABLE UNIT I

The two sources of groundwater contamination contained within the OU I project are the former Hazardous Waste Management Facility (HWMF) and the Current Landfill. The former HWMF was BNL's central RCRA receiving facility for processing, neutralizing, and storing hazardous and radioactive wastes for off-site disposal until 1997, when a new Waste Management Facility was constructed along East Fifth Avenue. Several hazardous materials spills were documented at the former HWMF. A soil remediation program was completed for this facility in September of 2005.

The plumes from the Current Landfill and former HWMF became commingled south of the former HWMF. The commingling was partially caused by the pumping and recharge effects of the Spray Aeration System, which operated from 1985 to 1990. This system was designed to treat VOC-contaminated groundwater originating from the former HWMF. The VOC plume is depicted on **Figure 3.1-1**.

The on-site segment of the Current Landfill/former HWMF plume is being remediated by a groundwater pump and treat system consisting of two wells screened in the deep portion of the Upper Glacial aquifer at the site property boundary (OU I South Boundary Treatment System). The extracted groundwater is treated for VOCs by air stripping, and is recharged to the ground at the RA V basin, located northwest of the Current Landfill (**Figure 3.1-1**). A second system (North Street East System) was built to treat the off-site portion of the plume. The off-site groundwater remediation system began operations in June 2004 and was included under the Operable Unit III Record of Decision (**Section 3.2.9**).

Tritium was detected in several on-site monitoring wells at concentrations below the 20,000 pico Curies per liter (pCi/L) DWS in 2008. Sr-90 is detected in on-site wells, two of which exceeded the 8 pCi/L DWS in 2008, as discussed in **Section 3.1.5.**

3.1.1 OU I South Boundary Pump and Treat System

This section summarizes the operational and monitoring well data for 2008 from the OU I South Boundary Groundwater Pump and Treat System, and presents conclusions and recommendations for its future operation. This system began operating in December 1996.

Three quarterly reports were prepared with the operational data from January 1, 2008 through September 30, 2008. This Report also serves as a summary of the fourth quarter operational data. Discharge Monitoring Reports for treated effluent water from the air-stripping tower were submitted to EPA and NYSDEC each month.

3.1.2 System Description

For a complete description of the OU I South Boundary Treatment System, see the *Operations and Maintenance Manual for the RA V Treatment Facility* (BNL 2005b).

3.1.3 Groundwater Monitoring

Well Network

The OU I South Boundary monitoring program uses a network of 46 monitoring wells (**Figure 1-2).** A discussion of monitoring well data specific to the Current Landfill source area is provided in BNL *2008 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2009a).

Sampling Frequency and Analysis

The wells are monitored as per the schedule provided on **Table 1-5**.

3.1.4 Monitoring Well VOC Results

Figure 3.1-1 shows the areal extent of VOC contamination from the Current Landfill/former HWMF area based on the full round of samples collected in the third and fourth quarters of 2008. The primary VOCs detected in the on-site segment of this plume include chloroethane and dichloroethane (DCA), which originated from the Current Landfill. The VOCs prevalent in the off-site segment of the plume (North Street East) are 1,1,1-trichloroethane (TCA), 1,1-dichloroethylene (DCE), trichloroethylene (TCE), and chloroethane. TVOC concentrations less than 40 µg/L are currently detected in monitoring wells immediately downgradient of the Current Landfill. The landfill was capped in November 1995 and the leading edge of the VOC plume appears to be attenuating to TVOC levels below 5 µg/L approximately 800 feet southeast of the landfill footprint.

The OU I South Boundary/North Street East plume (defined by TVOC concentrations greater than 5 µg/L) extends from south of the former HWMF and monitoring well 098-59 to the site boundary (a distance of approximately 2,000 feet), where it has been hydraulically cut off from the off-site segment of the plume by extraction wells EW-1 and EW-2. The areas of the plume displaying the highest TVOC concentrations (greater than 50 µg/L) were between monitoring wells 107-40/107-41 and EW-2. Well 107-41 was installed in 2008 and is approximately 1,000 feet north of EW-2. The off-site portion of the plume is discussed in **Section 3.2.9,** the North Street East Pump and Treat System.

Figure 3.1-2 shows the vertical distribution of VOCs. The transect line for cross-section A–A' is shown on **Figure 3.1-1**. DCA and chloroethane are primarily detected in the shallow zone of the Upper Glacial aquifer near the source areas, and in the deep Upper Glacial at the site boundary and off site. TCA, DCE, TCE, chloroethane, and chloroform are found in the mid to deep Upper Glacial aquifer off site, south of North Street.

The plume remains bounded by the current network of wells. **Figure 3.1-3** gives the historical trends in VOC concentrations for key plume core and bypass wells that monitor the plume. **Appendix C** has a complete set of 2008 analytical results for the 44 wells. Significant findings for 2008 include:

- The trailing edge of the OU I South Boundary plume has migrated approximately 250 feet south of former plume core well 098-59 (**Figure 3.1-3**) based on the last several years of data. This well began to show a steadily decreasing trend in TVOC concentrations during 2002 after peaking at 371 µg/L in 1997, as a high-concentration slug of VOCs continues to migrate southward. The third-quarter 2008 TVOC concentration in this well was 0.5 µg/L and the concentration has remained below 7 µg/L since the third quarter of 2005. This well is screened in the Upton Unit immediately above the Gardiners Clay.
- Monitoring well 107-40 was installed to assist in defining the VOC hot spot migration south of well 098-59 and was sampled for the first time in 2006. TVOC concentrations during 2008 decreased from 154 µg/L in the first quarter to 93 µg/L in the fourth quarter. It appears that the remaining high concentration segment of VOCs is in the vicinity of this well, with the trailing edge of this area located south of well 107-41. Due to the presence of all or part of this portion of the plume within the Upton Unit and Gardiners Clay, the rate at which VOCs are migrating south towards EW-2 is significantly reduced. This is due to the lower hydraulic conductivity of these materials in comparison to the Upper Glacial aquifer sands.
- There were no detections of VOCs above NYS AWQS in perimeter wells.
- VOC concentrations in bypass wells 115-42 and 000-138 remained at levels just above detection limits in 2008. VOCs greater than NYS AWQS continue to be hydraulically contained at the site boundary.

3.1.5 Radionuclide Monitoring Results

The monitoring wells were analyzed for tritium and Sr-90 semiannually, and gamma spectroscopy annually. The complete results for these wells are provided in **Appendix C**.

The tritium concentration in the sampled wells continues to be significantly below the 20,000 pCi/L DWS. The tritium concentration in well 098-30 (immediately south of the former HWMF) declined to barely detectable levels during 2008 following a slight increasing trend begun in 2006 with a detection of 9,210 pCi/L in the fourth quarter of 2006. The occasional short-lived increases in tritium and Sr-90 in wells 088-26 (located within the former HWMF), 098-30, and other downgradient wells, is most likely due to periodic flushing of residual tritium and Sr-90 from the vadose zone in the source area by either high water-table events or significant precipitation events.

A plot of historical tritium results for select OU I South Boundary program wells is shown on **Figure 3.1-4**.

There are 10 wells used to monitor Sr-90 contamination from the former HWMF **(Table 1-5)**. The extent of Sr-90 concentrations is shown on **Figure 3.1-5**. Sr-90 has historically been detected in three wells located within and downgradient of the former HWMF (088-26, 098-21, and 098-30) at concentrations above the 8 pCi/L DWS. Well 088-26 was the only one of the three to show Sr-90 concentrations above the DWS in 2008, with a maximum concentration of 12 pCi/L detected in September 2008.

In 2001, a small area of Sr-90 concentrations (approximately 100 to 150 feet in width by 200 to 300 feet in length) exceeding the DWS, was delineated based on the data collected from 13 temporary wells (obtained using a Geoprobe®). The highest concentration detected during that characterization was 65 pCi/L at a location approximately 300 feet southwest of monitoring well 099-04. Four sentinel monitoring wells (107-34, 107-35, 108-43, and 108-44) were installed in 2002, downgradient of this area of elevated Sr-90. Sr-90 was detected in well 107-35 for the first time during the second half of 2004 at a maximum concentration of 2.6 pCi/L. Concentrations in this well have slowly increased to 14 pCi/L in November 2008. This sentinel well is approximately 1,000 feet from the site boundary. As part of this report, a recommendation will be made to perform additional characterization of this area and install new downgradient sentinel wells. Following this characterization, the groundwater model will be used to evaluate the travel time of this area of elevated Sr-90 to the extraction wells. Sr-90 concentration trends for key monitoring wells are provided on **Figure 3.1-6**.

3.1.6 System Operations

The extraction wells are currently sampled quarterly. The influent and effluent of the air-stripper tower are sampled monthly for VOCs and weekly for pH. **Table 3.1-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The system continued full-time operation in 2008 following a period of pulse pumping that was implemented from September 2005 till July 2007.

The following is a summary of the OU I operations for 2008:

January–September 2008
The system was off in January due to remediation and excavation of the former HWMF Waste Loading Area (WLA) requiring an electrical shutdown. The system operated normally during the second and third quarters with only minor electrical and communication problems.

October–December 2008
The system operated normally during the last quarter of 2008. The system was off three days in December due to construction and maintenance activities on a transformer next to the treatment building.

3.1.7 System Operational Data

Extraction Wells
During 2008, 258 million gallons of groundwater were pumped and treated by the OU I system, with an average flow rate of 501 gallons per minute (gpm) for the year. Typical operating flows are 550–650 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells. **Table 3.1-3** contains the monthly extraction well pumping rates. VOC and tritium concentrations in samples from EW-1 and EW-2 are provided on **Table F-1** (**Appendix F**). TVOC levels in both wells continued to show a slight decreasing trend with time (**Figure 3.1-7**). Year-end tritium levels were below detection limits in both wells.

Table 3.1-1.
OU I South Boundary Pump and Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Level	Max. Measured Value
pH	6.0 – 9.0 SU	6.1 – 8.8 SU
Benzene	0.8 µg/L	<0.50 µg/L
Chloroform	7.0 µg/L	<0.50 µg/L
Chloroethane	5.0 µg/L	<0.50 µg/L
1,2-Dichloroethane	5.0 µg/L	<0.50 µg/L
1,1-Dichloroethene	5.0 µg/L	<0.50 µg/L
1,1,1-Trichloroethane	5.0 µg/L	<0.50 µg/L
Carbon tetrachloride	5.0 µg/L	<0.50 µg/L
1,2-Dichloropropane	5.0 µg/L	<0.50 µg/L
Methylene chloride	5.0 µg/L	<0.50 µg/L
Trichloroethylene	5.0 µg/L	<0.50 µg/L
Vinyl chloride	2.0 µg/L	<0.50 µg/L
1,2-Xylene	5.0 µg/L	<0.50 µg/L
Sum of 1,3- & 1,4-Xylene	10.0 µg/L	<0.50 µg/L

Notes:
SU = Standard Units
Required sampling frequency is monthly for VOCs and weekly for pH.

System Influent and Effluent
VOC concentrations in 2008 for the air-stripper influent and effluent are summarized on **Tables F-2** and **F-3** (**Appendix F**). Tritium data for influent and effluent samples are shown on **Table F-4** (**Appendix F**). The influent concentrations of TCA and DCA generally have displayed an overall decrease over the 10 years of OU I South Boundary System operation.

The air-stripper system effectively removed all contaminants from the influent groundwater. All 2008 effluent data for this system were below the analytical method detection limit and below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal
Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent, to calculate the rate of contaminants removed. The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.1-8**). During 2008, 10.5 pounds of VOCs were removed. Cumulatively, 347 pounds have been removed since 1997. Cumulative mass removal data for this system are summarized on **Table F-5** (**Appendix F**).

Air Discharge

Table 3.1-2 presents the VOC air emissions data for the year 2008 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operations. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from µg/L to pounds per gallon (lb/gal), which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. The VOC air emissions were well below allowable levels.

Recharge Basin

There are nine sentinel monitoring wells in the immediate area surrounding the RA V recharge basin (**Figure 1-2**). These wells are used to monitor water quality and water levels to assess the impact of the recharge basin on the aquifer. **Appendix C** contains the data for these monitoring wells. During 2008 the highest detection of tritium was 1,520 pCi/L in well 076-174. Beginning November 2001, the RA V recharge basin began receiving treated groundwater from the OU III South Boundary and Middle Road treatment systems. The OU III South Boundary SPDES equivalency permit was modified to include the Middle Road Treatment System and their outfalls at the OU III and RA V recharge basins. The RA V basin resumed receiving water from the HFBR Tritium Pump and Recharge Wells in December 2007.

3.1.8 System Evaluation

The pump and treat system continued to maintain hydraulic control of contaminants originating from the Current Landfill and former HWMF, and to prevent further contaminant migration across the site's southern boundary. No SPDES or air equivalency permit limits have been exceeded, and no operating difficulties were experienced beyond normal maintenance. There have been no problems and no observed interference with other BNL operations, such as the recharge to Basin HO or the OU III South Boundary Pump and Treat System. Pulse pumping (1 month on, 1 month off) of the system was implemented beginning in September 2005, per recommendations in the *2004 Groundwater Status Report* (BNL 2005c). Pulse pumping was discontinued in July 2007 per the recommendations in the *2006 Groundwater Status Report*.

Table 3.1-2
OU I South Boundary System 2008 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual** ERP* (lb/hr)
Carbon tetrachloride	0.016	<0.0002
Chloroform	0.0086	0.0002
1,1-Dichloroethane	10**	0.00043
1,2-Dichloroethane	0.011	<0.0002
1,1-Dichloroethylene	0.194	<0.0002
Chloroethane	10**	0.0004
1,1,1-Trichloroethane	10**	<0.0002
Trichloroethylene	0.119	<0.0002

ERP = Emissions Rate Potential, stated in pounds per hour (lb/hr).
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

The OU I South Boundary Pump and Treat system performance can be evaluated based on the five major decisions identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected concentrations of contaminants observed in monitoring or extraction wells associated with the OU I South Boundary Pump and Treat System during 2008.

2. Has the plume been controlled?
Yes. An analysis of the plume perimeter and bypass wells reveals no significant increases in VOC concentrations in perimeter and bypass monitoring wells during 2008; thus, the VOC plume has not grown and continues to be controlled. **Figure 3.1-1** illustrates that the plume has been effectively cut off at the south boundary and there is separation with the off-site segment of the plume.

The groundwater contour maps are used to evaluate the capture zones of the OU I South Boundary Pump and Treat System (**Figures 2-2 and 2-3**). The capture zone for the OU I South Boundary Pump and Treat System is indicated on **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L TVOC isocontour that is the capture goal of this system.

The area of elevated Sr-90 contamination has increased to concentrations greater than the DWS in sentinel well 107-35. It is recommended that new sentinel wells be installed to monitor this area as it continues to slowly migrate south.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?

Yes. The hydraulic capture performance of the system is operating as previously modeled and the system continues to be effective in capturing and removing VOCs from the deep Upper Glacial aquifer. Monitoring well 107-40 was installed in 2006 and is used to track this high concentration segment as it migrates to the south boundary. The system resumed full-time operation in 2007 based on increasing VOC concentrations in well 107-40. VOC concentrations in EW-1 and EW-2 were observed to remain stable; however, it is anticipated that there will be some increase in concentrations in the near future as the area of higher VOC concentrations arrives at the site boundary. Based on monitoring well results and mass removal of contaminants, the system is operating as planned.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

Asymptotic conditions are demonstrated by analyzing the average trends in TVOC concentrations in the plume core wells. Asymptotic conditions have not yet been achieved. Aquifer cleanup continues to be demonstrated based on the continued decreasing slope to the trend of average TVOC concentrations in plume core wells, as shown on **Figure 3.1.9**. Changes in the distribution of the plume are shown on **Figure 3.1-10**, which compares the TVOC plume from 1997 to 2008.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?

Yes, the mean TVOC concentration is currently less than 50 µg/L (**Figure 3.1-9**).

4c. How many individual plume core wells are above 50 µg/L?

Monitoring well 107-40, which was installed in 2006, is the only plume core well to have TVOC concentrations exceeding 50 µg/L. TVOC concentrations are currently stable in this well.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?

No. Pulsing of the OU I South Boundary System that began in September 2005 was suspended in July 2007 to allow the plume hot spot detected in well 107-40 to migrate south to the extraction wells. The arrival of the hot spot should result in some increase in VOC concentrations in EW-1 and EW-2.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.1.9 Recommendations

The following are recommendations for the OU I South Boundary Pump and Treat System and groundwater monitoring program:

- Based on an elevated TVOC concentration in upgradient plume core well 107-40, the leading edge of the high concentration segment of the VOC plume is approaching the south boundary. As a result, full-time operation of extraction wells EW-1 and EW-2 will continue until further notice.
- Install up to nine shallow temporary wells using the Geoprobe® to characterize the current extent of the elevated area of Sr-90 contamination. These temporary wells will be installed in east-west transects beginning just south of monitoring well 107-35 and continuing to the north. Following review of the temporary well data, one or two monitoring wells may be installed.
- Add analysis of Sr-90 to system effluent sampling.
- Reduce and/or eliminate sample analyses for monitoring wells 098-33, 098-58, 098-59, 098-61, 107-10, 107-23, 107-24, 107-25, 107-26, 108-08, 108-12, 108-13, 108-14, 108-17, 108-18, 115-03, 115-30, 115-36 as described on **Table 5-1**. The frequencies have been reduced in these wells based on the lack of detections for given parameters over the past several years.
- The routine operation and maintenance monitoring frequency implemented in the fourth quarter of 2004 should be continued unless otherwise noted. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency. Maintain a quarterly sampling frequency for well 107-40 to monitor the hot spot.

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3.2 OPERABLE UNIT III

There were several VOC, Sr-90, and tritium plumes addressed under the OU III Remedial Investigation/Feasibility Study (RI/FS). The VOC plumes originated from a variety of sources, including Building 96, various small sources in the north-central developed portion of the site, the Former Landfill, OU IV, and the former carbon tetrachloride underground storage tank (UST). **Figure 3.2-1** is a representation of the plumes using TVOC concentrations. The eastern portion of **Figure 3.2-1** also includes the OU IV plume and the North Street (OU I/IV) plumes. **Figure 3.2-2** is cross-section B–B′, which is drawn through the north–south center-line of the primary OU III VOC plumes, as shown in **Figure 3.2-1**.

The primary chemical contaminants found in OU III groundwater are TCA, tetrachloroethylene (PCE), and carbon tetrachloride. These three chemicals are the primary VOCs detected in the OU III on-site monitoring wells. Off site, carbon tetrachloride and PCE are the main contaminants detected.

Figure 3.2-3 presents a comparison of the OU III plumes between 1997 and 2008. Several changes in the plumes can be observed in this comparison:

- The extent of the higher concentration segments of the plumes both on and off-site has decreased over the 11-year period. This is due primarily to the groundwater remediation that has been implemented, along with the affects of natural attenuation.
- Hydraulic control of the plumes by the OU III South Boundary Treatment System at the site boundary is evidenced by the break in the plume in this area.
- Concentrations have been significantly reduced in the vicinity of the Industrial Park East System.
- The attenuation of the on-site portion of the North Street VOC plume.
- The migration of the off-site higher VOC concentration slug from the vicinity of Moriches–Middle Island Road in 1997 to the Airport Treatment System extraction wells in 2008.

Three radiological plumes were addressed under Operable Unit III. The HFBR tritium plume extends several thousand feet south from the HFBR spent fuel pool. The downgradient, higher concentration slug is presently being captured by EW-16. Sr-90 plumes are present downgradient of the former WCF and several sources related to the BGRR. A Sr-90 plume is also present downgradient of the Chemical/Glass Holes and Animal Pits area.

Sections 3.2.1 through **3.2.17** summarize and evaluate the groundwater monitoring and system operations data for the OU III VOC and radiological plumes, including both operational groundwater treatment systems and the monitoring-only programs.

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3.2.1 Carbon Tetrachloride Pump and Treat System

This section summarizes the data from the OU III Carbon Tetrachloride Pump and Treat System and offers conclusions and recommendations for monitoring. This system began operating on October 6, 1999, and was formally shut down and placed in standby mode on August 1, 2004 after receiving regulatory approval of the petition for shutdown. This plume originated from a former 1000-gallon UST that had been used to store carbon tetrachloride. The tank was removed in 1998 and several gallons of carbon tetrachloride were released to the groundwater during this removal.

3.2.1.1 System Description

A complete description of the pump and treat system is contained in the *Carbon Tetrachloride Groundwater Removal Action Operations and Maintenance Manual* (BNL 2000a).

3.2.1.2 Groundwater Monitoring

Well Network

A network of 32 wells was designed to monitor the extent of the plume and the effectiveness of remediation. As was recommended in the petition to shut down the carbon tetrachloride pump and treat system, two monitoring wells (095-300 and 095-301) were installed in the vicinity of extraction well EW-15 in 2004. Well 095-300 was installed to monitor the western edge of the plume in the vicinity of well EW-15, and well 095-301 was installed upgradient of well EW-15.

Sampling Frequency and Analysis

The wells are sampled semiannually, and samples are analyzed for VOCs (**Table 1-5**).

3.2.1.3 Monitoring Well Results

Carbon tetrachloride is the primary contaminant in this plume, but there are also low levels of chloroform (a breakdown compound of carbon tetrachloride). The plume extends from the former UST southeast to the vicinity of Weaver Drive, a distance of approximately 1,300 feet (**Figure 3.2.1-1**). The width of the plume, as defined by the 5 µg/L carbon tetrachloride isocontour, is approximately 125 feet. The complete 2008 analytical results from the monitoring of wells in the carbon tetrachloride program are provided in **Appendix C**. A summary of key monitoring well data for 2008 follows.

- Plume core well 085-98, just south of the former UST, had carbon tetrachloride concentrations greater than 150,000 µg/L in 1999. A dramatic reduction in concentrations has been observed in this well, beginning in 1999 with the start of groundwater pump and treat. The concentration of carbon tetrachloride was 3.9 µg/L in October 2008 (**Figure 3.2.1-2**).
- Plume core well 085-17 is sited next to the BNL service station on Rochester Avenue and downgradient of the source area. It has continued to show declining carbon tetrachloride trends from a peak of more than 4,000 µg/L in 2000 to a concentration of 36 µg/L in October 2008 **(Figure 3.2.1-2)**. Note that other compounds related to petroleum products were also detected in this well due to the service station located in this area (**Section 4.8)**.
- Plume core well 85-161 is approximately 120 feet downgradient of the source area. Concentrations in this well have remained low throughout 2008, with a concentration of 1.3 µg/L detected in October 2008.
- Plume core well 095-183 is approximately 450 feet downgradient of the source area. Carbon tetrachloride concentrations in this well have decreased from greater than 2,000 µg/L in 2000, to <0.5 µg/L in October 2008 **(Figure 3.2.1-2)**.
- Plume perimeter well 095-300 and core well 095-301 were installed in 2004, as recommended in the *Petition to Shutdown the OU III Carbon Tetrachloride Treatment System* (BNL 2004a).

Well 095-300 was installed west of EW-15 to confirm the western edge of the carbon tetrachloride plume. The October 2008 analytical results for this well show a carbon tetrachloride concentration of 0.79µg/L, thus confirming the western edge of the plume. Well 095-301 was installed to monitor concentrations of the plume immediately upgradient of well EW-15. Concentrations of carbon tetrachloride were <0.5 ug/L in October 2008.

- Four Geoprobe® groundwater sample locations were installed in February 2009. These were installed to obtain supplemental groundwater data and confirm the low levels of carbon tetrachloride detected in the monitoring wells. Three Geoprobe® points were installed in an east-west line near well 095-88 (GP-01CCl4–2 009, GP-02CCl4-2009, GP-03 CCl4–2009) and one was installed further south, upgradient of well 095-279. The locations and data are shown on **Figure 3.2.1-1**. Each location was sampled at ten-foot increments from a depth of approximately 82 feet bls to the water table at about 40 feet bls. The data showed low and non-detectable levels of carbon tetrachloride, with a high concentration of 43 µg/L in GP-4 at 52 feet below land surface (bls) (**Table 3.2.1-1**) These data will also be included in the Petition for Closure being prepared concurrently with this report.

3.2.1.4 System Operations

Operating Parameters

In 2008, the extraction wells were sampled quarterly. These samples are analyzed for VOCs. The extraction well data are located on **Table F-6** (**Appendix F**). The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. However, the system was in standby in 2008. The system operations are summarized below.

January – December 2008

The system was in standby mode during this period. Sampling for the SPDES equivalency permit was stopped, but will be resumed if the system is restarted.

3.2.1.5 System Operational Data

The system was shut down for the entire year so only quarterly sample data were collected from the extraction wells. All samples collected from the extraction wells in 2008 showed concentrations below the NYS AWQS of 5 µg/L for carbon tetrachloride.

3.2.1.6 System Evaluation

The system was placed in a standby mode in August 2004 after approval of the petition for shutdown. The system remained in standby mode for all of 2006, 2007 and 2008. The groundwater extraction wells will remain on a quarterly sampling schedule to monitor for any significant rebound in concentrations of carbon tetrachloride.

The Carbon Tetrachloride Pump and Treat System performance can be evaluated based on the five major decision rules identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no detections of either carbon tetrachloride or any other contaminants in wells associated with this monitoring network during 2008 that would have triggered the BNL Groundwater Contingency Plan.

2. Were the cleanup goals met?

Yes. The groundwater cleanup goals for the system have been met. The system was shut down in August 2004. A petition to close the system is being prepared.

3. Has the plume been controlled?
Yes. The plume has been controlled, and the system is in standby mode.

4. Is the system operating as planned?
The system is currently shut down and being maintained in standby mode. Shutdown of the system at these concentrations is consistent with obtaining the OU III ROD cleanup objectives of meeting MCLs by 2030.

5. Is an engineering evaluation needed to modify the Middle Road treatment system to ensure the capture and remediation of the carbon tetrachloride plume?
Based on data from bypass and Middle Road tracking wells, no engineering study is required at this time. The Middle Road system will capture any higher levels of carbon tetrachloride not captured by this system.

3.2.1.7 Recommendations

The following are recommendations for the OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- Submit the Petition for Closure to the Regulators.
- Maintain the system in standby mode until the Petition for Closure is reviewed and approved.

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3.2.2 Building 96 Air Stripping System

This section summarizes the 2008 operational data from the OU III Building 96 Treatment System, which consists of recirculation wells with air stripping and vapor-phase carbon treatment. It also presents conclusions and recommendations for future operation of the system. The system began operation in February 2001. Well RTW-1 was placed in standby mode in June 2006, and downgradient well RTW-2 was restarted in October 2007 due to a rebound in TVOC concentrations. Due to increasing TVOCs in upgradient monitoring wells, wells RTW-3 and RTW-4 were placed back on-line in March of 2008. In May 2008, well RTW-1 was modified from a recirculation well to a pumping well with hexavalent ion exchange treatment, and discharge to the nearby surface drainage culvert.

3.2.2.1 System Description

Contaminated groundwater is drawn from the aquifer via a submersible well pump in a lower well screen, 48 to 58 feet bls, near the base of the contaminant plume. The groundwater then is pumped into a stripping tray adjacent to each of the four wells. After treatment the clean water is recharged back to the shallow portion of the plume through the upper screen, 25 to 35 feet bls. As recommended in the *2007 Groundwater Status Report* (BNL 2008b, in February 2008 a design modification for treatment well RTW-1 was submitted to the regulators, along with the SPDES equivalency permit application. In addition to VOC treatment using air stripping, ion exchange resin was added to treat for hexavalent chromium prior to discharge. In March 2008 NYSDEC approved the SPDES equivalency permit. In May 2008 the discharge from well RTW-1 was redirected to the nearby surface drainage culvert. The contaminated air stream from the air stripper from the four treatment wells, is routed to a treatment and control building, where it is passed through two vapor-phase granular activated carbon (GAC) units in series to remove the VOCs. Treated air is then discharged to the atmosphere. A complete description of the system is included in the *Building 96 Groundwater Source Control Treatment System Operations and Maintenance Manual* (BNL 2002a). A modification to this manual was prepared and is titled *OU III Building 96 Operations and Maintenance Manual Modification* (BNL 2004b).

3.2.2.2 2008 Source Area Characterization

Initial subsurface characterization of the area identified a shallow low permeability zone, referred to as the “silt zone.” Monitoring data indicate that high concentrations of VOCs were present in this zone. Due to the high concentrations of VOCs in the silt zone, three injections of the oxidizer potassium permanganate ($KMnO_4$) were conducted from December 2004 through January 2006. Based on the data collected since these injections, VOCs remain in high concentrations in groundwater.

To reevaluate the nature and extent of the source area, from April through October 2008, 22 soil borings were drilled in the area of the most contaminated groundwater (**Figure 3.2.2-1**). The soil data indicate that high PCE concentrations are located in the unsaturated zone from just below land surface to a depth of approximately 15 feet bls, and not below the water table as previously thought. This area of approximately 25 by 25 feet is just south of former Building 96. Maximum PCE concentrations detected in the soil were 1,800 milligrams per kilogram (mg/kg) at approximately 9 feet bls. This subsurface zone is characterized by interbedded thin silt layers. The soil data are included on **Table 3.2.2-1**. Cross sections of the soil contamination area are shown on **Figures 3.2.2-2 and 3.2.2-3**. In September 2008, a soil vapor survey was performed to supplement the soil boring data and identify any additional high concentration soil contamination areas that may have been located outside the area identified by the soil borings. A total of 58 locations were sampled, spaced at 25-foot increments. The soil vapor results confirmed that the area previously identified in the vicinity of soil boring B-2 contains the highest soil vapor concentrations. **Figure 3.2.2-4** shows the soil vapor locations and PCE concentrations detected.

The delineation of the contaminated soils to a discrete relatively small and shallow area resulted in focusing remedial alternatives on excavation due to its implementability and effectiveness in completely removing the contamination.

In November 2008, as a temporary measure to minimize infiltration from precipitation, a plastic liner was installed over the soil contamination area.

To optimize the effectiveness of the Building 96 groundwater remedy, in December 2008 BNL recommended excavation of contaminated soils with off-site disposal. This is in addition to the continued operation of the groundwater treatment system until the capture goal is attained, which is expected within several years of the soil excavation. Optimization of the remedy by reducing the number of years of treatment will enable BNL to achieve the cleanup goal of the ROD for this groundwater plume (i.e., meeting drinking water standards by 2030). The regulatory approach for this action will be to document the change in an Explanation of Significant Differences (ESD) to the OU III ROD. Agreement was reached with the regulators for the approach, and BNL issued the *Final Report for Building 96 Recommendation for Source Area Remediation* in March 2009. The Draft ESD to the OU III ROD was submitted to the regulators for review in April 2009. Following regulatory review and approval of the ESD in the summer of 2009, excavation will be performed.

3.2.2.3 Groundwater Monitoring

A network of 33 wells is used to monitor the VOC plume and the effectiveness of the Building 96 groundwater remediation system (**Figure 1-2**). The wells are sampled quarterly and analyzed for VOCs in accordance with **Table 1-5**. As per the recommendation in the *2007 Groundwater Status Report,* quarterly sampling for chromium (Cr) and hexavalent chromium (Cr [VI]) began in 2008.

3.2.2.4 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. The fourth quarter 2008 plume is shown on **Figure 3.2.2-5**. A summary of key monitoring well data for 2008 follows.

- The highest TVOC concentration seen in 2008 was 3,255 µg/L in groundwater from core well 085-347 during the first quarter sampling round. The primary contaminant in this plume is PCE, with a value of 3,200 µg/L in well 085-347. As shown in trend **Figure 3.2.2-6**, this well has historically detected significant contamination, with TVOC levels never lower than 600 µg/L. Although these levels are high, they are approximately 20% of the historical maximum concentration seen in this area of 18,000 µg/L in well 095-84. In early 2009, well 085-353 detected a TVOC concentration of 7,345 µg/L. Well 085-353 is located in the center of the soil contamination source area identified in **Section 3.2.2.2**. As shown on trend **Figure 3.2.2-6**, plume core monitoring wells 085-347, 085-353, and 095-84 continue to show significant rebounding of contaminant levels over the last few years.
- TVOC concentrations in plume core well 085-352 (screened in the silt zone) continued rebounding in 2007 and 2008 (up to 720 µg/L in October 2008) after two years of lower concentrations from mid 2005 through 2006 (maximum of 110 µg/L in May 2006). Similarly, in well 085-351 the TVOC concentration rose to 1,925 µg/L in July 2008, from less than 400 µg/L in 2006 and 2007. Except for an elevated TVOC detection in late 2004 of 1,200 µg/L when plume core well 095-306 was installed, concentrations have been below 300 µg/L. However, in 2008 concentrations started rebounding back up to 1,200 µg/L TVOCs detected in October. This contamination will be captured by RTW-1.
- Plume core wells 095-162 and 095-172 (located between treatment well RTW-1 and downgradient recirculation wells RTW-2 through RTW-4) began showing increasing TVOC concentrations in 2006 and 2007 after several years of concentrations below 50 µg/L. This is due to the plume passing by RTW-1 while it was in standby mode from June 2006 through May 2008. In 2008, maximum TVOC concentrations in these wells were 510 µg/L and 652 µg/L,

respectively. However, well 095-162 dropped to 2.0 µg/L TVOCs in July 2008. Plume core well 095-159 also increased to 185 µg/L TVOCs in October 2008, its highest level since 2001. This contamination will be captured by the downgradient recirculation treatment wells.

- Plume perimeter well 095-295, located on the west side of the plume, maintained low TVOC concentrations from 2006 through 2008. The highest 2008 TVOC concentration in well 095-295 was 4.7 µg/L. Plume perimeter wells 085-97 and 095-171, located east of the plume, remained below the NYS AWQS.
- The bypass monitoring wells immediately downgradient of extraction wells RTW-2, RTW-3, and RTW-4 generally showed lower TVOC concentrations in 2008 when compared to 2007. The reduced concentrations are consistent with the downgradient extraction wells being placed back in service. In 2008, TVOC concentrations in the bypass wells were below 5.0 µg/L, except for well 095-169. Well 095-169, located immediately downgradient and between RTW-3 and RTW-4, showed a maximum concentration of 750 µg/L in February 2008. Concentrations reduced to 2.2 µg/L in April 2008 and have remained low since. As noted in **Section 3.2.2**, extraction well RTW-2 was placed back in service in October 2007, and RTW-3 and RTW-4 were placed back in service in March 2008.
- In conjunction with the soil investigation previously described (**Section 3.2.2.2**), in June 2008 a temporary vertical profile well was installed as Boring B-16 to check for the presence of dense non-aqueous phase liquid (DNAPL) in a location immediately downgradient of the highest soil PCE concentrations (detected at B-2). This boring encountered a clay layer at 175 feet bls. Groundwater samples were obtained at 10-foot intervals from just above the top of the clay to the water table. PCE was detected at a concentration of 80 µg/L just below the water table. The remainder of the sample intervals revealed little or no PCE, and therefore no DNAPL immediately downgradient of the source area. See **Figure 3.2.2-7** for the cross section identifying this well.
- As recommended in the *2007 Groundwater Status Report*, in February 2009 a core monitoring well (B96-MW01-2009) was installed west of well 095-172 to monitor VOC concentrations just upgradient of RTW-2.
- Seven of 33 monitoring wells detected hexavalent chromium above 100 µg/L. The highest hexavalent chromium detection of 389 µg/L was in January 2008 in monitoring well 095-169. The hexavalent chromium monitoring well data for 2008 is posted on **Figure 3.2.2-8.**

3.2.2.5 System Operations

Operating Parameters

Due to a rebound in VOC concentrations in the downgradient portion of the plume, recirculation well RTW-2 was restarted in October of 2007, and recirculation wells RTW-3 and RTW-4 were placed back in service in March 2008. Extraction well RTW-1 was placed back on-line in May 2008 following the modification to surface discharge.

January – September 2008

Due to increasing VOC concentrations in upgradient monitoring wells, recirculation wells RTW-3 and RTW-4 were placed back on-line in March of 2008. RTW-2 was on line for this period. In May, well RTW-1 was modified from a recirculation well to a pumping well with hexavalent ion exchange treatment, and the treated water is discharged to the nearby surface drainage culvert. Well RTW-4 was off during August and September due to a faulty flow transmitter. From January through September, approximately 22 million gallons of water were pumped.

October – December 2008

All wells operated normally this period with the exception of well RTW-4, which was turned off from October 1 to 14 due to replacement of a faulty flow transmitter. The groundwater treatment system pumped and treated approximately 12 million gallons of water in the third quarter of 2008.

During 2008, the groundwater treatment system pumped and treated a total of approximately 34 million gallons of water.

Table 3.2.2-2
OU III Building 96 RTW-1 Pump & Treat Well
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	5.7–8.0 SU
chromium (hexavalent)	100	23.8
tetrachloroethylene	5.0	<0.5
1,1,1-trichloroethane	5.0	<0.5
Thallium	Monitor	0.79

Note:Required effluent sampling frequency is monthly following a period of 24 consecutive weekly with no exceedances. Weekly for pH.

3.2.2.6 System Operational Data

Recirculation/Treatment Well Influent and Effluent

Table F-7 (**Appendix F**) lists the quarterly influent and effluent TVOC concentrations for the three recirculation wells and treatment well RTW-1. The highest TVOC concentration from the influent of these wells was 187 µg/L in RTW-1 in the second quarter. The maximum TVOC in the influent of the downgradient wells was 121 µg/L in RTW-4 in March 2008. RTW-2 and RTW-3 influent showed a maximum of 8 µg/L and 42 µg/L TVOCs in 2008, respectively. **Figure 3.2.2-9** shows the TVOC concentrations in the treatment wells over time. The highest effluent TVOC concentration was 9.7 µg/L in RTW-4 in February 2008. This sample showed the only historical detection of PCE (at 9.2 µg/L) above the DWS in the effluent of any of the treatment wells, and it is believed that it was a sampling error. (Note: There is no discharge equivalency permit for recirculation treatment well RTW-4). **Table 3.2.2-2** shows the maximum measured contaminant concentrations compared to the equivalency permit for well RTW-1. The maximum hexavalent chromium detection in the influent to RTW-1 in 2008 was 52.8 µg/L, approximately half of the SPDES discharge standard. The maximum discharge level detected in this well for the year was 23.8 µg/L.

Air Treatment System

In 2008, quarterly air sampling was performed from the GAC vessels before treatment (influent), between the two vessels (midpoint), and after the second vessel (effluent). The analytical data are available on **Table F-8** (**Appendix F**), and the VOC emission rates are summarized on **Table 3.2.2-3** below**.** The findings are utilized to monitor the efficiency of the GAC units and to determine when a carbon change-out is required. Airflow rates, measured for each air-stripping unit inside the treatment building, show that they typically range between 250 and 450 cubic feet per minute (cfm) for each of the four wells. Assuming a total airflow rate of 1,200 cfm, all compounds detected in the carbon effluent during the operating year were much lower than the New York State DAR-1 Air Toxics Assessment limits for the worst-case potential impacts to the public.

Cumulative Mass Removal

Table 3.2.2-4 shows the monthly extraction well pumping rates. The pumping and mass removal data are summarized on **Table F-9** (**Appendix F**). In 2008, approximately 13 pounds of VOCs were removed. Since February 2001, the system has removed approximately 84 pounds of VOCs.

3.2.2.7 System Evaluation

The OU III Building 96 Treatment System performance can be evaluated based on the five major decisions identified by applying the DQO process.

Table 3.2.2-3.
OU III Building 96
2008 Average VOC Emission Rates

Parameter	Allowable ERP*	Actual** ER
dichlorodifluoromethane	0.0000187	0.00000222
acetone	0.000674	ND
methylene chloride	0.000749	0.00000105
2-butanone	0.000187	ND
benzene	0.000112	0.00000657
tetrachloroethylene	0.000165	ND
m,p-xylene	0.0000116	0.00000161
isopropylbenzene	0.000243	ND
n-propylbenzene	0.0000599	ND
1,3,5-trimethylbenzene	0.000375	0.00000143
1,2,4-trimethylbenzene	0.000225	0.00000442
4-isopropyltoluene	0.00000749	ND
naphthalene	0.0000225	ND
carbon disulfide	0.0000487	ND
styrene	0.00000637	ND
trans-1,3-dichloropropane	0.0000157	ND

Notes:

ER = Emissions Rate
ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
ND = Analyte not detected

<u>*1. Was the BNL Groundwater Contingency Plan triggered?*</u>
Yes. As noted in Section 3.2.2.2, high concentrations of PCE (up to 1,800 mg/kg) were identified in the soil borings obtained near the high PCE contamination in the groundwater. The regulators were informed of the results. This area was characterized as a significant source of contamination to the underlying groundwater. Although the intent of the sampling was to try to identify an existing source area, the significant concentrations detected in the vadose zone were not expected. As noted previously, excavation of the source area is planned to address this issue.

As a follow-up to the triggering of the Contingency Plan in 2007, ion-exchange resin treatment for hexavalent chromium was included on well RTW-1 in 2008.

<u>*2. Have the source control objectives been met?*</u>
No. As a result of the soil boring investigation performed in 2008, a localized continuing source area exists in the vadose zone. Excavation of the source area followed by continued operation of the existing RTW-1 treatment well will allow for the source control objectives to be met. Groundwater modeling performed in late 2008 determined that without excavation of the source area, the overall cleanup goals would probably not be achieved. Modeling also determined that following some "tailing" effect from the vadose zone source area after it is excavated, well RTW-1 will need to operate for another three to six years (2012 - 2015).

<u>*3. Has the plume been controlled?*</u>
Yes. With all four extraction wells in operation, the plume is hydraulically controlled (**Figure 3.2.2-10**).

<u>*4. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?*</u>
No. The effectiveness of treatment well RTW-1, located near the source area, has reached a plateau without significantly reducing the high concentrations of PCE. Significant reduction of PCE in groundwater cannot be achieved without excavation of the source area defined in 2008.

5. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements. Significant concentrations of VOCs continue to slowly leach into the groundwater from the source area upgradient of RTW-1. In addition, elevated VOCs are located just upgradient of the three recirculation wells.

5a. Is the mean TVOC concentration in core wells less than 50 µg/L?
No. The mean TVOC concentration in the core wells was 384 µg/L during the fourth quarter 2008.

5b. How many individual plume core wells are above 50 µg/L TVOCs?
TVOC concentrations in 16 of 20 core wells were above 50 µg/L in 2008.

5c. Have the groundwater cleanup goals been met? Are MCLs expected to be achieved by 2030?
No. MCLs have not been achieved for individual VOCs in all plume core wells. However, following soil excavation and several more years of treatment system operation, MCLs are expected to be achieved by 2030.

3.2.2.8 Recommendations

The following are recommendations for the OU III Building 96 Groundwater Remediation System and monitoring program:

- Maintain operation of treatment well RTW-1 and downgradient recirculation wells RTW-2, RTW-3, and RTW-4. Continue operation until TVOC concentrations <50 µg/L are seen in the influent and adjacent monitoring wells. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Maintain integrity of the plastic liner covering the PCE-contaminated soils. Following regulator approval of the OU III ESD, excavate the PCE-contaminated soils from the vadose zone source area. This also involves the removal of monitoring well 085-353 located in the center of the proposed excavation area. Following excavation, three additional monitoring wells will be installed to monitor the effectiveness of the excavation, including a replacement for well 085-353.
- Once hexavalent chromium concentrations drop below allowable discharge levels and all monitoring wells in the vicinity of the pumping well are below these levels, treatment for chromium will be eliminated.
- Due to low historical TVOC detections, the sampling frequency for the following monitoring wells will be reduced as follows:
    - Wells 085-97, 095-171, and 095-296 will change from quarterly to annual.
    - Wells 095-294, 095-295, 095-307, and 095-308 will change from quarterly to semiannual.
    - The remaining monitoring wells will remain at the quarterly sampling frequency.
- Continue to analyze for total chromium (Cr) and hexavalent chromium (Cr [VI]) in the monitoring wells.

3.2.3 Middle Road Pump and Treat System

The Middle Road Groundwater Pump and Treat System began operating on October 23, 2001. This section summarizes the operational data from the Middle Road system for 2008, and presents conclusions and recommendations for future operation. The analytical data from the monitoring wells are also evaluated in detail.

3.2.3.1 System Description

The Middle Road system was designed with six extraction wells and air-stripping technology to remove VOCs from the groundwater. In September 2003, extraction wells RW-4 and RW-5 were placed in standby mode due to low concentrations of TVOCs. In September 2006, well RW-6 was also placed in standby mode due to low TVOC concentrations. The system is currently operating utilizing wells RW-1, RW-2 and RW-3 at a pumping rate of approximately 300 to 400 gpm. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL 2003a).

3.2.3.2 Groundwater Monitoring

The Middle Road Monitoring Program consists of a network of 29 monitoring wells located between the Princeton Avenue firebreak road and the OU III South Boundary Pump and Treat System (**Figure 1-2**). Four new monitoring wells were added in 2008: one upgradient of well RW-1 (MW 105-66), one approximately 100 feet to the west of well 113-09 (113-29), and two upgradient wells, located just south of Princeton Avenue (104-37 and 104-38).

The 29 Middle Road wells are sampled and analyzed for VOCs. Nine of the wells are sampled quarterly, and the remainder are sampled semiannually (**Table 1-5**).

3.2.3.3 Monitoring Well Results

The complete VOC results are provided in **Appendix C**. The highest plume concentrations are found between extraction wells RW-1 and RW-3, based on influent data for these wells and available monitoring well data (**Figure 3.2.3-2**). TVOC concentrations in monitoring wells east of RW-3 are generally below 10 µg/L. TVOC concentrations have generally been stable in 2008. Results for key monitoring wells are as follow.

- The highest TVOC concentration detected (519 µg/L) was in bypass detection well 113-11 in October 2008. The VOCs in this bypass well were present prior to the operation of the pump and treat system, and are expected to be captured by the OU III South Boundary system.
- Bypass well 113-17 has shown a significant decrease in TVOCs since 2005, with concentrations dropping from 1,347 µg/L to less than 200 µg/L in 2008.
- Plume core well 105-23 is approximately 2,000 feet upgradient of RW-1, near Princeton Avenue. TVOC concentrations have decreased from 1,794 µg/L during 2001, to 52 µg/L in the fourth quarter of 2008 (**Figure 3.2.3-1)**.
- TVOC concentrations in plume core wells to the east of well 105-23, along Princeton Avenue, were generally below 100 µg/L in 2008. This includes the two new wells 104-37 (43 ug/L) and 104-38 (111 µg/L). TVOC concentrations decreased in well 105-44, from 423 µg/L in 2001 to 6 µg/L in the fourth quarter of 2008. These two wells will be sampled semiannually. (**Figure 3.2.3-1)**.
- New monitoring well 113-29, located west of RW-1, showed TVOC concentrations of 26 µg/L in 2008. This well is a perimeter monitoring well for the Middle Road System and will be sampled semiannually.

- New monitoring well 105-66, installed upgradient of extraction wells RW-1 and RW-2, showed TVOC concentrations of 242 µg/L in 2008. This is a new core well installed to monitor levels of TVOCs migrating to these extraction wells. This well will be sampled on a quarterly basis.

Figure 3.2.3-2 shows the vertical distribution of contamination running along an east–west line through the extraction wells; the location of this cross section (E–E') is given on **Figure 3.2-1**. VOC contamination in the western portion of the remediation area (RW-1 through RW-3) extends into the upper Magothy aquifer, as does the screen on well RW-3. This figure shows that the area of TVOCs exceeding the capture goal of 50 µg/L is limited to the western portion of the treatment system in the vicinity of RW-1, RW-2 and RW-3.

3.2.3.4 System Operations

The effluent sampling parameters for pH and VOCs follow the requirements for monthly sampling, as per the SPDES equivalency permit (**Table 3.2.3-1**). In addition, system influent samples are analyzed for tritium during each system-sampling event. Tritium remains below detection limits in these samples. The effluent concentrations from the treatment system during this period of operation were below equivalency permit levels.

Table 3.2.3-1.
OU III Middle Road Air Stripping Tower
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Observed Value
pH range (SU)	6.5–8.5	6.6 – 7.54
carbon tetrachloride	5 µg/L	ND
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	ND
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2-trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units
Required sampling frequency is monthly for VOCs and pH.

Approximately 150 million gallons of water were pumped and treated in 2008 by the OU III Middle Road System. The following paragraphs summarize the Middle Road System operations for 2008.

January – September 2008

The system operated sporadically from March to June due to electrical repairs and numerous electrical storms that knocked out electric and communications to the system. Approximately 97 million gallons of water were treated.

October – December 2008

The system operated normally in October and November, and pumped and treated approximately 53 million gallons of water during this quarter. The system was down most of December due to communication problems between the extraction wells and stripping tower.

3.2.3.5 System Operational Data

System Influent and Effluent

Figure 3.2.3-3 plots the TVOC concentrations in the extraction wells versus time. Results of the extraction wells samples are found on **Table F-10 (Appendix F).** The influent VOC concentrations remained constant over the reporting period. The average TVOC concentration in the influent during 2008 was 41 µg/L . The results of the influent and effluent sampling are summarized on **Tables F-11** and **F-12** (**Appendix F**), respectively.

Cumulative Mass Removal

Mass balance was calculated for the period of operation to determine the mass removed from the aquifer by the pumping wells. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to determine the pounds removed. Flow averaged 331 gpm during 2008 (**Table 2-3**, and **Table F-13** in **Appendix F**), and approximately 56 pounds of VOCs were removed. Approximately 798 pounds of VOCs have been removed since the system began start-up testing on October 23, 2001. The cumulative total of VOCs removed vs. time is plotted on **Figure 3.2.3-3**.

Table 3.2.3-2.
OU III Middle Road Air Stripper
2008 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0004
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	0.000048
1,2-dichloroethane	0.008	0.000004
1,1-dichloroethylene	0.034	0.0003
cis-1,2-dichloroethylene	10***	0.0001
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0069
1,1,1-trichloroethane	10***	0.0008
trichloroethylene	0.143	0.0004

Notes:
ERP = Emission Rate Potential. Reported in lb/hr.
*ERP based on NYSDEC Air Guide 1 Regulations.
** Rate reported is the average rate for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

Air Discharge

Table 3.2.3-2 shows the air emissions data from the system for the OU III Middle Road tower during 2008, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for the water treated during that time (**Table F-10** in **Appendix F**). The concentration of each constituent was averaged for 2008, and those values were used in determining the emissions rate. The air emissions determined for the Middle Road system were below permitted limits.

Extraction Wells

Extraction wells RW-4 and RW-5 were shut down in September 2003 and placed on standby due to low concentrations of VOCs. The extraction wells are sampled quarterly. RW-6 was shut down in September 2006 due to low VOC concentrations in this well. Quarterly sampling of the wells will continue. The influent VOC concentrations remained constant over the reporting period for the operational wells. **Table 3.2.3-3** shows the monthly extraction well pumping rates.

3.2.3.6 System Evaluation

The system has been operating since October 23, 2001. Groundwater contours indicate that hydraulic control has been achieved.

The OU III Middle Road Pump and Treat System performance can be evaluated based on the five major decisions identified for this system from the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells or extraction wells associated with the OU III Middle Road Pump and Treat System during 2008.

2. Has the plume been controlled?
Yes. TVOC concentrations in plume perimeter wells remained stable at low concentrations during 2008, indicating that the plume is being controlled. High TVOC concentrations in bypass wells were present before the system was operational and are not within the capture zone of the extraction wells. It will take several additional years before the contaminants migrate to the South Boundary System. Semiannual groundwater elevation data were obtained from many of the OU III Middle Road monitoring program wells, in addition to wells located throughout the BNL on-site and off-site monitoring areas. Groundwater contour maps are generated using these data (**Figures 2-2** and **2-3**).

The capture zone for the OU III Middle Road system is depicted on **Figure 3.0-1**. The capture zone includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?
Yes. The system is operating as planned based on the mass removal of VOCs. Monitoring wells show generally steady concentration trends during 2008 (**Figure 3.2.3-1**).

4. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?
No. Monitoring and extraction wells have shown generally decreasing concentration trends since 2002 and these trends have continued.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?
No, the average TVOC concentration for the plume core wells was 52 µg/L (**Figure 3.2.3-5**).

4c. How many individual plume core wells are above 50 µg/L?
Five of the 16 plume core wells contain TVOC concentrations greater than 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
To date, the OU III Middle Road System has not been pulsed.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in all plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.3.7 Recommendations

The following recommendations are made for the OU III Middle Road Pump and Treat System and groundwater monitoring program:

- Maintain the routine operation and maintenance monitoring frequency that began in 2003. However, the following wells will be changed to an annual sampling frequency due to low VOC concentrations: 105-52, 105-54, 113-06, 113-07, 113-16, 113-18, 113-20, and 113-21.
- Maintain extraction wells RW-4, RW-5, and RW-6 in standby mode during 2009. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Install a temporary well approximately 100 feet west of well RW-1 to identify the vertical distribution of contaminants in this area. Based on the results of this temporary well, evaluate the pumping rates and pump locations in extraction wells RW-1, RW-2 and RW-3.

3.2.4 South Boundary Pump and Treat System

This section summarizes the operational data from the OU III South Boundary Groundwater Pump and Treat System for 2008, and gives conclusions and recommendations for future operation. Also included within this section is an evaluation of the system and extraction well monitoring and sampling data.

3.2.4.1 System Description

This system began operation in June 1997. It utilizes air-stripping technology for treatment of groundwater contaminated with chlorinated solvents. There are seven extraction wells. The system is currently operating at a pumping rate of approximately 350 gpm, utilizing three extraction wells. Extraction wells EW-12 and EW-8 were placed on standby in October 2003 and October 2006, respectively, due to low VOC concentrations. Wells EW-6 and EW-7 were placed in standby mode in November and December 2007, respectively. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL 2003a).

3.2.4.2 Groundwater Monitoring

The monitoring well network consists of 43 wells and was designed to monitor the VOC plume(s) in this area of the southern site boundary, as well as the efficiency of the groundwater remediation system (**Figure 3.2.4-1**). The South Boundary wells are sampled and analyzed for VOCs at frequencies detailed on **Table 1-5**. A number of OU III South Boundary wells are also analyzed for radionuclides as detailed in **Section 3.2.14**.

3.2.4.3 Monitoring Well Results

The south boundary segment of the OU III VOC plume continued to be bounded by the existing monitoring well network. Individual VOC concentrations in the plume perimeter wells were less than 5 μg/L except for well 121-08, which had a concentration of 5.5 μg/L TCA in October 2008 (TVOCs at 21 μg/L) (**Figure 3.2.4-1**). This is still well below the capture goal of the system of 50 μg/L TVOCs. VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary, as depicted on **Figures 3.2-2, 3.2.4-1, and 3.2.4-2. Appendix C** has the complete groundwater monitoring results for 2008.

The plume core wells continued to show the same trend of decreasing VOC concentrations that were observed following the start-up of the pump and treat system in 1997, with several exceptions. The bulk of the VOC contamination in this area is currently located between EW-3 and EW-5, as can be seen on **Figure 3.2.4-2,** which is a cross section (F–F') drawn along the south boundary. The VOC concentration trends for specific key wells are shown on **Figure 3.2.3-1.** Results for key monitoring wells are as follow:

- Plume core well 114-07 is immediately upgradient of EW-12. Increasing VOC concentrations in this well during 1998 prompted the addition of EW-12, which began pumping in December 1999. VOC concentrations in 2008 remained below the NYS AWQS, with no VOCs exceeding NYS AWQS since 2001.
- Plume core well 122-22 is immediately east of EW-8. A sharp drop in TVOC concentrations was observed during 1997 and 1998 from its pre start-up concentration of 1,617 μg/L. VOC concentrations have remained very low, with only PCE being detected at 5 μg/L in 2008.
- Plume core well 122-19 is directly downgradient of EW-8. TVOC concentrations were as high as 367 μg/L in 1997; VOCs have not been detected above standards during 2008.
- Plume core well 122-04 is located between EW-7 and EW-8. VOC concentrations remained low during 2008 with no detections above standards.

- Plume core well 121-23 is immediately downgradient of EW-5. During 2008, the TVOC concentrations ranged between 33 and 42 µg/L. The primary contaminant detected was PCE. This is consistent with the contaminants in EW-4 and EW-5.
- Plume core well 121-13 is immediately upgradient of, and between, EW-4 and EW-5. TVOC concentrations in this well have fluctuated somewhat since 1997, peaking at 1,098 µg/L in 1999. The PCE concentration in this well was 2.6 µg/L in October 2008. PCE is the primary compound in wells 121-13, 121-23, EW-4, and EW-5.
- New monitoring well 121-45 was installed in 2006 to monitor the higher VOC concentrations present at wells 113-17 and 113-11. This well is located between the Middle Road and South Boundary systems. The 2008 results showed TVOC concentrations as high as 456 µg/L during July **(Figure 3.2-2)**.
- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations ranged from 29 µg/L in April 2008 to approximately 33 µg/L in October 2008.
- Bypass detection wells 122-34 and 122-35, located south of EW-8, were below NYS AWQS for VOCs from 2003 through 2008.
- Plume core well 122-05 is a Magothy monitoring well west of EW-8. TVOC concentrations have been showing a declining trend with a concentration of 26 µg/L in October 2008.

3.2.4.4 System Operations

The individual extraction wells are sampled quarterly and analyzed for VOCs. The effluent sampling parameters of pH and VOCs are done monthly, in accordance with SPDES permit equivalency requirements (**Table 3.2.4-1**). In addition, samples are analyzed for tritium with each system-sampling event. In these samples, tritium continues to remain below analytical reporting limits. Effluent VOC concentrations from the treatment system during this period of operation were below permit equivalency requirements.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit*	Max. Observed Value
pH range (SU)	6.5 – 8.5	6.8–7.9
carbon tetrachloride	5 µg/L	ND
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	ND
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2-trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

Notes:
*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.
Required sampling frequency is monthly for VOCs and pH.

System Operations

In 2008, approximately 135 million gallons of water were pumped and treated by the OU III South Boundary System. Well EW-8 was put in standby mode in October 2006, and EW-12 has remained in standby since 2003. Wells EW-6 and EW-7 were put on standby near the end of 2007.

January – September 2008

Approximately 107 million gallons of water were pumped and treated. There were communications and electrical problems during this period, which resulted in the system operating sporadically during the summer months.

October 2008 – December 2008

The OU III South Boundary System pumped and treated approximately 28 million gallons of water. There were flow meter problems with EW-3 during this quarter, which resulted in down time due to repair. In addition, the system was off for part of December due to communications problems with the wells and NSLS-II construction activities affecting electrical supply to the system.

3.2.4.5 System Operational Data

System Influent and Effluent

Figure 3.2.4-3 plots the concentrations of TVOCs in the extraction wells versus time. The overall influent water quality and the individual extraction wells show a general declining trend of concentrations. The system was also sampled monthly for tritium, which was not detected above the reporting limit in any sample during 2008. System influent and effluent sampling results are summarized on **Tables F-15** and **F-16 (Appendix F**), respectively.

Cumulative Mass Removal

Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to calculate the mass removed (**Table F-17** in **Appendix F**). The cumulative total of VOCs removed by the treatment system versus time is plotted on **Figure 3.2.4-4**. The 2008 total was approximately 60 pounds. Cumulatively, the system has removed approximately 2,630 pounds since it was started in June 1997.

Table 3.2.4-2.
OU III South Boundary Air Stripper
VOC Emission Rates, 2008 Average

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0007
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	<0.0002
1,2-dichloroethane	0.008	<0.0002
1,1-dichloroethylene	0.034	0.0001
cis-1,2-dichloroethylene	10***	<0.0002
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0060
1,1,1-trichloroethane	10***	0.0003
trichloroethylene	0.143	0.0001

Notes:
ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

Air Discharge

Table 3.2.4-2 shows the air emissions data from the OU III South Boundary system for 2008, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for water treated during that time (**Table F-15**). The concentration of each constituent was averaged for the year, and that value was used in the calculation. System air emissions were below allowable levels.

Extraction Wells

In general, the extraction wells continued to show slowly decreasing VOC concentrations during 2008 (**Figure 3.2.4-3**). **Table F-14** in **Appendix F** summarizes the data for the extraction wells. **Table 3.2.4-3** shows the monthly extraction well pumping rates.

3.2.4.6 System Evaluation

The pump and treat system continues to maintain hydraulic control and continues to prevent further plume migration across the southern site boundary. Plume core and bypass wells continued to show stable or decreasing VOC concentrations. The system operated at an average of 259 gpm during 2008. There was some significant downtime due to electrical problems and scheduled maintenance. No permit equivalency standards were exceeded. There have been no air emission exceedances.

The OU III South Boundary Pump and Treat System performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected VOC concentrations observed in the monitoring and extraction wells associated with the OU III South Boundary Pump and Treat System during 2008.

2. Has the plume been controlled?
Yes. The capture zone for the OU III South Boundary Pump and Treat System is depicted on **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?
Yes. The OU III South Boundary System continues to be effective in removing VOCs from the deep portions of the Upper Glacial aquifer. The overall reduction in the high-concentration areas of the plume near the south boundary is evident.

The OU III South Boundary System is planned to operate for 15 years; at the end of 2008 it had operated for approximately 11.5 years. The system is removing contamination at the expected rate and hydraulic control of the plume was demonstrated. The duration of operation for the OU III South Boundary System is dependent on the effectiveness of the Middle Road System, and the travel time from Middle Road to the South Boundary. The Middle Road System started operation approximately 4.5 years after the OU III South Boundary System. The contaminant travel time from Middle Road to the OU III South Boundary system is approximately 5 to 10 years. Therefore, the high concentrations observed in the vicinity of well 113-17 (located just south of the Middle Road System) will likely determine the operating period of this system (**Figures 3.2-1 and 3.2-2**). This well has shown a significant decrease in TVOCs from over 1,300 µg/L to 174 µg/L. New monitoring well 121-45 was installed in 2009 to monitor concentrations of TVOCs immediately upgradient of EW-2, which has historically had the highest TVOC concentrations.

4. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?
No. The average TVOC concentrations of the OU III South Boundary wells showed a slight increase in 2008 (**Figure 3.2.4-5**).

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?
Yes, starting in late 2005 and continuing through 2008. The average TVOC concentration in 2008 was 35 µg/L **(Figure 3.2.4-5)**.

4c. How many individual plume core wells are above 50 µg/L?
One core well, 121-45, has TVOC concentrations above 50 µg/L. Extraction well EW-4 also has concentrations above 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
To date, the OU III South Boundary System has not been pulsed.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. Based on modeling results, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.4.7 Recommendations

The following are recommendations for the OU III South Boundary Pump and Treat System and groundwater monitoring program:

- Maintain wells EW-6, EW-7, EW-8, and EW-12 in standby mode. The system's extraction wells will continue to be sampled on a quarterly basis. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Maintain the routine operations and maintenance monitoring frequency that began in 2003 except for the changes noted below.
- Stop sampling the following wells that have historically been below MCLs: 121-07, 121-19, 122-02, 122-15, and 122-16. The following wells are to be reduced to an annual sampling schedule due to low VOC concentrations: 122-04, 122-19, 122-18, 122-20, 122-31, 122-32, 122-33, 122-34, and 122-35.

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3.2.5 Western South Boundary Pump and Treat System

The Western South Boundary Pump and Treat System was designed to capture TVOC concentrations exceeding 20 µg/L in the Upper Glacial aquifer along the western portion of the BNL south boundary. The system reduces additional off-site migration of the contamination, and potential impacts of the VOC plume to the Carmans River. The system began operating in September 2002 and was changed to pulse pumping in late 2005, one month on and two months off. Based on increasing VOC concentrations in a monitoring well, extraction well WSB-1 was put back into full-time operation in November 2008. Extraction well WSB-2 remains in a pulse-pumping mode.

3.2.5.1 System Description

A complete description of the Western South Boundary Treatment System is contained in the *Operations and Maintenance Manual for the Western South Boundary Treatment System* (BNL 2002b).

3.2.5.2 Groundwater Monitoring

A network of 18 wells is used to monitor this portion of the plume. As noted below, well 119-06 was installed in October 2008. Their locations are shown on **Figure 1-2**. The wells are sampled at the O&M phase frequency (see **Table 1-5** for details).

3.2.5.3 Monitoring Well Results

The primary VOCs associated with this portion of the plume are dichlorodifluoromethane (a freon), TCA, TCE, and chloroform. VOC contamination is located in the mid to deep Upper Glacial aquifer. Groundwater monitoring for this system was initiated in 2002. **Figure 3.2-1** presents fourth-quarter 2008 monitoring well concentrations. A summary of key monitoring well data for 2008 follows.

- Plume core wells 121-42, 126-13, 127-04, and 127-06 have been generally decreasing in concentrations since the treatment system was started in 2002. TVOC concentrations in wells 121-42 and 127-06, located upgradient of extraction well WSB-2, have remained around 20 µg/L since 2005. TVOC concentrations in core well 126-15, located midway between the two extraction wells, has remained consistently below 5 µg/L from 2002 through most of 2006. In late 2006 and 2007, the concentrations began increasing but still remained below 20 µg/L TVOCs. In 2008, the TVOC levels did not exceed 10 µg/L.
- TVOC concentrations in plume core well 126-14, located upgradient of WSB-1, have decreased slightly since system start-up, but have remained above 20 µg/L. TVOC concentrations (primarily TCA) in plume core well 126-11, located adjacent to WSB-1, dropped off significantly since system start-up; however, TVOC concentrations began increasing since 2006 and reached 31 µg/L in the second quarter 2008 (see trends on **Figure 3.2.5-1**). This was the highest TVOC concentration detected in the seven downgradient plume core wells in 2008.
- As a follow-up to a recommendation from EPA, six temporary wells were installed in September and October 2008 along Middle Road to further characterize the extent of VOC contamination in the upgradient portion of the plume (**Figure 3.2-1**). The maximum TVOC concentration detected was 120 µg/L in WSB VP-1 at 135 feet bls. The maximum individual VOC detected at this interval was TCA at 72 µg/L. The second highest temporary well TVOC concentration was 70 µg/L at 145 feet bls in WSB VP-4. The maximum individual VOC detected at this interval was TCA at 40 µg/L. See **Figure 3.2.3-2** for a cross-sectional view of these temporary wells.
- In March 2009, two additional temporary wells (WSB VP-7 and WSB VP-8) were installed between Middle Road and Princeton Avenue to further evaluate the upgradient extent of the VOC contamination. The maximum TVOC concentration detected was 63 µg/L in WSB VP-7 at 192 feet bls. This was the deepest interval for the temporary well. The maximum individual VOC

detected at this interval was dichlorodifluoromethane at 50 µg/L. TVOC concentrations in WSB VP-8 were less than 10 µg/L. **Table 3.2.5-1** presents the detections for the eight temporary wells.

- As a follow-up to the six temporary wells along Middle Road, monitoring well 119-06 was installed at the location of WSB VP-1. This core well had TVOC concentrations up to 170 µg/L in December 2008, with TCA (100 µg/L) as the primary compound. This is the highest VOC detection for the plume in 2008.
- In bypass detection well 130-08, located south of extraction well WSB-1, the maximum TVOC concentration during 2008 was 48 µg/L in the first quarter. The highest individual VOC detected was dichlorodifluoromethane at 25 µg/L.
- In bypass well 126-16, located south and between the two extraction wells, TVOC concentrations were approximately 35 µg/L. Bypass well 127-07, located downgradient of WSB-2, has shown steadily declining VOCs since 2005. In 2008, TVOC concentrations were less than 10 µg/L.
- Plume perimeter well 130-03, located west of extraction well WSB-1, had a maximum TVOC concentration of 24 µg/L in May 2008. This well has shown a decreasing trend from the historical high TVOC concentration of 58 µg/L in December 2004. The capture zones of the Western South Boundary extraction wells were not intended to include this area.
- Because there have been no detections of VOCs exceeding NYS AWQS for plume perimeter wells 119-03 and 125-01 since they were installed in 2002, per the recommendation in the *2007 Groundwater Status Report*, VOC analysis was discontinued in mid 2008. These wells monitored the groundwater quality in the vicinity of the OU III Western South Boundary recharge basin. Also, since background well 124-02 has not had any detections of VOCs above the NYS AWQS, this parameter was dropped.

Table 3.2.5-2
OU III Western South Boundary Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	6.5–8.5 SU	6.9–8.0 SU
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

Note:
Required effluent sampling frequency is 2x/month for VOCs and monthly for pH.

3.2.5.4 System Operations

During 2008, the extraction wells were sampled quarterly. The influent and effluent of the air-stripper tower were sampled twice per month when the system was running in February, May, August, November, and December. The system was in standby mode for pulse pumping the remainder of the time. As per the recommendation in the *2007 Groundwater Status Report* (BNL 2008b), extraction well WSB-1 was put back into full-time operation in November 2008 due to increasing TVOC concentrations greater than the capture goal of 20 µg/L in core well 126-11. System samples were analyzed for VOCs. In addition, the effluent sample was analyzed for pH and tritium twice a month. No tritium was detected in 2008. **Table 3.2.5-2** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The system's effluent discharges met the SPDES equivalency permit requirements. The system operations are summarized below.

January – September 2008

The treatment system operated normally from January to September. The system has been on a pulse-pumping schedule since 2005. The schedule is one month on and two months off. The system operated in February, May, and August. During this time, approximately 39 million gallons of groundwater were pumped and treated.

October – December 2008

The system was off in October as part of the pulse-pumping schedule. In November, WSB-1 was placed back into full-time operations. WSB-2 continued following the pulse-pumping schedule of one month on and two months off. The system operated without interruption. During this quarter, approximately 20 million gallons of groundwater were pumped and treated.

Table 3.2.5-4
OU III Western South Boundary
2008 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	<0.0002
chloroform	0.0086	0.0002
1,1-dichloroethane	10**	<0.0002
1,2-dichloroethane	0.011	<0.0002
1,1-dichloroethene	0.194	0.0004
chloroethane	10**	<0.0002
1,1,1-trichloroethane	10**	0.0006
trichloroethylene	0.119	0.0002

Notes:

ERP = Emissions Rate Potential, stated in lb/hr.
* Based on NYSDEC Air Guide 1 Regulations.
** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

3.2.5.5 System Operational Data

Extraction Wells

During 2008, approximately 60 million gallons of groundwater were pumped and treated by the OU III Western South Boundary System, with an average flow rate of approximately 274 gpm while in operation. **Table 2-3** gives monthly pumping data for the two extraction wells. **Table 3.2.5-3** shows the monthly extraction well pumping rates. VOC and tritium concentrations for extraction wells WSB-1 and WSB-2 are provided on **Table F-18** (**Appendix F**). VOC levels in both wells continued to show a slight decreasing trend since system start-up in 2002, through 2005. In 2006 WSB-2 showed increasing TVOCs, but has been decreasing in 2007 and 2008. The maximum TVOC concentration in 2008 was 10 µg/L. Since 2006 there has been a slight increasing trend in WSB-1 TVOC concentrations; however, they were still lower than the 20 µg/L capture goal. **Figure 3.2.5-2** provides a graph of extraction well trends over time. Most of the individual VOC compounds were either below or slightly above the NYS AWQS.

System Influent and Effluent

Influent TVOC concentrations were less than 15 µg/L, and individual VOC concentrations were less than the NYS AWQS, except for February and December 2008 data that detected TCA up to 5.2 µg/L. These levels are consistent with the historical influent concentrations. The influent consists primarily of dichlorodifluoromethane, TCA, TCE, and chloroform (**Tables F-19** and **F-20** in **Appendix F**).

The air-stripper system effectively removed all elevated contaminants from the influent groundwater. The system's effluent data were below the analytical method detection limit and below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal

Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent, to calculate the pounds of VOCs removed per month (**Table F-21** in **Appendix F**). The cumulative mass of VOCs removed by the treatment system is provided on **Figure 3.2.5-3**. During 2008, 5 pounds of VOCs were removed. A total of 54 pounds have been removed since the start-up of the system in 2002.

Air Discharge

Table 3.2.5-4 presents the VOC air emission data for the year 2008 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operation. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from µg/L to lb/gal, which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. The VOC air emissions were well below allowable levels.

3.2.5.6 System Evaluation

The Western South Boundary Pump and Treat System performance can be evaluated based on the five major decisions identified for this system from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

Yes. TVOC concentrations up to 120 µg/L in WSB VP-1 were detected in the upgradient portion of the plume at 135 feet bls along Middle Road. The maximum individual VOC concentration detected at this interval was 72 µg/L TCA. This was an unexpected concentration based on historical data. The intent of the investigation was to further characterize the extent of VOC contamination in this upgradient portion of the plume. The regulators were informed of the results and additional temporary wells were installed. This contamination will be captured by existing extraction well WSB-1.

2. Has the plume been controlled?

Yes. VOC concentrations in the plume perimeter wells (except 130-03) remained stable at or below the drinking water standard during 2008, indicating that the plume is being controlled. Perimeter well 130-03 has been slowly decreasing since late 2004 to a low of 24 µg/L in the second quarter of 2008. The capture zone of WSB-1 was not intended to include this area. As noted above, low VOC concentrations in the bypass wells were present before the system was operational and not within the capture zone of the extraction wells. The capture zone for the treatment system is depicted on **Figure 3.0-1**.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

Yes. The system is operating as planned based on meeting the capture goal of 20 µg/L TVOCs. Plume core monitoring wells began showing decreasing concentration trends since 2002. Well 126-11 began decreasing in 2006 and 2007. In 2008, VOC concentrations in well 126-11 also started declining. VOCs present in monitoring wells immediately upgradient of WSB-1 (i.e., 126-11 and 126-14) will be captured by the system. Based on groundwater modeling performed in late 2008, it is projected that VOCs detected in the temporary wells installed along Middle Road will be captured by existing extraction well WSB-1. However, the estimated duration for operation of the treatment system would be extended until approximately 2019.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements. However, the extraction wells began pulse pumping in late 2005 based on low VOC concentrations in core monitoring wells and the extraction wells (see 4a through 4b). Extraction well WSB-1 was placed back into full-time operation in late 2008 due to elevated VOCs in a nearby monitoring well.

4a. Have asymptotic VOC concentrations been reached in core wells?

No. Although there has been a steady decrease of VOCs in most core wells since 2002, there have been fluctuations. As noted in **Section 3.2.5.3**, core monitoring wells have been steadily decreasing since the system became operational in mid 2002, except for well 126-11. This well, immediately upgradient of WSB-1, steadily increased from 2006 through early 2008.

4b. Is the mean TVOC concentration in core wells less than 20 µg/L?
No. The mean TVOC concentration in the core wells is 32 µg/L (**Figure 3.2.5-4**). This value includes recently installed monitoring well 119-06.

4c. How many individual plume core wells are above 20 µg/L TVOC?
TVOC concentrations in three of eight core wells were above 20 µg/L. Wells 126-11, 126-14, and 119-06 showed TVOC concentrations up to 170 µg/L in 2008.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?
Yes. As noted above, plume core well 126-11 has been steadily increasing since 2006, shortly after pulse pumping began. The highest TVOC concentration in 2008 was 31 µg/L. TVOC concentrations in the extraction wells increased slightly since 2006; however, they remained below 20 µg/L in 2008.

5. Have the groundwater cleanup goals been met? Are MCLs expected to be been achieved by 2030?
No. MCLs have not been achieved for individual VOCs in all plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.5.7 Recommendations

The following are recommendations for the OU III Western South Boundary Treatment System and groundwater monitoring program:

- Continue full-time operation of extraction well WSB-1, and pulse pumping of WSB-2 at the schedule of one month on and two months off. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.
- If any of the three bypass detection wells starts showing increasing trends, the need to take further action will be evaluated.
- Due to the elevated dichlorodifluoromethane detected at the deepest interval in WSB VP-7 between Middle Road and Princeton Avenue, a monitoring well will be installed in 2009. The data will be evaluated for approximately one year to determine if additional actions are necessary.
- Maintain the routine O&M monitoring frequency that began in 2005.
- Due to low historical detections of VOCs, the sampling frequency for monitoring wells 126-01 and 130-04 will be reduced from semiannual to annual.

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3.2.6 Industrial Park In-Well Air Stripping System

This section summarizes the operational data from the OU III Industrial Park In-Well Air Stripping System for 2008 and presents conclusions and recommendations for its future operation. The system began operation on September 27, 1999. The OU III Industrial Park system was designed to contain and remediate a portion of the OU III plume between BNL's southern boundary and the southern boundary of the Parr Industrial Park. **Figure 3.2.4-1** illustrates the extent of the OU III contaminant plume in the vicinity of the Industrial Park. The primary VOCs associated with this portion of the OU III plume are TCA, TCE, and carbon tetrachloride.

3.2.6.1 System Description

The OU III Industrial Park system consists of a line of seven in-well air stripping treatment wells. Each treatment well is constructed with two well screens separated by an inflatable packer. Contaminated groundwater is withdrawn from the aquifer via submersible pump through a lower screen (extraction screen) set at the base of the treatment well. The groundwater is pumped to a stripping tray located in a below ground vault over the wellhead. After passing through the stripping tray, treated groundwater flows back down the well and is recharged to a shallower portion of the aquifer through an upper screen (recharge screen). Some of the treated groundwater that is recharged through the upper screen recirculates through the cell and is drawn back into the extraction screen for further treatment, while the balance flows in the direction of regional groundwater flow.

A closed-loop air system through a single blower keeps the vault under a partial vacuum. This vacuum draws air from below the stripping tray as contaminated groundwater is discharged on top. VOCs are transferred from the liquid phase to the vapor phase as contaminated groundwater passes through the stripping tray. The contaminated air stream is carried from the vault to a treatment and control building, where it is passed through two GAC units in series to remove the VOCs. Treated air is then recirculated back to the wellhead. The carbon units, system blower, and system control panel are all housed in a one-story masonry treatment building. A complete description of the system is included in the *Operations and Maintenance Manual for the OU III Offsite Removal Action* (BNL 2000b).

3.2.6.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 43 wells and is designed to monitor the VOC plumes in the vicinity of the industrial park south of the site, and also the effectiveness of the in-well air stripping groundwater treatment system on this part of the high-concentration OU III VOC plumes. The wells are located throughout the industrial park and on Carleton Drive, as shown on **Figure 3.2.4-1.** Screen depths are set to capture water levels at multiple depths and to obtain water quality data as follow:
1) above the treatment well effluent depth, 2) at the effluent depth, and 3) at the treatment well influent depth.

Sampling Frequency and Analysis

Plume core and perimeter wells are sampled either annually or semiannually and analyzed for VOCs. Bypass detection and Magothy wells are sampled quarterly and analyzed for VOCs (**Table 1-5**).

3.2.6.3 Monitoring Well Results

The complete analytical results are included in **Appendix C**. VOC concentrations in the plume perimeter wells that monitor the width of the plume (000-245 and 000-272) remained below NYS AWQS during 2008. Based on these data, the plume is effectively bounded by the current well network. **Figure 3.2.4-1** shows the plume distribution based on fourth-quarter 2008 data. The vertical extent of contamination is shown on **Figure 3.2.6-1**. The location of this cross section (G–G') is illustrated on **Figures 3.2-1 and 3.2.4-1**. 2008 results for key monitoring wells are as follow:

Plume Core Wells

- Wells 000-253 (just east of UVB-1) and 000-256 (between UVB-1 and UVB-2), which both contained TVOC concentrations over 1,000 µg/L in 2001, have continued to show concentrations at or below NYS AWQS. Since 2003, UVB-1 has remained in standby due to low VOC concentrations.
- Well 000-259 (located between UVB-2 and UVB-3), which was sampled in May and November 2008, had elevated TVOC concentrations of 102 µg/L and 161 µg/L, respectively. This is consistent with data observed in extraction wells UVB-2 and UVB-3.
- A steady decline in TVOC concentrations was observed in well 000-112 (immediately upgradient of UVB-1 and UVB-2) since 1999, when concentrations were near 2,000 µg/L. TVOC concentrations were at 13 µg/L in November 2008 (**Figure 3.2.6-2**).
- Well 000-262 (between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002 (**Figure 3.2.6-2**). The TVOC concentration in this well peaked at 2,175 µg/L in 2001 and has fluctuated for the past few years between 200 and 600 µg/L. Data from 2008 showed TVOC concentrations of 385 µg/L in May and 224 µg/L in November.
- The TVOC concentration in well 000-268 (between UVB-6 and UVB-7) was 14 µg/L in November 2008 (**Figure 3.2.6-2**). This is consistent with data observed in UVB wells 6 and 7.

Plume Bypass Wells

- TVOC concentrations in most of the wells located near Carleton Drive were stable or decreasing during 2008. Wells 000-431 and 000-432 serve as bypass monitoring points downgradient of UVB-2. Well 000-432 has shown TVOC concentrations between 6 and 10 µg/L during 2008. TVOC concentrations in 000-431 were below NYS AWQS during 2008. The low TVOC concentrations in these wells indicate that the system is effective in hydraulically controlling the plume.
- TVOC concentrations in wells 000-275, 000-276, and 000-277 are below the capture goal of 50 µg/L, indicating that the system is effective in capturing the plume. The highest concentration observed was 12 µg/L (November 2008) in well 000-277.
- In 2008, well 000-278 showed a significant increase in TVOC concentrations, from 14 µg/L in January to 217 µg/L in November. This well is directly downgradient of well UVB-4, which had been shutdown for about one year, and it is likely detecting contaminants were hung up in the "stagnation zone." The data from January 2009 shows concentrations decreasing to 109 µg/L.
- TVOC concentrations in well 000-273 decreased from 177 µg/L in May 2008 to 34 µg/L in November 2008. Well 000-274 varied from 44 µg/L in May 2008 to 176 µg/L in November 2008. These wells are located immediately downgradient of well UVB-1, which was shut down in October 2005. These TVOC concentrations observed in the monitoring wells are from contamination that was in the "stagnation zone" downgradient of UVB-1 while it was operating. Now that it has been shut down, the contaminants have migrated downgradient of the extraction well. These contaminants could not be captured by the extraction well because they were too far downgradient but were held up by the pumping. As these higher concentration slugs of contaminants are passing by the monitoring wells, the concentrations first increase then decline. These contaminants will be captured by the down gradient LIPA extraction wells.

Perimeter Wells

VOC concentrations for individual constituents remained below NYS AWQS (5 µg/L) in each of the shallow wells screened to monitor above the adjacent UVB effluent well screens.

3.2.6.4 System Operations

In 2008, approximately 128 million gallons of groundwater were pumped and treated by the Industrial Park In-Well Air Stripping System.

Operating Parameters

Water samples are obtained monthly from each of the seven extraction wells before air stripping in each UVB tray and after treatment. The samples are analyzed for VOCs. These samples determine the wells' removal efficiency and performance. Based on these results, operational adjustments are made to optimize the system's performance.

System Operations

System extraction well pumping rates are included on **Table 3.2.6-1**. The following summarizes the system operations for 2008.

Well UVB-1 remained in standby mode throughout the year.

January – September 2008

In March, wells UVB-4 and UVB-5 were off for part of the month due to electrical problems. In June, wells UVB-3 and UVB-4 were down for the month for repairs. Wells UVB-2 through UVB-4 were off for the month of August waiting for new flow meters. The system was off from August 12 to 22 due to problems with the blower.

October – December 2008

The system was off from October 13 to 21 due to electrical problems. Well #7 was off for the month of December in order to install a new drive. Wells UVB-4 and UVB-6 ran sporadically in December due to electrical and mechanical problems. The rest of the system operated normally for the remainder of the period. Well UVB-1 remained in standby mode for this period.

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent

During 2008, influent TVOC concentrations in the treatment system wells showed a steady or declining trend, except for well UVB-5 which showed an increase (**Figure 3.2.6-3**). The corresponding effluent well concentrations (**Figure 3.2.6-4**) showed decreasing or stable TVOC concentrations for the year. UVB-1 remained in standby mode for 2008. There was significant downtime for individual wells in 2008 due to electrical problems, and routine maintenance and cleaning of the wells.

For 2008, the overall average removal efficiency was 83 percent (**Table F-22** in **Appendix F**). Well UVB-1 was not used in this calculation because it was off.

Cumulative Mass Removal

Calculations were performed to determine the VOC mass removed from the aquifer by the remediation wells during the year. The average estimated flow rates for each monthly monitoring period were used, in combination with the influent and effluent TVOC concentrations. **Table F-23** summarizes these data (**Appendix F**). During 2008, flow averaged approximately 41 gpm per well for the six operating wells. **Figure 3.2.6-5** plots the total pounds of TVOCs removed by the treatment system vs. time. During 2008, 24 pounds were removed from the aquifer, with a total of 1,033 pounds removed since 1999.

Air Treatment System

Air samples were collected quarterly from the GAC vessels prior to treatment, between the two vessels, and after the second vessel (effluent). The samples were used to determine when a GAC change-out was needed. In addition, airflow rates were recorded to optimize the efficiency of individual recirculation wells.

Airflow rates are measured for each in-well air-stripping unit inside the treatment building. These rates averaged 536 cfm during 2008 (**Table F-24** in **Appendix F**).

3.2.6.6 System Evaluation

The OU III Industrial Park In-Well Air Stripping System performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells or extraction wells associated with the OU III Industrial Park System during 2008.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass well data reveals that there were no significant VOC concentration increases in these wells during 2008, except for higher concentrations in wells 000-273 and 000-274, 000-277 and 000-278. These concentrations were expected, as explained in **Section 3.2.6.3**. Therefore, it is concluded that there has been no plume growth and the plume continues to be controlled.

The capture zone for the OU III Industrial Park System is depicted on **Figure 3.0-1**. The capture zone depicted includes the TVOC 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?

Yes. The treatment system is effectively removing contamination. The current estimate for treatment system operations is approximately 12 years (through 2012). The OU III Industrial Park System continues to effectively remove VOCs from the deep Upper Glacial aquifer. **Figure 3.2-3** compares the OU III plume from 1997 to 2008. The overall reduction in the high-concentration areas of the plume near the south boundary is evident. This is an indication that concentrations of VOCs approaching the Industrial Park System will continue to decrease over time.

The overall trend in the mean TVOC concentrations in the core groundwater monitoring wells is declining (**Figure 3.2.6-6**). The system is removing contamination at the expected rate and hydraulic control of the plume is demonstrated; hence, it is operating as planned.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

No. Concentrations show an overall slightly decreasing trend.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?

Yes, the mean TVOC concentration in the plume core wells was approximately 47 µg/L.

4c. How many individual plume core wells are above 50 µg/L TVOC?
Three (000-249, 000-259, and 000-262) of the nine plume core wells had TVOC concentrations exceeding 50 µg/L in 2008.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
No. To date, the OU III Industrial Park In-Well Air Stripping System has not been pulsed.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in plume core wells. Based on model predictions, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.6.7 Recommendations

The following are recommendations for the Industrial Park In-Well Air Stripping System and groundwater monitoring program:

- The current routine operations and maintenance monitoring frequency will be maintained during 2009.
- The system will continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. It is recommended that well UVB-7 be placed in standby as TVOC concentrations have dropped to below 5 µg/L in this well. Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, well UVB-1 or UVB-7 will be restarted.
- Wells 000-272 and 000-280 (plume perimeter wells) should be changed to an annual sampling schedule, as these have historically shown low VOC concentrations.

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3.2.7 Industrial Park East Pump and Treat System

This section summarizes the 2008 operational and monitoring well data for the OU III Industrial Park East (IPE) Groundwater Pump and Treat System, and presents conclusions and recommendations for its future operation. The system began full operation in June 2004 to provide capture and control for a downgradient portion of the OU III VOC plume, which has migrated beyond the BNL site boundary.

3.2.7.1 System Description

The IPE treatment facility (Building OS-2) is located at the Industrial Park immediately east of Building OS-1, the Industrial Park Groundwater Treatment System. This system includes two extraction wells and two recharge wells. Extraction well EWI-1 is screened in the Upper Glacial Aquifer and EW I-2 is screened in the upper portion of the Magothy aquifer (**Figures 3.2.6-1 and 3.2.7-1**). Extraction well EWI-1 is designed to operate at a maximum rate of approximately 120 gpm; extraction well EWI-2 is designed for approximately 100 gpm. In 2007, a new injection well was added to this system.

The treated water is recharged to the Upper Glacial aquifer through two recharge wells located near the extraction wells, designated as DWI-1 and DWI-2. A complete description of the system is contained in the *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System* (BNL 2004c).

3.2.7.2 Groundwater Monitoring

The monitoring network consists of 12 wells (**Figure 1-2**) that are sampled quarterly and analyzed for VOCs. These wells monitor the VOC plume south of the Long Island Expressway (LIE) to Astor Drive in the East Yaphank residential area, as well as the effectiveness of the groundwater treatment system.

3.2.7.3 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are TCA, trichloroethylene, and 1,1-dichloroethylene. Groundwater monitoring for this system was initiated in 2004; however, three of the wells have been monitoring the plume since 1999. Fourth-quarter well data are posted on **Figures 3.2.4-1, 3.2.6-1, and 3.2.7.1**. The complete analytical results are in **Appendix C.** Results for key monitoring wells are as follow:

- The maximum TVOC concentration detected during 2008 was 38 µg/L in downgradient well 000-494 during the fourth quarter, with TCA (22 µg/L) as the highest individual VOC detection (**Figure 3.2.6-2**). TVOC concentrations in well 000-494 have recently increased to 38 µg/L in November 2008. This is a Magothy monitoring well screened to 310 feet below land surface and located 1,200 feet downgradient of the extraction wells. This contamination was likely downgradient of the extraction wells prior to their installation.
- In plume core well 000-514, approximately 100 feet west of the extraction wells, VOC concentrations were less than NYS AWQS during 2008.
- VOCs in plume bypass well 000-493, have remained below the MCL since it was installed in June 2004.
- Upgradient wells 122-24 and 122-25, which had shown concentrations as high as 570 µg/L in 2002, have been below 50 µg/L since August 2004. All VOCs analyzed were below MCLs in 2008.

3.2.7.4 System Operations

Operating Parameters

The influent, midpoint, and effluent of the carbon vessels are sampled once a month and analyzed for pH and VOCs. The extraction wells are sampled monthly and are analyzed for VOCs. Sampling for pH and VOCs adheres to the requirements of the SPDES equivalency permit. The system's effluent samples during this period of operation were within the permit levels (**Table 3.2.7-1**). In November 2007, the system began a one month on and one month off pulse-pumping schedule.

Table 3.2.7-1.
OU III Industrial Park East Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.5–8.5 SU	5.7–6.4 SU
bromoform	50	<0.50
carbon tetrachloride	5	<0.50
chloroform	5	0.54
methylene chloride	5	<0.50
tetrachloroethylene	5	<0.50
toluene	5	<0.50
trichloroethylene	10	<0.50
1,2-dichloroethane	5	<0.50
1,1-dichloroethane	5	<0.50
1,1-dichloroethylene	5	<0.50
1,1,1-trichloroethane	5	<0.50

Note:
Required sampling frequency is monthly for VOCs and pH.

System Operations

The following information summarizes the system operations for 2008.

January – September 2008

The system was off for most of the month of February due to electrical problems. The system was also off part of June due to damage caused by a lightning strike, and August 12 to 21 due to a bad power supply card in the programmable logic controller (PLC). The system operated normally for the rest of this period. Eighteen million gallons were pumped and treated during the first three quarters of 2008.

October – December 2008

The system operated normally for this period. The system pumped and treated 15 million gallons of groundwater this quarter.

Extraction Wells Operational Data

During 2008, approximately 33 million gallons were pumped and treated by the IPE system, with an average flow rate of 66 gpm. The system is pulse pumped, one month on and one month off, so the average rate for the months it was in operation was 132 gpm. **Table 3.2.7-2** shows the monthly pumping data for the system. VOC concentrations for the IPE extractions wells are provided on **Table F-25** (**Appendix F**). In 2008, TVOC concentrations in EWI-1 ranged from 2.3 to 3.7 µg/L and 5.7 to 8.3 µg/L in EWI-2.

3.2.7.5 System Operational Data

System Influent and Effluent

The overall TVOC influent concentrations to the carbon vessels were slightly lower than 2007 levels (**Figure 3.2.7-3**). **Tables F-27** and **F-28** (**Appendix F**) present the influent and effluent data.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system.

Table F-26 lists and gives total pounds of VOCs removed by the treatment system in 2008. **Figure 3.2.7-2** plots mass removal versus time. Approximately 2.7 pounds of VOCs were removed from the aquifer during 2008 and 34.5 pounds since system start-up in 2004.

3.2.7.6 System Evaluation

This system is designed to achieve the overall OU III ROD objectives of minimizing plume growth and meeting MCLs in the Upper Glacial aquifer in 30 years (i.e., 2030) or less. According to the *OU III Explanation of Significant Differences* (BNL 2005a), MCLs within the Magothy aquifer must be met within 65 years (i.e., 2065) or less. The system will address the highest VOC concentration portion of the plume (above 50 µg/L).

The Industrial Park East Pump and Treat System performance during 2008 can be evaluated based on the five major decisions identified for this system from the groundwater DQO process:

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells or extraction wells associated with the Industrial Park East Groundwater Pump and Treat System during 2008.

2.Has the plume been controlled?
Yes, the downgradient monitoring shows concentrations of TVOCs below the capture goal of 50 µg/L.

3. Is the System operating as planned?
Yes, the system is operating as planned.

4. Can the groundwater treatment system be shut down?
Yes, the system has met all shutdown requirements.

4a. Have asymptotic VOC concentrations been reached in core wells?
IPE monitoring wells are below the capture goal of 50 µg/L for the treatment system, therefore reaching asymptotic conditions is no longer required since other shutdown criteria have been met.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?
Yes, all core wells are less than 50 µg/L.

4c. How many individual plume core wells are above 50 µg/L?
None.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
The Industrial Park East System began pulse pumping in November 2007, and no rebound has been observed to date.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved in the Upper Glacial aquifer (expected by 2030) and the Magothy aquifer (expected by 2065)?
No. MCLs have not been achieved for individual VOCs in all IPE plume core wells. However, concentrations are very close to this level, with the highest concentration being 5.1 µg/L TCA in well 122-24. MCLs are expected to be achieved by 2030 and 2065 for the Upper Glacial and Magothy aquifers, respectively, as required by the OU III ROD and ESD.

3.2.7.7 Recommendations

The following is recommended for the Industrial Park East Pump and Treat System and groundwater monitoring program.

- Submit Petition for Shutdown to the Regulators in July 2009. The system has met all shutdown requirements.

3.2.8 North Street Pump and Treat System

The North Street Pump and Treat System addresses a VOC plume that originated at the Former Landfill/Chemical Holes area. The VOC plume is presently located south of the site boundary, with the leading edge extending south to the vicinity of the Brookhaven Airport. The groundwater pump and treat system began operating in May 2004 (**Figure 3.2-1**).

Groundwater treatment consists of two extraction wells operating at a combined pumping rate of approximately 450 gpm. This pumping captures the higher concentration portion of the VOC plume (i.e., TVOC concentrations greater than 50 µg/L) in the Upper Glacial aquifer, and will minimize the potential for VOC migration into the Magothy aquifer.

The North Street plume has been divided into two segments for remediation purposes. The area to the north of extraction well NS-2 is being addressed by the remediation system on North Street, whereas the Airport System handles the area to the south (**Figure 3.0-1**). The Airport System was constructed to address the leading edge of this plume (**Section 3.2.10**).

3.2.8.1 System Description

The North Street system consists of two extraction wells. Extracted groundwater is piped through two 20,000-pound GAC units and discharged to four injection wells. Both the North Street and North Street East systems share the four injection wells. Extraction well NS-1 is designed to operate at a rate of approximately 200 gpm, and extraction well NS-2 is designed for 250 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004d).

3.2.8.2 Groundwater Monitoring

Well Network

A network of 28 wells monitors the North Street VOC plume (**Figure 1-2**). However, two wells (086-05 and 086-70) were abandoned in 2008 due to the planned construction of the NSLS-II. The VOC concentrations in these wells had decreased to levels below the NYS AWQS. The monitoring program also addresses radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 sump outfall areas), as well as the Former Landfill/Chemical Holes. Wells sampled under the Airport program are also utilized for mapping this plume.

Sampling Frequency and Analysis

The 26 wells are sampled and analyzed for VOCs at the operations and maintenance sampling frequency according to the schedule on **Table 1-5**. As recommended in the *2007 Groundwater Status Report* (BNL 2008b), Sr-90, gamma spectroscopy, and gross alpha/beta analysis for monitoring wells were eliminated due to the absence of any detections of radionuclides over the past several years. The 26 wells are sampled and analyzed annually for tritium.

3.2.8.3 Monitoring Well Results

The primary VOCs associated with this plume are carbon tetrachloride, PCE, TCA, and chloroform. **Figure 3.2-1** and **Figure 3.2.8-1** depict the TVOC plume distribution and include data from the monitoring wells. The complete groundwater monitoring well data for 2008 are included in **Appendix C**. A north–south hydrogeologic cross section (H–H') of the plume is provided on **Figure 3.2.8-2.** The location for the cross section is shown on **Figure 3.2-1**. A summary of key monitoring well data for 2008 follows.

- In 2008 the highest TVOC concentration in the plume was 174 µg/L in well 800-63 in January. TVOC concentrations started declining in late 2008 to 67 µg/L. The primary VOC in this well is chloroform at a maximum concentration of 95 µg/L in July 2008. This well is located on Vita

Drive, approximately 1,600 feet south of extraction well NS-1. As noted in trend **Figure 3.2.8-3** this well has displayed increasing VOC concentrations since late 2003. The leading edge of the higher concentration plume segment, which had migrated beyond the extraction well location prior to system start-up, has reached this location. This contamination will be captured by the Airport System.

- Plume core well 000-465 was installed 100 feet upgradient of extraction well NS-1 in 2004. This well had historically shown the highest VOC concentrations (primarily carbon tetrachloride) in the North Street area. TVOC concentrations were as high as 1,796 µg/L in 2004 and have since declined to 25 µg/L in May 2008. This correlates well with the TVOC concentrations observed in NS-1.
- VOC concentrations in plume core well 000-463, located approximately 200 feet north of NS-1, remain elevated (peak TVOC of 74 µg/L in during 2007 and 2008), but have been steadily declining, as shown on **Figure 3.2.8-3.**
- Plume core well 000-154 had historically shown high VOC concentrations (primarily carbon tetrachloride) in the North Street area. TVOC concentrations greater than 1,000 µg/L were observed in 1997 and 1998, but have steadily declined since then to approximately 5 µg/L in 2008. The trailing edge of the higher concentration segment of this plume has migrated south of this location.
- Plume core well 000-472, adjacent to NS-2, has shown a steady decline in the TVOC concentration in the past two years, from 308 µg/L in 2006 to 70 µg/L in the second-quarter 2008 sample. This contamination will be captured by NS-2.
- The plume continues to be bounded by perimeter wells.
- Several Airport monitoring wells (800-90, 800-92, 800-59, and 800-106) located south of the North Street extraction wells have displayed increasing TVOC concentrations over the past several years. Well 800-92 reached a high of 90 µg/L TVOCs in the second quarter 2008 and Magothy well 800-90 detected a maximum TVOC concentration of 81µg/L in January 2008. This suggests that the leading edge of the higher concentration segment, which had migrated beyond the North Street extraction well locations prior to that system start-up, has reached this location. This contamination will be captured by the Airport System treatment wells RTW-3A and RTW-4A.
- Historically, tritium has been detected in localized off-site areas approximately within the area covered by the North Street VOC plume. Potential sources for this tritium were located in the Former Landfill/Chemical Holes and OU IV Building 650 areas of the site. Tritium has been detected in the deep Upper Glacial aquifer at concentrations well below the DWS of 20,000 pCi/L. Historically, the highest tritium concentration (9,130 pCi/L) was detected in 2001 in temporary well 000-337. This location is approximately 300 feet north of well 000-153. Tritium has been detected historically in well 000-153, but concentrations have decreased from 2,560 pCi/L in 2001 to below minimum detectable activity (<MDA) in 2007 and 2008. In 2008, tritium was detected in three wells within the North Street plume at estimated values below 600 pCi/L. This is consistent with the steady decline in tritium concentrations observed over the past several years. Tritium monitoring of North Street wells will continue in 200.

3.2.8.4 System Operations

Monthly laboratory analyses are performed on influent, midpoint, and effluent samples from the GAC units. All monthly system samples are analyzed for VOCs, and the influent and effluent samples are also analyzed for pH. In addition, the system effluent is analyzed for tritium. **Table 3.2.8-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The extraction wells are sampled quarterly for VOCs and tritium.

Table 3.2.8-1
OU III North Street
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH (range)	5.5 – 8.5 SU	5.6 - 7.0 SU
carbon tetrachloride	5	ND
chloroform	5	ND
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
Required effluent sampling frequency is monthly for VOCs and pH.

January – September 2008

Routine operations continued from January through September, with approximately 141 million gallons pumped and treated during the first three quarters. The system was off periodically to allow for scheduled carbon filter change-outs. Various power surges due to lightning strikes were experienced during the first three quarters, all of which required system restarts and repair.

October – December 2008

Routine operations continued from October through December. The system was off periodically to allow for scheduled carbon change-outs. Approximately 39 million gallons were pumped and treated during this quarter.

3.2.8.5 System Operational Data

The system was operational from January to December 2008, with only minor shutdowns due to electrical outages, PLC issues, scheduled maintenance, and GAC change-outs.

Extraction Wells

Table F-29 (**Appendix F**) contains the monthly pumping data and mass removal data for the system. **Table 3.2.8-2** shows the monthly extraction well pumping rates. **Figure 3.2.8-4** shows the plot of the TVOC concentrations from the extraction wells over time. VOC concentrations for the extraction wells are provided on **Table F-30** (**Appendix F**). TVOC values in well NS-1 declined from 21 to 13 µg/L over the year, and well NS-2 remained virtually unchanged, with TVOC values ranging from 11 to 13 µg/L. The decline in NS-1 TVOC concentrations correlates to the concentrations in monitoring wells 000-463, 000-464, and 000-465, located immediately upgradient of NS-1. There was no tritium detected in the extraction wells in 2008.

System Influent and Effluent

The 2008 VOC concentrations for the NS carbon influent and effluent are summarized on **Tables F-31** and **F-32** (**Appendix F**). The combined influent TVOC concentration declined from 75 µg/L in December 2004 to 13 µg/L in December 2008. There was only one estimated detection of tritium (380 pCi/L) in the effluent in 2008. The influent is no longer sampled for tritium.

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. All 2008 effluent data for this system were below the MDL.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU III North Street Pump and Treat System was calculated using the average flow rates for each monthly monitoring period, in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds removed per month. The cumulative mass of VOCs removed by the treatment system vs. time is plotted on **Figure 3.2.8-5**. During 2008, approximately 181 million gallons of groundwater were pumped and treated by the North Street system, and approximately 21 pounds of VOCs were removed. Since May 2004, the system has removed 290 pounds of VOCs. The mass removal data are summarized on **Table F-29** (**Appendix F**).

3.2.8.6 System Evaluation

Figure 3.2.8-6 compares the TVOC plume from 1997 to 2008. The following significant changes were observed in the plume over this period:

- The trailing edge of the plume has migrated south of the BNL site.
- Monitoring wells 200 feet upgradient of NS-1 are showing a steady decline in TVOC concentrations.
- In wells downgradient of NS-1 and NS-2, TVOC concentrations are increasing as this plume segment that was south of the North Street system prior to start-up migrates toward the Airport.

The OU III North Street Monitoring Program can be evaluated from the five decision rules identified in the groundwater DQO process.

<u>1. Was the BNL Groundwater Contingency Plan triggered?</u>

No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells or extraction wells associated with the North Street Pump and Treat System during 2008.

<u>2. Has the plume been controlled?</u>

Yes. The cleanup goals have not been met; and it must be verified that the plume is not growing. An analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2008; thus, it can be concluded that that plume has not grown and continues to be controlled. As noted above, a segment of the plume now located near Vita Drive was beyond the capture zone of the North Street extraction well NS-1 at the time of system start-up. This portion of the plume will be addressed by the Airport extraction wells directly downgradient.

The leading edge of the plume was defined at Flower Hill Drive at concentrations below the NYS AWQS for individual VOCs. The Airport Pump and Treat System is designed to capture any contaminants migrating south of Flower Hill Drive.

<u>3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?</u>

The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing VOCs from the deep Upper Glacial aquifer. After four years of operation, the system influent VOC concentrations have been slightly higher than originally projected in the final design. The pre-design modeling predicted that the system will need to operate until 2012. Based on current data this prediction appears to remain valid.

<u>4. Are there off-site radionuclides that would trigger additional actions?</u>

No. As noted in **Section 3.2.8.3**, during 2008 there were only estimated values of tritium detected in three monitoring wells with concentrations below 600 pCi/L.

5. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements (see below).

5a. Have asymptotic TVOC concentrations been reached in core wells?
No. Although concentrations in a few of the upgradient wells have plateaued over time, overall asymptotic conditions have not yet been achieved.

5b. Are there individual plume core wells above 50 µg/L TVOC ?
Currently five of 12 plume core wells are showing concentrations greater than 50 µg/L TVOC.

5c. During pulsed operation of the system, is there significant concentration rebound in the core wells?
To date, the North Street System has not been pulsed.

5d. Have the groundwater cleanup goals been met? Will MCLs be achieved by 2030?
MCLs have not been achieved for ind ividual VOCs in plum e core wells. Based on grou ndwater modeling and current system performance, MCLs are expected to be achieved by 2030.

3.2.8.7 Recommendations

The following are recommended for the North Street Pump and Treat System and groundwater monitoring program:

- Maintain the operations and maintenance sampling frequency for monitoring wells.
- Due to historically low VOC concentrations, the sampling frequency for monitoring wells 000-108, 000-154, and 000-212 will be reduced from semiannual to annual.
- Due to the location of well 086-43 north of the Former Landfill and since groundwater samples have not exceeded DWS since it was installed, it is recommended that this well be dropped from the North Street monitoring program.
- VOCs have remained below DWS for wells 115-33, 115-34, and 115-35 since they were installed in 1996, and there have been no detections above DWS for well 115-32 since 2004. Additionally, tritium concentrations have been less than 400 pCi/L in each of these four wells since they were installed. As a result, it is recommended that these four wells be dropped from the North Street monitoring program.

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3.2.9 North Street East Pump and Treat System

This section summarizes the 2008 operational and monitoring well data for the OU III North Street East (NSE) Groundwater Pump and Treat System, and presents conclusions and recommendations for its future operation. The system began operation in June 2004 to provide capture and control of the downgradient portion of the OU I VOC plume, which has migrated beyond the BNL site boundary.

3.2.9.1 System Description

The North Street East System consists of two extraction wells. The water is pumped through two 20,000-gallon GAC units and the treated water is discharged to two of four injection wells located on North Street. Both the North Street and North Street East systems are located in the same building. Extraction well NSE-1 is designed to operate at a rate of approximately 200 gpm; extraction well NSE-2 is designed for 100 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004d).

3.2.9.2 Groundwater Monitoring

The monitoring network consists of 15 wells. The monitoring program was designed to monitor the VOC plume off site, south of the OU I South Boundary System, as well as the efficiency of the NSE groundwater remediation system (**Figure 1-2**). During 2008, the wells were sampled at the O&M phase frequency (i.e., core and perimeter wells sampled semiannually, and sentinel wells sampled quarterly). However, as recommended in the *2007 Groundwater Status Report* (BNL 2008b), plume core wells 000-481, 000-482, 000-483, and 000-484 were maintained at a quarterly sampling frequency because they are immediately upgradient of extraction well NSE-2. Since there have been no detections above the standards in any of the monitoring wells, Sr-90, gross alpha/beta, and gamma spectroscopy were removed from the analyte list in 2008. The wells have continued to be sampled annually for tritium. See **Table 1-5** for details.

3.2.9.3 Monitoring Well Results

Figure 3.1-1 shows the extent of the VOC plume. The plume originated from the Current Landfill and former HWMF (sources in OU I). The OU I South Boundary Remediation System is treating the on-site segment of the plume. The NSE Remediation System is addressing the off-site segment of the plume, located south of BNL. This segment of the plume extends from the vicinity of North Street to south of the Long Island Power Authority (LIPA) right-of-way. The length of the plume exceeding the DWS is approximately 2,500 feet. The maximum width of this segment of the plume is approximately 400 feet. The higher concentration segment of the plume (greater than 10 µg/L TVOCs) is just north of the LIPA right-of-way and extraction well NSE-1.

Figure 3.1-2 depicts the vertical distribution of VOCs (primarily TCA, DCE, TCE, chloroform, and choroethane) within the deep Upper Glacial aquifer. The transect line for cross section A–A' is shown on **Figure 3.1-1**. **Figure 3.1-3** gives the historical trends in VOC concentrations for key core and bypass wells along the Current Landfill/former HWMF/NSE plume. **Appendix C** contains a complete set of 2008 analytical results for the 15 NSE program wells. A summary of key monitoring well data for 2008 follows:

- The plume continues to be bounded by the current network of wells.
- All monitoring wells in the plume have remained below the treatment system capture goal of 50 µg/L TVOCs from 2005 through 2008, except for one detection in well 000-478 (58 µg/L) in March 2005.
- The maximum plume TVOC concentration observed in 2008 was 30 µg/L in plume core well 000-480. The primary compound identified in the sample was chloroform at 23 µg/L. This well is

located in the center of the plume downgradient of well 000-478 and just upgradient of NSE-1. This is the highest historical TVOC concentration detected in this well, except during system start-up in mid 2004. From 2005 through 2007, TVOC concentrations in this well were less than 2 µg/L.

- The 2008 TVOC concentrations in core well 000-478 were significantly less than the previous year's results. In 2008, the maximum TVOC concentration was 17 µg/L. When the well was installed in 2004, TVOC concentrations were as high as 205 µg/L. This is indicative that the plume is migrating south to the extraction well. Plume core well, 000-477, located slightly west of 000-478, has remained consistent with TVOC concentrations less than 40 µg/L since system start-up. The primary VOC in this well is TCA.
- TVOC concentrations in core well 000-479 were as high as 77 µg/L in 2004, but have dropped to less than 5 µg/L from mid 2005 through 2007. In 2008, TVOC concentrations increased slightly to 12 µg/L. This well is upgradient of NSE-1.
- TVOC concentrations in plume perimeter well 000-137 remained very low, with detections below 5 µg/L since 2002. This signifies that the trailing edge of the shallower lobe of this plume has migrated south of North Street (**Figure 3.1-2**). TVOC concentrations in core well 000-138 have dropped from 253 µg/L in 1999 to less than 50 µg/L since 2000. In 2007 and 2008, TVOC concentrations dropped below 5 µg/L.
- The maximum TVOC concentration in plume core well 000-124 was less than 5 µg/L in 2007 and 2008, down from a high of 489 µg/L in 1998.
- Following an increase in the TVOC concentration in 2005 and 2006 in plume core well 000-481, located between NSE-1 and NSE-2, the concentration has dropped over an order of magnitude to less than 5 µg/L in 2007 and 2008. In addition, nearby core wells 000-482, 000-483, 000-484, and 000-485 have remained below 5 µg/L since 2005. As recommended in the *2007 Groundwater Status Report* (BNL 2008a), in the first quarter 2008 the pump location was lowered four feet in monitor wells 000-482, 000-483, and 000-484 to obtain data from a slightly deeper portion of the aquifer. However, no significant differences in concentrations were observed.
- Plume bypass well 000-486 has not detected TVOCs above 2 µg/L since it was installed in 2004.
- In 2008, the highest tritium concentration in the plume (520 pCi/L) was detected in well 000-215. There have been no detections of tritium above 1,000 pCi/L in any of the NSE wells since 2005. Historically, the maximum tritium concentration in NSE monitoring wells was 8,200 pCi/L in well 000-215 (less than half of the DWS) in 1998.

3.2.9.4 System Operations

Influent, midpoint, and effluent samples from the GAC units are sampled every other month since the system is in pulse-pumping mode. The extraction wells were sampled quarterly during 2008. All NSE system samples were analyzed for VOCs. In addition, the influent and effluent samples were analyzed monthly for pH. During 2008, the extraction wells and system effluent were also analyzed quarterly and monthly for tritium, respectively. **Table 3.2.9-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit.

Table 3.2.9-1.
OU III North Street East
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH range	5.5–8.5 SU	5.6– 6.66 SU
carbon tetrachloride	5	ND
chloroform	5	2.5
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
ND = Not Detected above method detection limit of 0.50 µg/L.
Required effluent sampling freq. is monthly for VOCs and pH.

3.2.9.5 System Operational Data

The system was operational throughout 2008 with only minor shutdowns due to electrical outages, PLC issues, and scheduled maintenance. During 2008, approximately 4.5 pounds of VOCs were removed. Since October 2006 the system has been pulse pumped with the system on one month and off the next.

January through September 2008

The system operated normally with only minor shut downs due to electrical surges and injection well maintenance. The system pumped and treated approximately 49 million gallons of water.

October through December 2008

The system operated normally for the last quarter of 2008. Due to a pulse-pumping schedule, the system was only operational in November. In this quarter, the system pumped and treated approximately 14 million gallons of water.

Extraction Wells

During 2008, 64 million gallons were pumped and treated by the NSE system; **Table 2-3** contains the monthly pumping data for the two extraction wells. **Table 3.2.9-2** shows the monthly extraction well pumping rates. **Figure 3.2.9-2** plots the TVOC concentrations in the extraction wells. VOC concentrations for NSE-1 and NSE-2 are provided on **Table F-33** (**Appendix F**). Steady TVOC concentration trends are noted for both wells during 2008, with concentrations below 15 µg/L reported in both wells during the entire year. This is significantly below the 50 µg/L capture goal for the extraction wells. The historical maximum TVOC concentrations in NSE-1 and NSE-2 were 58 and 25 µg/L at system start-up, respectively.

System Influent and Effluent

VOC concentrations for 2008 for the carbon treatment influent and effluent are summarized on **Tables F-34** and **F-35** (**Appendix F**). Influent TVOC concentrations have been at or below 12 µg/L since 2005. The carbon treatment system effectively removed VOCs from the influent groundwater resulting in all 2008 NSE effluent concentrations being below the regulatory limit specified in the equivalency permit. No tritium has been detected in the system effluent above 600 pCi/L since the system began operating in 2004.

Cumulative Mass Removal

Using average flow rates for each monthly monitoring period, in combination with the VOC concentration in the system influent, the rate of contaminant removal was calculated (**Table F-36** in **Appendix F**). The cumulative mass of VOCs removed by the treatment system versus time is shown on **Figure 3.2.9-1**. During 2008, 4.5 pounds of VOCs were removed, with a cumulative total of 24 pounds of VOCs removed since system start-up in April 2004.

3.2.9.6 System Evaluation

The system began operations in June 2004 and was predicted to run for approximately 10 years. The system is operating as designed. No operating difficulties were experienced beyond normal maintenance, and system effluent concentrations did not exceed SPDES equivalency permit requirements.

The North Street East Pump and Treat System performance can be evaluated based on the four major decisions identified for this system from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected concentrations of contaminants observed in monitoring or extraction wells associated with the NSE System.

2. Has the plume been controlled?
Yes. The system has been in operation for four years, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2008, indicating that the plume has not grown and is controlled.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?
The system is operating as designed, and the system has been effectively removing VOCs from the deep Upper Glacial aquifer. System influent VOC concentrations have been less than originally projected. In addition, the monitoring wells have shown low concentrations following initial start-up of the system.

4. Can the groundwater treatment system be shut down?

Yes. The shutdown criteria of reaching less than 50 µg/L TVOCs for at least four consecutive sampling rounds has been met in the core monitoring and extraction wells. However, additional monitoring data will be collected and, if concentrations remain below the capture goal of 50 µg/L TVOCs, a Petition for Shutdown of the NSE system will be prepared.

4a. Have asymptotic TVOC concentrations been reached in core wells?
No. Since the shutdown criteria of less than 50 µg/L has been achieved, asymptotic conditions are no longer a required measure for system shutdown.

4b. Are there individual plume core wells above 50 µg/L TVOC ?
No. All NSE core wells were below 50 µg/L TVOCs.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?
Since the system was first shut down for pulse pumping starting October 2006, all core wells have remained low and no significant rebounding has been identified.

4d. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.9.7 Recommendations

The following recommendations are made for the NSE Pump and Treat System and groundwater monitoring program:

- Continue pulse pumping of both extraction wells. The pulse pumping consists of having the system on for one month, then off in standby mode for the next month. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction wells, the extraction well(s) will be put back into full-time operation.

- Following the review of additional monitoring well data, a Petition for Shutdown of the system will be prepared.
- Change the monitoring frequency for the monitoring wells from routine operations and maintenance to shutdown monitoring in the second quarter 2009. This calls for all NSE monitoring wells to be sampled quarterly.
- It is recommended that monitoring well 000-394 be added to the North Street East well network.

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3.2.10 LIPA/Airport Pump and Treat System

3.2.10.1 System Description

The three components of the LIPA/Airport Pump and Treat System are as follows.

1. The Magothy extraction well (EW-4L) on Stratler Drive (**Figure 3.2.10-1**) addresses high-level VOCs identified in the Magothy aquifer immediately upgradient of this well on Carleton Drive. The capture goal for this well is 50 µg/L TVOCs.
2. The three LIPA extraction wells (EW-1L, EW-2L, and EW-3L) were installed to address high concentrations of VOCs in the Upper Glacial aquifer that had migrated past the Industrial Park System before that system became operational in 1999. The capture goal for these extraction wells is 50 µg/L TVOC.
3. Six extraction wells in the Airport System were installed to address the leading edge of the plumes and to prevent further migration of the plumes, which have migrated past the LIPA extraction wells and the North Street extraction wells. The sixth well (RW-6A) was added in 2007 to address concentrations of VOCs observed to the west of extraction well RTW-1A. The Airport system wells have a capture goal of 10 µg/L TVOC.

The water from the four LIPA wells is pumped to the treatment plant, about one mile south on Brookhaven [Town] Airport property, where it is combined with the water from the six airport extraction wells (RTW-1A through RW-6A) and treated via granular activated carbon. The treated water is released back to the ground via a series of shallow reinjection wells located on Brookhaven Airport and Dowling College property.

A more detailed description of this system is contained in the *Operations and Maintenance Manual for the LIPA/Airport Groundwater Treatment System* (BNL 2008c).

3.2.10.2 Groundwater Monitoring

Well Network

The monitoring network consists of 53 wells. There are 18 wells associated with the LIPA Upper Glacial portion of the plume that were installed to monitor the VOC plume off site, south of the OU III Industrial Park System. The Airport System network has 29 monitoring wells, which monitor the portions of the plume south of the LIPA and the North Street systems. The Magothy extraction well on Stratler Drive has six monitoring wells associated with its operation. All of these wells are used to monitor and evaluate the effectiveness and progress of the cleanup associated with these three components of the system. **Figure 1-2** identifies the monitoring wells for these plumes.

Sampling Frequency and Analysis

The monitoring wells for LIPA are currently on a quarterly and semiannual sampling schedule for VOCs. The Airport wells are sampled quarterly (**Table 1-5**).

3.2.10.3 Monitoring Results

The primary VOCs associated with these portions of the plume are carbon tetrachloride, TCA, TCE, and 1,1-dichloroethylene. Groundwater monitoring for these systems was initiated in 2004. Fourth-quarter 2008 well data are posted on **Figures 3.2-1, 3.2.10-1** and **3.2.10-2**. The complete analytical results are in **Appendix C.** Results for key monitoring wells and extraction wells are as follow.

- During 2008 TVOC concentrations for the Magothy extraction well EW-4L on Stratler Drive ranged from 63 µg/L in January to 45 µg/L in October. Carbon tetrachloride is the primary VOC detected in this well. The Magothy monitoring wells associated with this portion of the plume show concentrations below 50 µg/L TVOCs, with well 000-130 showing the highest concentration (31 µg/L) in January 2008. **Figure 3.2.10.3** plots the TVOC influent trends for the LIPA extraction wells.

- Two of the three Upper Glacial LIPA extraction wells, EW-1L and EW-3L, were shutdown in October 2007. Well EW-2L had a high TVOC concentration of 29 µg/L in January and a low of 18 µg/L in October 2008. Well EW-3L continued to show VOC concentrations below MCLs. EW-1L showed TVOC concentrations ranging from 15 µg/L in April to 11 µg/L in January 2008. The highest individual VOC concentration detected in this well was 9.6 µg/L PCE in April 2008. The capture goal of the LIPA extraction wells is 50 µg/L TVOCs.
- VOC concentrations in monitoring wells near the Airport System extraction wells are below MCLs, except for well 800-96. However, upgradient monitoring wells 800-94 and 800-95, approximately 1,500 feet north of wells RTW-1A and RTW-2A, have historically shown TVOC concentrations primarily composed of carbon tetrachloride ranging up to 100 µg/L.
- Five of the six airport extraction wells had VOC concentrations below MCLs throughout 2008. Newly installed extraction well RW-6A showed TVOC concentrations of 18 µg/L in January dropping to 10 µg/L in December.
- Well 800-96 was installed as a western perimeter monitoring well for extraction well RTW-1A. Sampling of this well began in March 2004. No detections of carbon tetrachloride were found in this well until December 2005, when it was detected at 1.6 µg/L. In June 2006, 10 µg/L of carbon tetrachloride was detected in this well, and in August 2006 the concentration increased to 40 µg/L. Due to these VOC increases, the monitoring frequency for this well was changed from quarterly to monthly beginning in December 2006. During 2007 a new extraction well RW-6A and five new monitoring wells (800-126, 800-127, 800-128, 800-129, and 800-130) were installed to monitor and capture the contaminants in the vicinity of well 800-96 (**Figure 3.2.10-1**). Well 800-96 has had carbon tetrachloride concentrations close to 100 µg/L throughout 2008. None of the monitoring wells installed downgradient of this area have shown carbon tetrachloride above MCLs.
- As per recommendation in last year's annual report, in February 2009 a vertical profile well (APVP-1-2009) was installed about 200 feet west of well RTW-3A to bound the western edge of the plume in this area. The vertical profile showed low concentrations of TCA (1.3 µg/L at 215 and 225 ft bls). **Table 3.2.10-3** summarizes the vertical profile data. In March 2009, a permanent monitoring well was installed at this location (AP MW-1 2009) that is screened from 215 to 235 ft bls (**Figure 3.2.10-1**). Analytical data from the permanent well were not available in time for this report.

3.2.10.4 System Operations

In 2008, the extraction wells were sampled once per month. The influent, midpoint, and effluent of the carbon units were sampled two times per month. All System samples were analyzed for VOCs. The Airport extraction wells are on a pulse-pumped schedule, being pumped one week per month, except for wells RTW-1A and RW-6A which are pumped on a full-time basis. RW-6A began full-time operations in September 2008.

The following is a summary of the OU III Airport/LIPA System operations for 2008.

January – September 2008

The LIPA System was down in August and September due to communication problems with the BNL Tower. The Airport wells continued normal operations, with wells RTW-1A and RW-6A operating on a full-time basis. RTW-3A began full-time operations in September.

October – December 2008

The system operated normally for the last quarter of 2008 with minimal down time due to scheduled maintenance and carbon change-outs.

Extraction Wells Operational Data

During 2008, approximately 226 million gallons were pumped and treated by the OU III Airport/LIPA System, with an average flow rate of 474 gpm (**Table 3.2.10-2**). **Table F-37** (**Appendix F**) summarizes the System's mass removal. **Table 3.2.10-2** shows the monthly extraction well pumping rates. VOC concentrations for the airport and LIPA extractions wells are provided on **Table F-38** (**Appendix F**). VOC levels in the airport extraction wells were below MCLs, except for well RW-6A and several detections of trichloroethylene above the MCL in well RTW-3A during May and June of 2008. Subsequent results showed VOCs below MCLs.

3.2.10.5 System Operational Data

System Influent and Effluent

VOC concentrations for the carbon influent and effluent in 2008 are summarized on **Tables F-39** and **F-40** (**Appendix F**).

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. 2008 System effluent data were below the analytical method detection limit and below the regulatory limit specified in the SPDES equivalency permit.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU III Airport/LIPA Treatment System was calculated using the average flow rates for each monitoring period (**Table F-37** in **Appendix F**) in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds per month removed. The plot of cumulative mass of VOCs removed vs. time (**Figure 3.2.10-4**) shows that 23 pounds of VOCs were removed during 2008, with a total of 260 pounds removed since system start-up.

3.2.10.6 System Evaluation

The Airport Treatment System was designed to capture the leading edge of the OU III and OUI/IV VOC plumes. The newly installed extraction well (RW-6A) has shown carbon tetrachloride above MCLs since it was installed and began operations in November 2007. Some higher concentrations of VOCs have been detected upgradient of these wells. VOC concentrations in the LIPA wells are consistent with the groundwater modeling performed for the design of this system. **Table 3.2.10-1** shows maximum measured values and the values allowed under the SPDES equivalency permit.

The OU III Airport/LIPA system performance can be evaluated based on the five major decision rules identified for this system resulting from the groundwater DQO process.

<u>*1. Was the BNL Groundwater Contingency Plan triggered?*</u>

No, there were no unusual or unexpected VOC concentrations observed in the monitoring wells of the LIPA/Airport Treatment System during 2008.

<u>*2. Has the plume been controlled?*</u>

Yes, based on the historical analytical data collected from the monitoring wells and the

Table 3.2.10-1
OU III LIPA/Airport Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	5.9-7.3 SU
carbon tetrachloride	5	ND
chloroform	7	ND
1,1-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
methylene chloride	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
Sampling required an a monthly basis

results of the *LIPA/Airport Pump Test Report* (Holzmacher 2004), the plumes are being controlled. The capture zones (**Figure 3.0-1**) clearly show that the capture goal of 50 µg/L TVOC at the LIPA Upper Glacial and Magothy wells is being met. The leading edge of the plume has reached the airport.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?
Yes, the system is operating as planned.

4. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?
No, asymptotic concentrations have not been reached.

4b. Is the TVOC concentration in the LIPA core wells less than 50 µg/L?
Yes; however, extraction well EW-4L still shows concentrations greater than 50 µg/L. The extraction well data are utilized to help in tracking the plume.

4c. Are the TVOC concentrations in the Airport core wells less than 10 µg/L ?
No, seven airport core wells (800-63, 800-92, 800-94, 800-95, 800-96, 800-106, and 800-129) had TVOC concentrations greater than 10 µg/L in 2008.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?
The intent of the current pulse pumping is not to evaluate for rebound but to monitor for the high-concentration segment as it continues to travel south toward the northern perimeter of the Airport extraction wells.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved?
No, the cleanup goals have not been met. Based on model results, MCLs are expected to be achieved by 2030 for the Upper Glacial aquifer, and in the Magothy aquifer by 2070, as required by the OU III ROD and ESD.

3.2.10.7 Recommendations

The following recommendations are made for the LIPA/Airport Pump and Treat System and groundwater monitoring program:

- Continue the airport extraction wells pulse-pumping schedule of pumping one week per month except for wells RTW-1A and RW-6A, which will continue with full-time operations. Discontinue full-time pumping of well RTW-3A since VOC concentrations in this well are now well below MCLs and have been for over six months. This well will revert back to the one week per month pumping schedule. If concentrations above the capture goal of 10 µg/L TVOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.
- Maintain LIPA wells EW-1L and EW-3L in standby mode. These extraction wells will be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.

3.2.11 Magothy Aquifer

This section provides a brief summary of the Magothy Aquifer Groundwater Monitoring Program and the remedial approach for addressing the VOC contamination. The 41 monitoring wells used to characterize the Magothy are shown on **Figure 3.2.11-1**.

Detailed descriptions of the monitoring well analytical results and remediation progress are presented in the following sections of this report: Western South Boundary, Middle Road, Airport/LIPA, North Street, North Street East, OU III South Boundary, Industrial Park, Industrial Park East, and Central Monitoring. A brief summary of the results is provided on **Table 3.2.11-1**. Further details about these characterization results are in the *Final Magothy Aquifer Characterization Report* (Arcadis Geraghty & Miller 2003).

Table 3.2.11-1. Magothy Aquifer Contamination (Historical and 2008).

Location	Max. TVOC (in µg/L)		Primary VOCs	Results
	2008	Historical		
Western boundary on site	<5.0	<5.0	None	Magothy not impacted. Two monitoring wells serve as adequate outpost/sentinel wells for Suffolk County Water Authority William Floyd Well Field.
Middle Road and south boundary on site	112	340	PCE, CCl_4	VOCs identified in upper 20 to 40 feet of Magothy at Middle Road area where brown clay is absent. A temporary well installed in 2006 did not detect Magothy contamination between the Middle Road and South Boundary. VOCs not detected at South Boundary beneath the clay.
North Street off site	64	50	TCE	Low VOC concentrations have been detected in localized areas in the upper 30 feet of the Magothy aquifer and downgradient near Vita Drive. Leading edge of contamination is around Moriches-Middle Island Road.
North Street East off site	9	30	1,1-DCA; 1,1-DCE	Low VOC concentrations have been detected at the BNL south boundary to North Street below the brown clay at approximately 40 to 150 feet into the upper Magothy.
Industrial Park East off site and south boundary	38	570	TCA, CCl_4	TVOCs currently less than 60 µg/L off site in the Industrial Park, where brown clay is absent. Magothy and Upper Glacial contamination is contiguous in Industrial Park.
South of Carleton Drive off site	26	7,200	CCl_4	Historically high VOC concentrations just south of Carleton Drive where brown clay is absent. Levels of TVOCs are now less than 50 µg/L. Contamination is contiguous between Magothy and Upper Glacial aquifer.

The Magothy Remedy identified in the *Explanation of Significant Differences* (ESD) document calls for the following:

1. Continued operation of the five extraction wells as part of the Upper Glacial treatment systems that provide capture of Magothy VOC contamination (Middle Road, South Boundary, Airport, Industrial Park East, and LIPA).

2. Continued evaluation of the monitoring wells' data to ensure protectiveness. **Table 3.2.11-2** describes how each of the Magothy investigation areas is addressed by the DOE's selected Magothy aquifer remedy.
3. Institutional controls and five-year reviews.

Data for all Magothy monitoring wells are presented in **Appendix C.**

Table 3.2.11-2. Magothy Remedy.

Area Investigated	Selected Remedy
Western boundary on-site area	Continue monitoring and evaluate data.
Middle Road and South Boundary on-site area	Continue operation of the Magothy extraction well at Middle Road, as well as the two Upper Glacial systems. Continue to monitor the three Magothy monitoring wells at Middle Road and three at the south boundary.
North Street off-site area	Continue operation of the two existing Upper Glacial extraction wells on Sleepy Hollow Drive and North Street until cleanup objectives are met. Continue monitoring and evaluate data.
North Street East off-site area	Continue monitoring and evaluate data.
Industrial Park East off-site area and s. boundary	Continue operation of the Industrial Park East Magothy extraction well until cleanup objectives are achieved. Continue monitoring and evaluate data.
South of Carlton Drive off-site area	Continue operation of the LIPA Magothy extraction well on Stratler Drive until cleanup goals are achieved. This will capture high concentrations of TVOCs identified on Carleton Drive and prevent migration of high concentrations of TVOCs through the hole in the brown clay and into the Magothy aquifer. Continue monitoring and data evaluation.

3.2.11.1 Monitoring Well Results

There are 41 monitoring wells in the Magothy monitoring program (**Figure 3.2.11-1**). **Figure 3.2.11-2** shows trend plots of several of the key monitoring wells. A discussion of some of the key wells follows.

Well 000-130: This well is on Carleton Drive and has historically had the highest concentrations of carbon tetrachloride observed off site related to BNL: over 7,000 µg/L. Concentrations of TVOCs ranged from 16 to 31 µg/L in 2008. The higher concentrations of carbon tetrachloride observed historically in this well are being captured by the LIPA extraction well on Stratler Drive. A more detailed discussion of this is available in **Section 3.2.10**, LIPA/Airport Pump and Treat System.

Wells 000-249 and 000-250: These wells are in the Industrial Park near well UVB-1. Well 000-249 had TVOC concentrations ranging from 75 µg/L in August to 27µg/L in December 2008. Well 000-250 had VOC concentrations below MCLs in 2008. Based on analytical data, the higher levels of contamination observed in well 000-249 are being captured by the UVB wells, even though 000-249 is on the edge of the capture zone for these wells. Any contaminants above the capture goal of 50 µg/L TVOC that migrate beyond the capture of this system will be captured by the Stratler Drive extraction well.

Wells 000-425 and 000-460: These wells are adjacent to the LIPA Stratler Drive Magothy extraction well. Well 000-425 had concentrations of TVOCs ranging from 9 to 23 µg/L during 2008. This well is immediately adjacent to the extraction well. Well 000-460, located east of the extraction well but within the capture zone, had concentrations ranging from 1 to 12 µg/L in 2008.

Well 122-05: This well, located at the eastern edge of the OU III South Boundary System, showed concentrations of TVOCs ranging from 26 to 28 µg/L in 2008.

Well 000-343: Located south and between the OU I and OU III South Boundary systems, this well had TVOC concentrations between 7 and 9 µg/L in 2008.

Well 115-50: Located south and between the OU I and OU III South Boundary systems, this well had VOC concentrations below MCLs in 2008.

Wells 000-427 and 000-429: These wells are located just south of the Industrial Park East System on Carleton Drive. In 2008, well 000-427 had TVOC concentrations ranging from 9 to 28 µg/L,and well 000-429 had concentrations ranging from 3 µg/L in August to 69 µg/L in January.

Well 800-90: This well is located near Moriches-Middle Island Road upgradient of Airport extraction wells 3 and 4. It is screened at about 255 feet below grade. This well is co-located with Well 800-92. TVOC concentrations ranged from 58 to 81 µg/L in 2008.

Well 800-92 (not a Magothy well; screened at a depth of ~200 feet): Located about 2,500 feet north of the Airport System, this well had VOC concentrations ranging from 48 to 89µg/L in 2008. The chemicals in wells 800-90 and 800-92 are similar. This is indicative of contamination that was already past the North Street extraction wells prior to operation, and will eventually be captured by the Airport extraction wells.

3.2.11.2 Recommendations

Continue the current monitoring schedule for the Magothy monitoring program, except for wells 000-428 and 115-50. Well 000-428 will be changed from quarterly to semiannual and well 115-50 from quarterly to annual. This is based upon historically low VOC concentrations in these wells (**Table 1-5**).

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3.2.12 Central Monitoring

The OU III Remedial Investigation (RI) identified several low-level (less than 50 µg/L) TVOC source areas and nonpoint contaminant sources within the developed central areas of the BNL site. These sources include spills within the Alternating Gradient Synchrotron (AGS) Complex, the Bubble Chamber spill areas, and the Building 208 vapor degreaser. Because these sources are not large enough to warrant a dedicated monitoring program, they are monitored under the OU III Central Monitoring Program. In addition, this program includes wells 109-03 and 109-04, located near the BNL western site boundary. These wells were installed by the SCDHS to serve as sentinel wells for the SCWA William Floyd Parkway Well Field.

3.2.12.1 Groundwater Monitoring

Well Network

The monitoring well network is comprised of 20 wells (**Figure 3.2.12-1**). The well locations aid in defining the VOC plumes that extend downgradient from the central areas of the site. This network is also supplemented by data from Facility Monitoring program wells that monitor active research and support facilities (**Table 1-6**). Results from the Environmental Surveillance (ES) programs are provided in **Section 4**.

Sampling Frequency and Analysis

The wells are sampled and analyzed annually for VOCs, and wells 109-03 and 109-04 are analyzed quarterly for VOCs, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**). Select Facility Monitoring wells in the AGS Complex are typically sampled annually for VOCs in order to complete the northern portion of the OU III VOC plume configuration.

3.2.12.2 Monitoring Well Results

VOC concentrations detected in most of the OU III Central wells are near or below NYS AWQS. In many of the wells in the north-central developed portion of the site, the primary constituent is TCA. A discussion of some of the key wells follows:

- Wells 083-01 and 083-02 are near the intersection of Brookhaven Avenue and Upton Road, and are screened in the Upper Glacial aquifer. These wells consistently have contained 1 to 9 µg/L and 4 to 25 µg/L of chloroform since 1997, respectively. In December 2008, well 083-01 had a detection of chloroform of 8.6 µg/L, exceeding the NYS AWQS of 7.0 µg/L. Well 083-02 had a chloroform detection of 3.9 µg/L in December 2008.
- SCDHS wells 109-03 and 109-04 serve as sentinel wells for the SCWA William Floyd Well Field and are near the western BNL property boundary. There were no detections of VOCs above the NYS AWQS during 2008. Tritium was detected in 109-04 at 1,010 pCi/L in March 2008.

3.2.12.3 Groundwater Monitoring Program Evaluation

The evaluation of the OU III Central Monitoring Program is based on four major decision rules established for this program using the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2008.

2. Are there potential impacts to the SCWA William Floyd Well Field from on-site contamination?

No. There were no detections of contaminants in the sentinel monitoring wells during 2008, with the exception of low-level (below 0.5 ug/L) chlorinated organic compounds (below NYS AWQS).

3. Are the performance objectives met?
No. Since 1997 the VOC concentrations in the central portion of the site have significantly decreased, as noted in TVOC plume comparison **Figure 3.2-3**. However, during 2008 several individual wells continued to contain VOC concentrations exceeding the NYS AWQS; therefore, the OU III ROD objective of meeting MCLs by 2030 has not yet been met.

4. If not, are observed conditions consistent with the attenuation model?
Yes. The observed VOC concentrations generally agree with the model-predicted concentrations, with respect to both the plume extent and contaminant concentrations.

3.2.12.4 Recommendation

The following is recommended for the OU III Central groundwater monitoring program:

- Based on the lack of VOC detections above standards, wells 064-03, 066-08, 066-09, 075-01, 075-02, 105-05, and 105-06 should be dropped from the sampling program.

3.2.13 Off-Site Monitoring

The OU III Off-Site Groundwater Monitoring Program consists of 12 wells. They were installed to monitor contamination in the southwest portion of the OU III plume or were installed as part of the early BNL hydrogeologic characterization.

3.2.13.1 Groundwater Monitoring

Well Network

The network has 12 wells that monitor the off-site southwest downgradient extent of the OU III VOC plumes (**Figure 1-2**). Some wells downgradient of the leading edge of the plumes serve as sentinel wells. These wells are screened in the deep portions of the Upper Glacial aquifer.

Sampling Frequency and Analysis

The wells were sampled annually and samples analyzed for VOCs (**Table 1-5**). Samples were collected in the fourth quarter of 2008.

3.2.13.2 Monitoring Well Results

The complete results for the monitoring wells in this program can be found in **Appendix C**. The horizontal extent of the off-site segment of the OU III VOC plume is shown on **Figure 3.2-1**.

The monitoring wells in the OU III Off-Site Monitoring Program are perimeter and sentinel wells. In 2008, they continued to have VOC concentrations below the NYS AWQS.

3.2.13.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2008 that would have triggered the BNL Groundwater Contingency Plan. All VOC detections were below NYS AWQS.

3.2.13.4 Recommendation

No changes to the monitoring program are warranted at this time.

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3.2.14 South Boundary Radionuclide Monitoring Program

The South Boundary Radionuclide Monitoring Program was initiated to confirm that groundwater impacted by radionuclides is not currently migrating off the south section of the BNL site. The sampling was conducted in conjunction with the OU III South Boundary, Western South Boundary, and OU VI Programs. The eastern portions of the site south boundary are monitored for radionuclides as part of the OU I South Boundary and OU V STP groundwater monitoring programs.

3.2.14.1 Groundwater Monitoring

A network of 59 monitoring wells is used to monitor radionuclides from the OU III South Boundary, OU III Western South Boundary, and OU VI programs. The well locations along the southern property boundary are shown on **Figure 3.2.14-1**.

Sampling Frequency and Analysis

The OU III South Boundary Radionuclide Monitoring Program wells were sampled annually for tritium, Sr-90, and gamma spectroscopy (**Table 1-5**).

3.2.14.2 Monitoring Well Results

The radionuclide analytical results for the wells can be found in **Appendix C**. There were no confirmed radionuclide detections during 2008. In July 2008, there was a reported low-level detection of tritium in well 122-04 (300 pCi/L). A data usability review indicates that this result is most likely a false positive. Therefore, the analytical result has been flagged to indicate this conclusion.

3.2.14.3 Groundwater Monitoring Program Evaluation

The OU III South Boundary Radionuclide Monitoring Program can be evaluated based on the decision rule identified for this program resulting from applying the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unexpected results during 2008 to trigger the BNL Groundwater Contingency Plan.

3.2.14.4 Recommendations

The following are recommendations for the OU III South Boundary Radionuclide Groundwater Monitoring program:

- Due to the wells' locations and the lack of detections of radionuclides, it is recommended that the following wells be dropped from the sampling program: 119-03, 124-02, 125-01, and 099-10.
- Due to the lack of detections of radionuclides, it is recommended that gamma and tritium analyses be dropped from the well 107-10 sampling.

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3.2.15 BGRR/WCF Strontium-90 Treatment System

The OU III Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility (WCF) Treatment System addresses the Sr-90 plumes in groundwater downgradient of these facilities. Some of the wells included in the OU III BGRR/WCF network are also monitored as part of the OU III AOC 29 HFBR and Building 801 programs (**Sections 3.2.17** and **4.11**). These wells are sampled concurrently for all of these programs to avoid duplication of effort. The BGRR/WCF remedy consists of:

1. Operation of five extraction wells using ion exchange to remove Sr-90, with on-site discharge of the clean water to injection wells
2. Operation of the system to minimize plume growth and meet DWS by 2070
3. Continued monitoring and evaluation of data to ensure protectiveness
4. Institutional controls and five-year reviews

The analytical results indicate three areas of elevated Sr-90: one from the WCF area, one in an area south of the BGRR Below Ground Ducts (BGD) and Canal House, and one that is south of the former Pile Fan Sump (PFS) area (**Figure 3.2.15-1**).

3.2.15.1 System Description

System operations for this treatment system began in January 2005. There are two extraction wells (SR-1 and SR-2) located south of the WCF and three extraction wells (SR-3, SR-4, and SR-5) located south of the BGRR. The treatment system typically operates at an average rate of 25 gpm total from the five extraction wells.

Groundwater from the five extraction wells is transported through pipelines to an ion exchange treatment system inside Building 855 (within the BNL Hazardous Waste Management complex). The vessels of ion exchange media are designed to treat groundwater contaminated with Sr-90 to below the 8 pCi/L DWS. In addition, the influent is also treated for low-level concentrations (less than 10 μg/L) of TVOCs using liquid-phase activated carbon.

Effluent is recharged to the Upper Glacial aquifer via three drywells approximately 850 feet west of Building 855. A New York SPDES equivalency permit regulates this discharge. A complete description of the system is included in the *Operations and Maintenance Manual for the Sr-90 BGRR/WCF/PFS Groundwater Treatment System* (BNL 2005d).

3.2.15.2 Groundwater Monitoring

Well Network

A network of 86 monitoring wells is used to monitor the Sr-90 plumes associated with the BGRR, WCF, and PFS areas. For the WCF plume in the vicinity of the HFBR, this network is currently being supplemented with temporary wells to monitor the high concentration Sr-90 and tritium (g-2) slugs identified in this area in 2007 and 2008. Most recently, temporary wells were installed in this area during the fourth quarter of 2008 and the first quarter of 2009.

Sampling Frequency and Analysis

In 2008, the sampling frequency for the BGRR and PFS plumes was shifted from a start-up to O&M phase (semiannual to annual) for most wells. The WCF plume remained at a semiannual frequency in order to obtain sufficient data to characterize this plume and support pre-design groundwater modeling for system modification. The well samples are analyzed for Sr-90. As noted on **Table 1-5,** wells also serve dual purposes for other programs.

3.2.15.3 Monitoring Well/Temporary Well Data

The Sr-90 plume distribution map is shown on **Figure 3.2.15-1**. The distribution of Sr-90 throughout the BGRR, WCF, and PFS areas is depicted based on groundwater data obtained from the fourth-quarter 2008 and first-quarter 2009 sampling of the monitoring well network and temporary wells. The following cross-sectional views are also provided:

- **Figure 3.2.15-2** (I–I') for the BGRR plume – A north–south cross section from the BGRR south to Brookhaven Avenue
- **Figure 3.2.15-3** (J–J') for the PFS plume – A north–south cross section from Building 801 south to Cornell Avenue
- **Figure 3.2.15-4** (K–K') for the WCF plume – A north–south cross section from WCF south to Cornell Avenue

In addition, historical Sr-90 concentration trend plots for key wells are plotted on **Figure 3.2.15-5**.

Historically, the highest overall Sr-90 concentration (3,150 pCi/L) occurred in 2003 in a temporary well installed approximately 200 feet south of Building 701 and slightly upgradient of the current location of extraction well SR-3. The highest historical Sr-90 concentration in the WCF area (1,560 pCi/L) occurred in April 2003 in a temporary well installed immediately downgradient of the six former underground storage tanks (USTs A/B) and approximately 25 feet north of the WCF (Building 811). This area within the WCF is upgradient of the current location of extraction well SR-1. The highest historical Sr-90 concentration in the former PFS area (566 pCi/L) occurred in March 1997 in a temporary well installed downgradient of the PFS.

The following is a summary of the 2008 monitoring well data for the three Sr-90 plumes.

WCF Plume

Refer to **Figure 3.2.15-4** for cross-sectional view of the WCF plume.

- In 2008, the highest Sr-90 concentration in all three plumes was 549 pCi/L during October in plume core well 065-175, located immediately south of the WCF yard. The historical high for this well was 821 pCi/L in 2000. **Figure 3.2.15-5** shows an increasing concentration trend in this well over the past two years. This follows a decreasing trend for the previous two years that was most likely the result of a plume shift caused by increased pumping from the eastern supply wells just prior to this time frame. This contamination will be captured by extraction well SR-2.
- Wells 075-47, 075-48, 075-87, and 075-684, located on Temple Place, are sentinel wells for the WCF Sr-90 plume. In well 075-684, the maximum Sr-90 detection was 0.3 pCi/L for 2008.

As recommended in the *2007 Groundwater Status Report* (BNL 2008b), select wells were analyzed for Sr-90 during the installation of temporary wells just northwest of the HFBR. These temporary wells were installed during the fourth quarter of 2008 and first quarter of 2009 as part of the characterization effort for the downgradient portion of the g-2 tritium plume. Most of the samples were collected at locations previously sampled in 2007/2008 using temporary wells. The goal of this characterization was to update the location of both the WCF Sr-90 high concentration slug and the downgradient g-2 tritium slug. The cross section on **Figure 3.2.15-4** shows both plumes and illustrates the relationship between the two plumes. The data from this characterization effort will be used to design the array of additional Sr-90 extraction wells necessary to remediate the high Sr-90 concentrations and enable the OU III ROD cleanup goals to achieved. From September 2008 through March 2009, five sets of east-west temporary well transects were installed and sampled for both tritium and Sr-90. The 29 temporary well locations (i.e., g-2-GP-#) are identified on **Figure 3.2.15-1** and the complete data set is available on **Table 3.2.15-1**. The transects were located as follow:

- A – The northern-most transect situated in the parking lot just south of Rutherford Drive to the east of the BGRR
- B – Approximately 175 feet south of transect A and 250 feet north of the HFBR.
- C – Immediately north of the HFBR
- D – Immediately south of the HFBR
- E – Along Temple Place

The following is a brief summary of the data for the five transects:

- Transect A – The data from the two temporary wells installed in March 2009 shows a slight decrease in the peak Sr-90 concentration from 52 to 46 pCi/L when compared to the 2007 data from this area. The maximum tritium concentration along this transect dropped slightly from 25,100 pCi/L in GP-80 (2007) to 23,200 in GP-79 (2009).
- Transect B – The maximum Sr-90 concentration in the four temporary wells installed in March 2009 was 160 pCi/L in GP-72. This is significantly lower than the 294 pCi/L observed at this location in 2007. The maximum tritium concentration in this area was 38,300 pCi/L in GP-73, which is also substantially lower than the 198,000 pCi/L detection at this location in 2007. The trailing edge of the Sr-90 high concentration slug appears to be approaching this area based on the declining concentrations in upgradient Transect A locations and the declining concentrations along Transect B. The core of the high concentration downgradient segment of the g-2 tritium plume has moved well south of this transect in early 2009, as expected based on tritium transport with groundwater flow.
- Transect C – Nine temporary wells were installed at this transect during March 2009. The maximum Sr-90 concentration was 154 pCi/L in GP-63 (2009), which is significantly lower than the 518 pCi/L detected at that location in 2007. The maximum tritium concentration along this transect was 23,900 pCi/L (2009) in GP-65 as compared to the 53,900 in GP-66 during 2007. In March 2009 an additional location, GP-33, was installed approximately 150 feet south of GP-63. The maximum Sr-90 concentration in that temporary well was 406 pCi/L. Based on the data from Transects C and D, the core of the Sr-90 high concentration slug has shifted south since the 2007 data was collected. The core of the g-2 tritium downgradient slug has largely migrated south of this transect in early 2009.
- Transect D – A total of six temporary wells were installed along this transect in December 2008 and January 2009. The maximum Sr-90 concentration in December 2008 was in GP-93 at 140 pCi/L. This is an increase from the 83 pCi/L detected in early 2008. The maximum tritium concentration in this area during the most recent sampling was 80,700 pCi/L in GP-84 (December 2008) which is comparable to the 83,000 pCi/L detected at this location in early 2008. The core of the g-2 tritium plume downgradient slug appears to be in the vicinity of the front of the HFBR based on the fourth-quarter 2008 data.
- Transect E - Six temporary wells were installed from late September to December 2008. There were only trace detections of Sr-90 along this transect, indicating that the leading edge of the plume remains north of this area. A tritium concentration of 33,300 pCi/L was observed at location GP-94 in September 2008. Based on these data, the leading edge of the g-2 tritium plume is located just south of Temple Place.

BGRR Plume

- The highest Sr-90 concentration in a monitoring well south of the BGRR was 69 pCi/L in the April 2008 sample from well 075-669. Sr-90 concentrations in this well have been declining following a high of 272 pCi/L in 2005. The October 2008 result was 20 pCi/L in this well. This is indicative of a higher concentration slug (that was south of SR-4 and SR-5 prior to the initiation of pumping) moving through this area. This slug of Sr-90 is expected to naturally attenuate on site to below the drinking water standards by 2070.

- The highest Sr-90 concentration downgradient of the BGRR occurred in extraction well SR-3, which reached a peak of 1,650 pCi/L in September 2007. This extraction well showed a steady decline during 2008 to 41 pCi/L in December. It appears that the trailing edge of a high concentration slug may be approaching this extraction well.
- Historic Sr-90 concentrations in plume core well 075-664 (located approximately 50 feet upgradient of SR-3) have not correlated well with the concentrations detected in SR-3. One possibility for the significantly lower concentrations than expected in this well is that it is screened slightly too deep to be in the core of the plume. The installation of a temporary well adjacent to 075-664 will be recommended. Pending the results, this temporary well may be followed up with a permanent monitoring well screened at a shallower depth than 075-664.
- Concentrations of Sr-90 in plume perimeter wells 075-195, 075-196, 075-197, and 075-200, located west of the downgradient portion of the plume, remained below the DWS.
- Sentinel wells 075-670 and 075-671 are north of Brookhaven Avenue on the south side of the NSLS-II. Prior to 2007, these wells were located just downgradient of the leading edge of the plume. In 2008, both wells detected Sr-90 above the DWS, at concentrations between 13 and 38 pCi/L. Based on these data, the leading edge of the plume defined by the 8 pCi/L DWS is located approximately 100 feet south of this location.

Pile Fan Sump Plume

- Plume core well 065-37, located just downgradient of the PFS, detected 47 pCi/L Sr-90 in both April and October 2008. As noted on **Figure 3.2.15-5**, this is a slight decrease from the 2007 data. See **Section 4.11** for further discussion.
- The highest Sr-90 concentration in the PFS plume was 42 pCi/L in core well 075-683, located just south of Cornell Avenue. This well was installed in 2007. This plume is not addressed by active pumping, but will naturally attenuate to below the DWS.
- Plume core wells 075-193, 075-194, 075-674, and 075-675 are located on the south side of Cornell Avenue, and monitor the western perimeter of the leading edge of the plume. The highest 2008 Sr-90 concentration in these wells was 5 pCi/L in well 075-674 during October.

3.2.15.4 System Operations

In accordance with the SPDES equivalency permit, the required frequency for Sr-90 and VOC sampling is monthly and the pH measurement is weekly. However, samples from the influent, effluent, and midpoint locations of the treatment system were collected twice a month throughout 2008 in order to optimize resin usage. All system samples were analyzed for Sr-90 and VOCs. The influent was also analyzed for tritium, and both the influent and effluent were analyzed weekly for pH. Sr-90 concentrations for the extraction wells in 2008 are summarized on **Table F-41** (**Appendix F**). System influent and effluent concentrations are summarized on **Tables F-42** and **F-43**. **Table F-44** contains the monthly Sr-90 removal totals for the system.

Operation details are given in the O&M manual for this system (BNL 2005d). Below is a summary of the system operations for 2008.

January – September 2008

Well SR-1 was off from January to May and well SR-3 was off February through April due to electrical and mechanical problems. The entire system was off from August 11 to 26 due to damage from a lightning strike. A resin vessel change-out was performed from July 11 to August 6, during which time the system was down. A second resin change-out was performed in February 2008.

October – December 2008

The treatment system ran normally for the entire period.

Extraction Well Operational Data

During 200 8, approxim ately 8.5 m illion gallons were pu mped and recharged b y the OU III BGRR/WCF SR-90 Treatment Systems, with an average flow rate of 16 gpm. **Table 3.2.15-3** shows the monthly extraction well pumping rates while **Table F-41** shows Sr-90 concentrations.

3.2.15.5 System Operational Data

During 2008, influent concentrations of Sr-90 ranged from 26 to 137 pCi/L, with the highest concentration observed in January. The highest influent tritium concentration during 2008 was 324 pCi/L in April. During 2008, Sr-90 was detected once in the effluent samples, at a concentration of 1.7 pCi/L in January. This detection was below the limit of 8.0 pCi/L (**Table 3.2.15-2**). There were no VOCs detected above the SPDES Equivalency Permit discharge limits in the 2008 influent or effluent samples. During 2008, approximately 8.8 million gallons of groundwater were processed through the system.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 influent concentrations, to calculate the number of milliCuries (mCi) removed. During 2008, the flow averaged 17 gpm. Approximately 2.7 mCi of Sr-90 was removed during 2008, for a total of 16.9 mCi removed since system start-up in 2005 (**Figure 3.2.15-6**). Cumulative mass removal of Sr-90 is shown on **Figure 3.2.15-7**.

Table 3.2.15-2
BGRR Sr-90 Treatment System
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range	5.5–8.5 SU	5.8–7.7 SU
Sr-90	8.0 pCi/L	1.69
Chloroform	7.0 µg/L	<0.5
1,1,1-Trichloroethane	5.0 µg/L	<0.5

Notes:
ND = Not detected above minimum detectable activity.
SU = Standard Units
Required sampling frequency is monthly for Sr-90 and VOCs, and weekly for pH.

Extraction Wells

Maximum Sr-90 concentrations in each of the extraction wells during 2008 were as follows:

- SR-1 113 pCi/L in January
- SR-2 146 pCi/L in October
- SR-3 269 pCi/L in January
- SR-4 23 pCi/L in January
- SR-5 116 pCi/L in January

During 2008, no VOCs were detected above the drinking water standard in the extraction wells. **Figure 3.2.15-6** shows the influent Sr-90 concentrations for individual extraction wells over time.

3.2.15.6 System Evaluation

The OU III BGRR/WCF Strontium-90 Pump and Treat System and Monitoring Program can be evaluated in the context of four basic decisions established for this program using the groundwater DQO process:

1. Was the BNL Groundwater Contingency Plan triggered?

WCF Plume: No. There were no unusual or unexpected concentrations in the monitoring wells associated with this program during 2008.

BGRR Plume: No.

PFS Plume: No.

2. Has the plume been controlled?

WCF Plume: No. Based on the monitoring well data, the area of high Sr-90 contamination near the WCF is controlled and captured by extraction wells SR-1 and SR-2. However, based on the additional temporary well data collected in the vicinity of the HFBR in 2007 through early 2009, there are high Sr-90 concentrations that are not actively controlled. Preliminary groundwater modeling of the recent data indicates that if left untreated, the OU III ESD cleanup objective of meeting the DWS by 2070 would not be met.

BGRR Plume: Yes. Based on the monitoring well data, the high concentration portion of the plume is being captured by extraction wells SR-3, SR-4, and SR-5.

PFS Plume: Yes. Based on the monitoring well data, the high concentration portion of the plume is expected to attenuate to below DWS.

3. *Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate identified in the Explanation of Significant Differences to the OU III Record of Decision?*

WCF Plume: The hydraulic capture performance of the system is operating as modeled in the system design. The system has been removing Sr-90 from the aquifer and the resin is effectively treating the Sr-90 to below MCLs. However, based on current model projections on the long-term restoration of the aquifer, the elevated Sr-90 concentrations identified just north of the HFBR indicate that the ESD cleanup objective of meeting DWS by 2070 may not be met. Additional extraction wells will be necessary to reduce the high concentration slug (identified as part of the recent characterization effort) to levels that will attenuate in accordance with the cleanup goal. A complication to addressing the high concentration slug is that it is co-located with tritium from the g-2 plume, well in excess of the DWS. This will not permit for pumping of the Sr-90 high concentration slug for the next six months to a year. The g-2 tritium slug has been well defined, and is moving in the aquifer at a rate five to 10 times faster than Sr-90. Once the tritium slug has moved south of this area it will be possible to pump and treat this segment of the plume.

BGRR Plume: The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing Sr-90 from the aquifer. The resin is effectively treating the Sr-90 to below DWS. The ESD objectives are expected to be met.

PFS Plume: Based on the Sr-90 concentrations detected in 2008, the plume it is attenuating as projected.

4. *Have the cleanup goals been met? Can the groundwater treatment system be shut down?*

WCF Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met. However, the system is minimizing plume growth of the higher concentrations of Sr-90 near the WCF. Based on the temporary well data from 2007 through March 2009, the OU III cleanup goal will not be met if the high concentration areas of the plume near the HFBR are not actively addressed.

BGRR Plume: No. The cleanup goal of achieving the DWS in the aquifer has not been met, but the system is preventing and minimizing plume growth of the higher concentrations of Sr-90.

PFS Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met. The plume is not being actively remediated.

3.2.15.7 Recommendations

The following are recommendations for the BGRR/WCF Groundwater Treatment System and Monitoring Program:

- Perform groundwater modeling for modifying the system to address the high concentration Sr-90 area in the vicinity of the HFBR. Utilize the fourth-quarter 2008 permanent and temporary well data and the first-quarter 2009 temporary well data for model initialization. Determine the number and placement of extraction wells necessary to remediate this area and reduce Sr-90 concentrations to levels that will allow for achievement of OU III ROD cleanup goals.
- Install additional extraction wells to address the Sr-90 hot spot identified in the WCF plume. The modification to the existing Sr-90 treatment system will consist of several new extraction wells. The location and exact number of wells will depend on the distribution of the hot spot following the departure/attenuation of the g-2 tritium slug from this area. It is currently estimated that the modification will be implemented in 2010.
- For the BGRR Sr-90 plume, install temporary wells near 075-670 and 075-671 to determine the width of the downgradient portion of the plume.
- Install a temporary well adjacent to monitoring well 075-664 to determine if a permanent well screened at a shallower depth is necessary at this location.
- Eliminate sampling at monitoring wells 065-11 and 065-177. These wells are significantly outside of the current plume position and have not detected more than trace levels of Sr-90 over a number of years.
- Install a temporary well approximately 75 feet north of monitoring well 075-86 at the corner of Cornell Avenue to characterize the centerline of the PFS plume.

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3.2.16 Chemical/Animal Holes Strontium-90 Treatment System

This section summarizes the operational data from the OU III Chemical/Animal Holes Strontium-90 Treatment System for 2008, and gives conclusions and recommendations for future operation. This system began operation in February 2003.

3.2.16.1 System Description

The Chemical/Animal Holes were located in the south-central portion of the BNL property (**Figure 1-1 and 3.2.16-1**). The area consisted of 55 pits east of the Former Landfill that were used for the disposal of a variety of laboratory chemicals and animal remains. The buried waste was excavated in 1997.

Following the excavation, a Sr-90 plume was characterized. As discussed in the *2006 Groundwater Status Report*, 17 temporary wells were installed between April 2006 and February 2007 to collect additional data as a result of increasing Sr-90 concentrations downgradient of EW-1. In addition, as discussed below and based on the recommendations of the *2007 Groundwater Status Report*, eight temporary wells were installed in the upgradient portion of the plume in 2008. Based on the data from the temporary and program monitoring wells, the plume (as defined by the 8 pCi/L isocontour) is now approximately 700 feet long and 65 feet wide, with a maximum thickness of 15 feet. It is approximately 22 to 45 feet below ground surface. To date, the highest Sr-90 concentration observed in groundwater in this area was 4,720 pCi/L at well 106-99 in March 2005. The areas of higher concentrations (>100 pCi/L) occur in very narrow bands. The first is an area at and immediately upgradient of EW-1. The second area, approximately 20 feet wide, begins just south of the Princeton Avenue firebreak and continues south for approximately 250 feet just upgradient of EW-3 (**Figure 3.2.16-1).**

The elements of the Sr-90 remediation at the Chemical/Animal Holes are:

1. Three extraction wells pumping into an ion exchange treatment system to remove Sr-90 from the extracted groundwater, and on-site discharge of the clean water into two drywells. Extraction wells EW-2 and EW-3 became operational in November 2007. Extraction Well EW-1 is now in a pulse-pumping phase and run on a one-month-on/one-month off schedule.
2. Operation of the system to minimize plume growth and meet DWS within 40 years.
3. Continued monitoring and evaluation of the data to ensure protectiveness.

Details of operations are provided in the *Chemical/Animal Holes Strontium-90 Groundwater Treatment System Operation and Maintenance Manual* (BNL 2008d). This manual was updated to reflect the additional extraction wells (EW-2 and EW-3).

3.2.16.2 Groundwater Monitoring

Well Network

As recommended in the *2007 Groundwater Status Report*, monitoring wells 106-20, 106-21, 106-43, 106-44, 106-45, and 106-64, located significantly west of the Chemical/Animal Holes plume, were transferred to the Former Landfill groundwater monitoring program in 2008. The data for these wells are discussed in the annual *2008 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2009b). With the transfer of the six wells, the Chemical/Animal Holes monitoring network now consists of 35 wells. **Figure 1-2** shows the monitoring well locations.

Sampling Frequency and Analysis

The monitoring wells are sampled in accordance with the O&M phase (semiannual and annual) frequency. As recommended in the *2007 Groundwater Status Report*, the sampling frequency for the five monitoring wells installed in 2007 was changed from quarterly to semiannually. Also, the sampling frequency for well 106-99 changed from annual to semiannual. Fourteen of the 35 monitoring wells were sampled semiannually for Sr-90; the remaining wells were sampled annually. As recommended in the *2007 Groundwater Status Report*, VOC analysis was dropped from the monitoring program starting in the fourth quarter of 2008 since VOCs have not been detected above the DWS since 2004.

3.2.16.3 Monitoring Well Results

Figure 3.2.16-1 shows the Sr-90 plume distribution. The plume depiction is derived from the fourth quarter monitoring well data and supplemented with the eight temporary wells.

A summary of key monitoring well data for 2008 follows.

- The highest Sr-90 concentration observed in 2008 was 859 pCi/L in plume core well 106-16. This well is approximately 50 feet upgradient of EW-1 and began to rebound in late 2006 following two previous years of lower values (<250 pCi/L). However, Sr-90 concentrations in plume core well 106-99, slightly downgradient of 106-16, have remained low over the past three years despite reaching a historical high concentration for the entire plume of 4,720 pCi/L in 2005.
- Plume core wells 106-103 and 106-105, located immediately downgradient of EW-1, only detected up to 4 pCi/L in 2008. This is the first year that a break in the plume downgradient of EW-1 was observed.
- Except for one detection in 2003 (11 pCi/L), SR-90 concentrations in plume perimeter well 106-48 have been below the DWS. However, in 2008 Sr-90 was detected twice above the DWS with a maximum of 32 pCi/L. This resulted in a slight shifting of the western portion of the plume below Princeton Avenue. Plume perimeter well 106-50 continues to bound the plume to the east since it has been below the DWS since 2006.
- Plume core well 106-49, located in the centerline of the plume approximately 170 feet downgradient of extraction well EW-1, detected Sr-90 at 146 pCi/L in January and 42 pCi/L in July 2008. As shown on **Figure 3.2.16-2,** the 2008 data for this well are the lowest since 1999. This indicates that the trailing edge of the high Sr-90 portion of the plume is now moving through the well 106-49 area. This is also supported by the declining trends in upgradient wells 106-103 and 106-105.
- Plume core well 106-125, approximately 100 feet downgradient of well 106-49 and just upgradient of EW-2, is picking up the leading edge of the higher concentration portion of the plume. This well detected 498 pCi/L of Sr-90 in October 2007 and dropped off to 94 pCi/L in July 2008. Plume core well 106-119, located upgradient of the southern-most extraction well EW-3, detected a maximum Sr-90 concentration of 62 pCi/L in July 2008. This is consistent with 2007 data.
- Bypass wells 106-120, 106-121, and 106-122 are approximately 100 feet south of EW-3. The only detection of Sr-90 in these wells in 2007 and 2008 was 1.02 pCi/L in well 106-122 in July 2008.

As noted previously in **Section 3.2.16.1**, eight temporary wells were installed in the upgradient portion of the plume in 2008. These wells were installed to determine if there is a continuing source of Sr-90 contamination upgradient of monitoring well 106-16. The highest Sr-90 concentration in these wells was 190 pCi/L in B-2. The data are presented on **Table 3.2.16-1**. Based on a review of the data, there doesn't appear to be a continuing source, and a permanent monitoring well was not installed.

All monitoring wells in this program were also analyzed annually for VOCs to monitor low-level VOC contamination originating from the Chemical/Animal Holes area. There were no detections of VOCs above the DWS in 2008 in any of the program well. The complete results are in **Appendix C**.

3.2.16.4 System Operations

The Chemical/Animal Holes Strontium-90 Treatment System influent, effluent, and midpoint locations were sampled once a week. These samples were analyzed for Sr-90. In addition, the influent and effluent samples were analyzed for pH on a monthly basis (**Table 3.2.16-2**). The SPDES Equivalency Permit, which expired in January 2008, was renewed in February 2008 and the Sr-90 sampling frequency was changed from weekly to monthly. As per the recommendations in the *2007 Groundwater Status Report*, well EW-1 was placed in a pulse-pumping mode in 2008 on a schedule of one month on and one month off. Sr-90 concentrations for the system influent and effluent in 2008 are summarized on **Tables F-45** and **F-46** in **Appendix F**. **Table F-47** contains a summary of the monthly Sr-90 mass removal for the system.

Summarized below are the system operations data for 2008. Details for this system are given in the O&M manual.

Table 3.2.16-2.
OU III Chemical/Animal Holes Sr-90 Treatment System
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range (SU)	5.0–8.5	5.2–7.7
Sr-90 (pCi/L)	8.0	0.786J

Notes:
pCi/L = pico Curies per liter
SU = Standard Units
J = Estimated value
Required sampling frequencies are monthly for Sr-90 and pH.

January – September 2008

For this period the system operated the majority of the time. The system was off from July 7 to 14 and September 23 to 29 due to electrical problems. From January through September, the treatment system pumped a total of 4.4 million gallons of water.

October – December 2008

The system operated normally for this quarter, with the exception of being off for a couple of days in October and December due to electrical problems. The system pumped and treated a total of 1.6 million gallons of water this quarter.

3.2.16.5 System Operational Data

Sr-90 concentrations in EW-2 and EW-3 have decreased as expected since these wells became operational in November 2007. Upon start-up EW-2 detected up to 139 pCi/L of Sr-90, but the Sr-90 concentration has steadily dropped to 20 pCi/L in late 2008. When EW-3 became operational, concentrations were already low at 13 pCi/L, and they remained close to the DWS for 2008. Concentrations of Sr-90 spiked up and down several times in EW-1, but averaged approximately 45 pCi/L for the year. However, in late 2008 a maximum of 86 pCi/L Sr-90 was detected in EW-1. The spikes may be attributable to the pulse pumping. **Figure 3.2.16-3** presents the extraction well influent data over time. The 2008 analytical data show that influent Sr-90 concentrations ranged from 12 to 51 pCi/L. Effluent samples were well below the SPDES equivalency permit level of 8 pCi/L for Sr-90. During 2008, approximately 6 million gallons of groundwater were processed through the system.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 concentration, to calculate the number of mCi removed. Flow averaged 11 gpm during 2008. **Table 3.2.16-3** shows the monthly extraction well pumping rates. The cumulative total mass of Sr-90 removed was approximately 0.74 mCi during 2008, with a total of approximately 3.33 mCi removed since 2003 (**Figure 3.2.16-4**).

3.2.16.6 System Evaluation

The Chemical/Animal Holes Treatment System performance can be evaluated based on the four major decisions identified for this system as part of the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected Sr-90 concentrations in the monitoring wells or extraction wells associated with the Chemical/Animal Holes Treatment System during 2008.

2. Has the plume been controlled?
The monitoring data indicate that the plume is controlled by the three extraction wells pumping at 6 gpm. Monitoring of the three plume bypass wells will continue to provide verification. The travel time from EW-3 to these wells is approximately three years (**Figure 3.2.16-1**). Based on the eight temporary wells installed in the upgradient portion of the plume, there doesn't appear to be a continuing source of contamination present.

3. *Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate identified in the Explanation of Significant Differences to the OU III Record of Decision?*
The system was designed to meet the ROD and ESD cleanup goal of reaching the MCL by 2040. The original system design was for one extraction well operating for approximately 10 years to actively treat the Sr-90 plume, followed by 30 years of natural attenuation and radioactive decay. Based on increased Sr-90 concentrations identified in monitoring wells further downgradient, two additional extraction wells were installed in 2007 to ensure the cleanup goals would be met. The additional two extraction wells are also expected to operate approximately 10 years.

4*. Have the cleanup goals been met? Can the groundwater treatment system be shut down?*
No. Based on groundwater monitoring data discussed in **Section 3.2.16.3**, significant contamination remains upgradient of extraction wells EW-1, EW-2, and EW-3. If this were left untreated, the cleanup goal of meeting the MCL within 40 years would not be met.

3.2.16.7 Recommendations

The following are the recommendations for the Chemical/Animal Holes Strontium-90 Treatment System and groundwater monitoring program:

- Due to the low influent concentrations, continue pulse pumping of EW-1 (one month on, one month off). If concentrations in this extraction well increase significantly, then EW-1 will be put back into full-time operation. Continue to operate extraction wells EW-1, EW-2 and EW-3 between 5 and 7 gpm.
- Maintain the operations and maintenance phase monitoring well sampling frequency started in 2007.
- Drop well 114-01 from the monitoring program since there have been no historical detections of Sr-90 in this well.
- Install temporary wells adjacent to monitoring well 106-48 to determine the extent of the Sr-90 contamination detected in this well. Following review of the temporary well data, a monitoring well may be installed.

3.2.17 HFBR Tritium Pump and Recharge System

In late 1996, tritium was detected in monitoring wells near the HFBR. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed and the spent fuel pool was drained. In May 1997, a three-well groundwater pump and recharge system was constructed on the Princeton Avenue firebreak road approximately 3,700 feet downgradient of the HFBR to capture tritium and assure that the plume would not move off site. Extracted water was recharged at the RA V recharge basin. Groundwater modeling projected that the tritium plume would attenuate naturally to below DWS (20,000 pCi/L) before reaching the site boundary. The extraction system was placed on standby status in September 2000, as groundwater monitoring data demonstrated that the plume was attenuating to concentrations well below DWS in the vicinity of the Pump and Recharge System.

As described in the OU III ROD, the selected remedy to address the HFBR tritium plume included implementing monitoring and low-flow extraction programs to prevent or minimize the plume's growth. Beginning in June 2000 and ending April 2001, 20 low-flow extraction events removed 95,000 gallons of tritiated water with concentrations greater than 750,000 pCi/L. This water was sent off-site for disposal.

The OU III ROD contingencies are defined as either a detection of tritium above 25,000 pCi/L in monitoring wells at the Chilled Water Facility Road, or above 20,000 pCi/L in monitoring wells along Weaver Drive. The OU III ROD contingency of exceeding 20,000 pCi/L at Weaver Drive was triggered with a detection of 21,000 pCi/L in GP-297 in November 2006. In 2007, new extraction well EW-16 was installed to supplement the three existing extraction wells and the system was restarted in November 2007 as per the ROD contingency.

Groundwater flow in the vicinity of the HFBR is primarily to the south (**Figures 2-2** and **2-3**). Evaluation of groundwater flow and quality data indicates that the downgradient portion of the tritium plume (south of Brookhaven Avenue) has shifted east since 1997 in response to decreased cooling water discharges to the HO recharge basin and the OU III recharge basin. The eastward shift is also demonstrated by observing the sharp declines in tritium concentration for monitoring wells 075-294, 075-418, 085-287, and 085-78 shown on **Figure 3.2.17-3**.

3.2.17.1 System Description

As a result of the implementation of the ROD contingency described above, operation of the system resumed in November 2007 and included the pumping of wells EW-16 and EW-11. Extraction well EW-16 was installed approximately 400 feet north of the existing pump and recharge wells located on Princeton Avenue (**Figure 3.2.17-1**). Extraction wells EW-9, EW-10, and EW-11 are being sampled quarterly and EW-16 is being sampled at a weekly frequency. A pre-startup sample obtained on November 28, 2007 showed tritium at 6,580 pCi/L. Since that time, the tritium concentrations in EW-16 have ranged from 970 to 2,950 pCi/L.

For a complete description of the HFBR Tritium Pump and Recharge System, see the *Operations and Maintenance Plan for the High Flux Beam Reactor Tritium Plume Pump and Recharge System* (BNL 2009c).

3.2.17.2 Groundwater Monitoring

Well Network

A monitoring well network of 116 wells is used to evaluate the extent of the plume, monitor the source area, and verify the predicted attenuation of the plume (**Figure 1-2**). The permanent monitoring well network is being supplemented with a semiannual temporary well characterization. A total of 37 temporary wells were installed and sampled in April 2008 to the first quarter of 2009. Eighteen temporary wells were installed between January 14 and March 25, 2008, four were installed between April 29 and May 19, 2008, and fifteen were installed between December 8, 2008 and March 17, 2009 (**Figure 3.2.17-1** and **Table 3.2.17-1)**. In 2008, a total of six wells were abandoned in preparation for NSLS-II Facility construction activities . Due to the eastward shift of the plume over the past 5 to 10 years, the abandoned wells are all currently located outside of the core of the plume. The loss of these wells should have no impact on the effectiveness of the groundwater monitoring program, as these areas are supplemented with temporary wells as needed.

Sampling Frequency and Analysis

Sampling details for the well network are provided on **Table 1-5**. Select wells are also analyzed for VOCs as part of the Carbon Tetrachloride and Middle Road programs.

3.2.17.3 Monitoring Well Data

The extent of the tritium plume is shown on **Figure 3.2.17-1**. This figure summarizes data collected from monitoring wells during the fourth quarter of 2008, supplemented with data obtained from 15 temporary wells installed from December 2008 through March 2009. The temporary wells were installed to fill in data gaps along key segments of the plume. Specifically, the temporary wells were installed on Temple Place and along four transects from the area immediately north of EW-16 to approximately 1,000 feet north where the high concentration segment of the plume is currently located (**Figure 3.2.17-1**). **Appendix C** contains the complete set of monitoring well data. Data from temporary wells installed from April 2008 through March 2009 are summarized on **Table 3.2.17-1**. A north–south cross-sectional view of the plume centerline is shown on **Figure 3.2.17-2**. Tritium concentration trends for key monitoring wells are shown on **Figure 3.2.17-3**.

Background

Samples are collected from a network of seven monitoring wells north of the HFBR. These wells serve as early detection points if groundwater flow shifts to a more northerly direction and toward supply wells 10, 11, and 12. Groundwater flow during 2008 was consistently to the south. Supply well 10 was not operated during 2008, while wells 11 and 12 provided approximately 10% of the lab's water supply. The g-2 plume is present in the vicinity of the HFBR, approximately 10 to 20 feet deeper than the HFBR plume. A characterization of the downgradient extent of the g-2 tritium plume was conducted again in 2008 and is summarized in **Section 4.2**.

HFBR to Brookhaven Avenue

Tritium concentrations directly downgradient from the HFBR have been observed to correlate with peak water-table elevations in response to water-table flushing of the unsaturated zone beneath the HFBR. There has been a steady decline in water-table elevations since the middle of 2007, which has minimized water-table flushing beneath the HFBR during that time, and is at least partially contributing to the declining tritium trends over the same period (**Figure 3.2.17-4)**. Based on the current trend, it is anticipated that peak tritium concentrations in these wells will be less than the 20,000 pCi/L DWS within the next several years.

The peak tritium concentration in this area was 103,000 pCi/L in well 075-240 (located on Cornell Avenue) in June 2008 (**Figure 3.2.17-5**). The tritium concentrations in this well declined to 2,490 pCi/L by December of 2008. The peak tritium concentration in this area was 200,000 pCi/L in well 075-240 during 2007. Decreasing tritium concentrations in this area were expected based on the declining water-table elevation from late 2007 through 2008. The HFBR tritium plume as depicted on **Figure 3.2.17-1** now consists of several discontinuous segments. The segment south of Temple Place is the result of periodic flushing of the remaining tritium inventory in the unsaturated zone beneath the HFBR.

Brookhaven Avenue to Weaver Drive

The monitoring well network in this area was supplemented with six temporary wells during 2008/2009. The plume in this area has become discontinuous as defined by the 20,000 pCi/L contour. There is now a break of approximately 500 feet in length to the north and south of Brookhaven Avenue and another east of the Chilled Water Facility (**Figure 3.2.17-1)**. These breaks were created by the intermittent nature of tritium flushing in the vadose zone beneath the HFBR over the past several years.

In the first quarter of 2009, the highest concentration segment of the HFBR tritium plume was located between the Chilled Water Facility Road and Weaver Drive. The highest tritium concentration detected during 2008 was 113,000 pCi/L in temporary well GP-282 in January 2008. The concentration at this location in December 2008 was 18,900 pCi/L. The leading edge of the higher concentration slug should be approaching the Weaver Drive area. Wells in this area are scheduled for sampling again in July 2009. The trailing edge of the high concentration downgradient slug is now south of the Chilled Water Facility Road area based on the tritium concentrations in that area decreasing to less than 20,000 pCi/L during the latest sampling round.

Weaver Drive to Princeton Avenue Firebreak Road

During 2008 and the first quarter of 2009, 11 temporary wells were installed in this area to supplement the monitoring well network. The highest detection observed south of Weaver Drive was 82,300 pCi/L in GP-349 in March 2008. The concentration at this location decreased to 3,700 pCi/L in January 2009. Temporary well GP-340, located approximately 100 feet north of EW-16, detected 10,000 pCi/L in March 2008. First-quarter 2009 data from temporary wells GP-340 (17,600 pCi/L), GP-338 (23,200 pCi/L), and permanent well 096-117 (27,800 pCi/L), located immediately north of EW-16, indicate that the leading edge of the plume, as defined by concentrations greater than 20,000 pCi/L, is approaching this vicinity. EW-16 is being sampled on a weekly basis, and concentrations to date have shown a slight increase with a maximum tritium concentration of 2,950 pCi/L in 2008. Tritium has not been detected in perimeter monitoring well 096-118, located approximately 200 feet east of EW-16, which confirms that the plume is within the capture zone of the extraction well. **Table F-48** (**Appendix F**) presents the VOC and tritium detections in the extraction wells for 2008.

3.2.17.4 System Operations

Extraction wells EW-9, EW-10, and EW-11 were sampled quarterly, whereas EW-16 was sampled quarterly for VOCs and weekly for tritium in 2008. The influent, midpoint, and effluent of the carbon units were sampled twice per month, along with weekly pH readings. These samples were analyzed for VOCs and tritium. However, the weekly EW-16 sample was only analyzed for tritium. Extraction wells EW-11 and EW-16 are in full-time operation, while EW-9 and EW-10 are in standby mode. **Table 3.2.17-2** shows the 2008 SPDES parameter levels.

The following is a summary of the OU III HFBR Tritium System operations for 2008:

Table 3.2.17-2
OU III HFBR Tritium System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–8.5 SU	5.6-7.4 SU
Carbon tetrachloride	5	ND
Chloroform	7	ND
1,1-Dichloroethane	5	ND
1,2-Dichloroethane	0.6	ND
1,1-Dichloroethene	5	ND
Cis-1,2-Dichloroethylene	5	ND
Trans-1,2-Dichloroethylene	5	ND
Tetrachloroethylene	5	ND
1,1,1-Trichloroethane	5	ND
Trichloroethylene	5	ND

Note:
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units

January – September 2008

The system operated normally during this period, with some down time in January due to routine testing and maintenance while flow rates were being set. Normal down time was experienced due to scheduled maintenance and alarm testing. During the first three quarters of 2008 approximately 61 million gallons of groundwater were pumped and recharged.

October – December 2008

The system operated normally during the last quarter of 2008 with some down time due to NSLS-II electrical construction activities. Approximately 24 million gallons of groundwater were pumped and recharged.

Extraction Well Operational Data

During 2008, approximately 86 million gallons of groundwater were pumped and recharged by the OU III HFBR Tritium System, with an average flow rate of 163 gpm. **Table 3.2.17-3** shows the monthly extraction well pumping rates while **Table F-48** (**Appendix F**) shows VOC and tritium concentrations.

3.2.17.5 System Evaluation

The OU III HFBR Tritium Pump and Recharge System and Monitoring Program can be evaluated based on five major decision rules established for this program using the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in the monitoring wells or the extraction wells associated with the HFBR Tritium Pump and Recharge System during 2008. EW-16 was installed and the Pump and Recharge system restarted in November 2007 in response to triggering the ROD contingency of 20,000 pCi/L at Weaver Drive in 2006.

2. Is the tritium plume growing?

No. Based on the position of the 20,000 pCi/L isocontour line, the high concentration segment of the plume has migrated to EW-16, which is positioned to capture the plume. See **Figure 3.2.17-6** for the plume distribution comparison between 1997 and 2008.

3. Are observed conditions consistent with the attenuation model?

Yes. The BNL HFBR groundwater model 2003 update predicted that the remnants of the hot spot would reach Weaver Drive in late 2005 (approximately) at concentrations between 30,000 and 60,000 pCi/L. Observed conditions with respect to both tritium concentrations and hot-spot position matched the model predictions reasonably well. The observed concentration of 82,300 pCi/L between Weaver Drive and EW-16 in 2008 is slightly higher than the model predicted concentration (30,000 – 60,000 pCi/L), but within an acceptable error range for a 5-year prediction.

4. Is the tritium plume migrating toward the zone of influence of water supply wells 10, 11, and 12?

No. Groundwater flow from this area was to the south during 2008 (**Figure 2-2**).

5. Has any segment of the plume migrated beyond the current monitoring network?

No. The plume is monitored by a combination of permanent wells supplemented with temporary wells, where necessary, to ensure that the plume extent is characterized.

3.2.17.6 Recommendations

The following are recommendations for the HFBR Tritium Pump and Recharge System and monitoring program:

- Reduce the sampling frequency for 11 wells along Cornell Avenue (075-225, 075-228, 075-231, 075-234, 075-237, 075-240, 075-244, 075-42, 075-43, 075-44, and 075-45) from monthly to quarterly. The sampling frequency for these wells was increased during the fall of 2006 in response to a water leak in the HFBR building. There is no need to continue data collection at a monthly frequency as this leak has had no impact on groundwater.

- Reduce the sampling frequency for tritium for a number of wells as noted on **Table 5-1**. It is now well documented that these wells are outside the plume perimeter and, in most cases, there is another well located between these wells and the plume.
- Continue to install and sample temporary wells twice per year over the next several years to characterize the location of the high tritium concentration area approaching EW-16. Results will be communicated to the regulators via the IAG conference call and quarterly/annual reports.
- Continue operating EW-16 and EW-11 in 2009. Monitor tritium concentrations in EW-16 on a weekly basis.
- The pump and recharge well(s) will be operated until the tritium concentrations from Weaver Drive to EW-16 drop below 20,000 pCi/L. The estimated operational duration of 2 to 4 years (2011 to 2013) is based on the length of the high concentration area slug and the time it would take to be completely captured by EW-16. The decision to turn the wells back to standby will be based on:
    - concentrations of tritium decreasing to less than 20,000 pCi/L in the monitoring wells at Weaver Drive as well as the extraction wells, and
    - verification that the new extraction well has captured concentrations of tritium in this area greater than 20,000 pCi/L. A decision to turn the wells back to standby will be supported with data from additional permanent and temporary wells, as needed.

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3.3 OPERABLE UNIT IV

3.3.1 Post Closure Monitoring (Former OU IV AS/SVE System)

The OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) System was shut down in August 2001, and further monitoring was continued as per *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort – Work Plan* (BNL 2001b). The *Petition for Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System* (BNL 2002c) was submitted to the regulatory agencies in June 2002. BNL received regulatory approval in July 2003 and decommissioned the system in December 2003.

A *Five-Year Review Report for OU IV* was submitted to the regulators in June 2002. A final report was approved in September 2003. This report included changes to the continued groundwater monitoring program.

3.3.1.1 Groundwater Monitoring

Well Network

The *Final CERCLA Five Year Review Report for OU IV* (BNL 2003b) stated that monitoring under this program should continue for three monitoring wells: 076-04, 076-06, and 076-185.

Monitoring wells 076-18 and 076-19 continue to be monitored under the BNL Facility Monitoring Program for the Central Steam Facility. The remaining monitoring wells were either included under the radionuclide monitoring under the Building 650 and Sump Outfall Strontium-90 Monitoring Program (**Section 3.3.2**) or abandoned as per the final report (BNL 2003b) **(Figure 1-2).**

Sampling Frequency and Analysis

As per the *2007 Groundwater Status Report* (BNL 2008b), the sampling frequency for VOCs and SVOCs in these wells was reduced to annually. Since the recommendation was not implemented until the fourth-quarter 2008, more than one sample was collected from each well in 2008.

3.3.1.2 Monitoring Well Results

Post-closure sampling of monitoring wells was conducted for 2008. The complete groundwater data are given in **Appendix C**. There were no detections of SVOCs above reporting limits in any of the samples collected. Well 076-06 had detections of 7 µg/L 1,2,4-trimethylbenzene and 6 µg/L 1,3,5-trimethylbenzene in the January sampling event. These are above the NYS AWQS of 5 µg/L for each of these compounds. Two subsequent sampling events showed concentrations below 1 µg/L for these analytes. Well 076-185 had detections of 10 µg/L cis-1,2-dichloroethylene and 9.1 µg/L tetrachloroethylene in the October 2008 sampling round. These are above the NYS AWQS of 5 µg/L for each of these compounds. This contamination most probably originated from spills at the Central Steam Facility.

3.3.1.3 Post-Closure Monitoring Evaluation

The system can be evaluated based on the decision rule identified during the groundwater DQO process.

<u>1. Was the BNL Contingency Plan triggered?</u>
No. There were no unexpected VOC concentrations in groundwater during 2008.

3.3.1.4 Recommendation

The following is recommended for the OU IV AS/SVE Post Closure Monitoring program:

- Collect a sample from well 076-185 for VOC analyses during the second-quarter 2009 to confirm the detections of cis-1,2-dichloroethylene and tetrachloroethylene.

3.3.2 Building 650 and Sump Outfall Strontium-90 Monitoring Program

The Building 650 and Sump Outfall Strontium-90 Monitoring Program monitors a Sr-90 plume emanating from a remediated source area known as the former Building 650 Sump Outfall Area. This former source consisted of a depression at the terminus of a discharge pipe from the building. The pipe conveyed discharges from a concrete pad located approximately 1,200 feet to the west, where radioactively contaminated clothing and equipment were decontaminated beginning in 1959.

Remediation (by excavation) of the contaminated soils associated with the Building 650 sump outfall and removal of the pipe leading to the outfall, as well as soil, concrete, and asphalt associated with the former decontamination pad behind Building 650, were completed in 2002.

3.3.2.1 Groundwater Monitoring

Well Network

The network consists of 29 wells used to monitor the Sr-90 concentrations originating from the former Building 650 sump outfall area (**Figure 1-2**).

Sampling Frequency and Analysis

During 2008, the wells were monitored either annually or semiannually, and the samples were analyzed for Sr-90 (**Table 1-5**).

3.3.2.2 Monitoring Well Results

The complete results of the radionuclide sampling can be found in **Appendix C**. The Sr-90 plume originating from the Building 650 sump outfall continues to migrate slowly southward away from the former sump outfall area. The leading edge of the plume is presently located to the southwest of well 076-24. The trailing edge of the plume appears to be migrating away from the sump outfall area as evidenced by the steadily declining Sr-90 concentrations in well 076-169 over the previous two years (**Figure 3.3.2-1**). During 2008, the highest Sr-90 concentration (19 pCi/L) was detected in well 076-24 in January.

Sr-90 concentrations in well 076-28 are shown on **Figure 3.3.2-2**. This well is immediately north of Building 650, adjacent to the former decontamination pad where contaminated soils were removed in 2002. Fluctuations in Sr-90 concentrations have been observed in this well over the past several years. The Sr-90 data from this well, which dates back to 1997, was compared to water-table elevation data to identify whether the Sr-90 increases may be in response to periodic water table rises that flush out residual Sr-90 residing in the unsaturated zone in the vicinity of the pad/building. This water-table flushing process of contaminants in the vadose zone has been observed in several former source areas across the site, including the HFBR, BGRR, and g-2. Based on an analysis of the data, there does not appear to be a direct correlation between water-table elevation and Sr-90 concentration in this well. Sr-90 concentrations were also compared to available precipitation data over the history of the well with no observable correlation.

3.3.2.3 Groundwater Monitoring Program Evaluation

The monitoring program can be evaluated based on the three decision rules identified from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unexpected Sr-90 concentrations detected in groundwater during 2008.

2. Were performance objectives met?
No. The performance objective for this project is to achieve Sr-90 concentrations below the DWS of 8 pCi/L. There were four monitoring wells exceeding this limit in 2008. Therefore, the performance objectives have yet to be achieved. The removal of contaminated soils in 2002 addressed the

predominate source of groundwater contamination. The groundwater plume continues to degrade due to natural attenuation (i.e., radioactive decay).

3. If not, are observed conditions consistent with the attenuation model?
Yes. The observed data are consistent with the attenuation model in terms of the extent of Sr-90 contamination.

3.3.2.4 Recommendations

The following recommendations are made for the Building 650 and Sump Outfall Strontium-90 Groundwater Monitoring Program:

- Reduce the sampling frequency for monitoring wells 076-167, 076-183, 076-20, and 076-262 from semiannual to annual. These are all perimeter wells that have not been detecting Sr-90 over the past several years. Eliminate sampling of monitoring wells 076-10, 076-182, 076-264, 076-265, and 076-27. After approximately ten years of monitoring these wells, BNL has established that they are outside of the plume and are no longer providing useful data. The sampling of wells can be resumed and sampling frequencies increased if warranted by future changes in groundwater flow conditions.
- Install two to three temporary wells approximately 150 feet south of monitoring well 076-24 to a depth of 60 feet bls. The data will help in characterizing the leading edge of the plume and the width of the plume in this area. A permanent monitoring well may be installed pending the results.

3.4 OPERABLE UNIT V

3.4.1 Sewage Treatment Plant Monitoring Program

The Sewage Treatment Plant (STP) processes sanitary wastewater from BNL's research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit. Historically, BNL's STP received discharges of contaminants from routine operations. Releases of low-level contaminants to groundwater (in particular, VOCs, metals, and radionuclides) occurred via the STP sand filter beds and discharges to the Peconic River. The OU V project monitors the identified groundwater contamination downgradient of the STP. Groundwater quality in the immediate vicinity of the STP is being monitored under the Facility Monitoring Program, which is discussed in **Section 4.6** of this document.

3.4.2 Groundwater Monitoring

Well Locations

A network of 34 monitoring wells was designed to track groundwater contamination downgradient of the STP, at the site boundary, and off site (**Figure 1-2**).

Sampling Frequency and Analysis

All 34 wells are sampled annually for VOCs and tritium, and eight wells are sampled for perchlorate as per **Table 1-5**. As recommended in the *2007 Groundwater Status Report* (BNL 2008b), due to low concentrations of perchlorate being detected, the frequency of this analysis for the eight monitoring wells was reduced from semiannual to annual.

3.4.3 Monitoring Well Results

The OU V wells were sampled once during 2008. **Appendix C** contains the complete data. The VOC plume extends from south and east of the STP to the vicinity of the Long Island Expressway (**Figure 3.4-1**). During 2008, the highest TVOC concentration was 7 µg/L in well 061-05, located along the Peconic River in the vicinity of the site boundary. VOC concentrations in on-site plume core wells continued to decline. The TVOC concentrations in off-site plume core well 000-122 have shown a decreasing trend since early 2005 (**Figure 3.4-2)**. It appears that this plume has reached an equilibrium state in the aquifer with the leading edge attenuating in the vicinity of 000-122. There were no individual VOCs detected at levels exceeding NYS AWQS. There have been no significant changes to the VOC plume over the past several years, other than the gradual decline in concentrations (**Figure 3.4-2**). A comparison of the plume from 1997 to 2008 is shown on **Figure 3.4-3**.

In August 2004, the 34 OU V monitoring wells were sampled and analyzed for perchlorate in response to a request from the SCDHS. In June of that year, perchlorate had been detected in SCDHS monitoring well EG-A (off site and east of BNL) in a sample from the deep section of the Upper Glacial aquifer. Perchlorate was detected during the August 2004 sampling event in four of the 34 BNL wells (049-06, 050-02, 061-04, and 061-05), with concentrations ranging between 5.0 and 12.7 µg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 µg/L. The EPA published a Drinking Water Equivalent Level for perchlorate of 24.5 µg/L in January 2006. However, in December 2008 EPA established an Interim Drinking Water Health Advisory for perchlorate of 15 µg/L.

Since 2004, BNL has been monitoring eight of the monitoring wells for perchlorate (000-122, 000-123, 049-05, 049-06, 050-01, 050-02, 061-04, and 061-05). During 2008, the wells were analyzed for perchlorate during the third quarter sampling round. The compound was detected in wells 049-06, 061-04 and 061-05, which monitor the deep portion of the Upper Glacial aquifer. Well 049-06 is near the eastern firebreak road and wells 061-04 and 061-05 are at the eastern site boundary. The maximum perchlorate concentration was 5.4 µg/L detected in well 061-05. This concentration is significantly below the NYSDOH action level. The same eight OU V wells will be sampled for perchlorate again in 2009.

Tritium has historically been detected at low concentrations in monitoring wells 049-06, 050-02, and 061-05. During 2008, the maximum tritium concentration detected was 1,060 pCi/L in well 049-06; this is approximately one-twentieth the DWS of 20,000 pCi/L. Tritium was not detected in the off-site monitoring wells.

3.4.4 Groundwater Monitoring Program Evaluation

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unexpected contaminant concentrations in groundwater from the OU V Monitoring Program during 2008.

2. Were the performance objectives met?
Yes. The performance objective for this program is to attain NYS AWQS for VOCs in groundwater in the Upper Glacial aquifer within 30 years through monitored natural attenuation. VOCs were below NYS AWQS in the program monitoring wells in 2008.

3. Is the extent of the plume still defined by the existing monitoring well network?
Yes. The leading edge of the plume is in the vicinity of well 000-122 (south of the Long Island Expressway). Currently, two well clusters serve as sentinel wells for this plume along South Street and Wading River Road.

3.4.5 Recommendations

The following recommendation is made for the OU V plume groundwater monitoring program:

- It appears that the OU V VOC plume has largely attenuated. No individual VOC exceeded the NYS AWQS in 2008. It is recommended that the monitoring well network be sampled on an annual basis for one more year. If individual VOC concentrations and tritium remain below NYS AWQS during 2009, BNL may recommend reducing the number of wells being monitored.

3.5 OPERABLE UNIT VI EDB PUMP AND TREAT SYSTEM

The OU VI EDB Program monitors the extent of an ethylene dibromide (EDB) plume in groundwater extending from just south of the Long Island Expressway for approximately 4,000 feet. EDB was used during the 1970s as a fumigant for the BNL Biology Department's agricultural fields located in the southeastern portion of the site. In 1995 and 1996, low levels of EDB were detected in groundwater near the fields. Higher levels were found migrating toward the southern site boundary and off site to the south. In addition, the depth of the plume increased within the Upper Glacial aquifer to the south. Currently, only trace levels of EDB are detected on the site property.

3.5.1 System Description

A groundwater remediation system to address the off-site EDB plume began routine operations in August 2004. The OU VI EDB Treatment System consists of two extraction wells and two recharge wells. A complete description of the system is included in the *Operations and Maintenance Manual for the OU VI EDB Groundwater Treatment System* (BNL 2004e).

3.5.2 Groundwater Monitoring

Well Locations

A network of 30 wells monitor the EDB plume from the former source area in the Biology Department's agricultural fields to locations on private property south of North Street (**Figure 3.5-1**).

Sampling Frequency and Analysis

The OU VI EDB plume monitoring program is in the O&M phase (**Table 1-7**). The sampling frequency for most of the plume core and perimeter wells (**Table 1-5**) is semiannual. As per the recommendation in the *2007 Groundwater Status Report* (BNL 2008b), the sampling frequency for on-site wells 058-02, 089-13, 089-14, 099-06, 099-10, 099-11, 100-12, 100-13, and 100-14 were changed to annual, since there have been no detections of EDB above the federal DWS since mid 2003. Also, the frequency for well 000-498 changed to semiannual (O&M phase). The exception to this was core well 000-178 and bypass detection well 000-508, which remained at a quarterly sampling frequency for the year. The wells are analyzed for EDB according to EPA Method 504. Samples are also analyzed annually for VOCs. Several wells are incorporated into the OU III South Boundary Radionuclide monitoring program and analyzed for tritium annually. The inclusion of these wells allows for radionuclide monitoring across the entire downgradient site boundary (**Table 1-5**).

3.5.3 Monitoring Well Results

Appendix C contains the complete analytical results of the OU VI EDB monitoring well sampling program. The distribution of the EDB plume is shown for the fourth quarter of 2008 (**Figure 3.5-1**). The leading edge of the plume is being captured by extraction wells EW-1E and EW-2E. The plume is located in the deep Upper Glacial aquifer and is generally moving horizontally, as depicted on cross section M–M' (**Figure 3.5-2)**. A summary of key monitoring well data for 2008 follows:

- During 2008, the highest EDB concentration observed in the plume was 1.5 µg/L in core well 000-283. The 2007 maximum concentration in the plume was 2.3 µg/L in well 000-283. As seen in trend **Figure 3.5-3**, the EDB concentrations in wells 000-283 and 000-284 have been declining over the past several years. The federal DWS for EDB is 0.05 µg/L.
- The trailing edge of the EDB plume is moving south, as evidenced by the reduction in concentrations over the past several years in upgradient plume core wells 000-110, 000-175, and 000-209.

- Well 000-178, installed in 1998, is upgradient of EW-2E. As shown on **Figure 3.5-3**, increased EDB values have been detected in this well since late 2006, indicating movement of the plume south.
- Plume perimeter well 000-500, installed in 2004 in the eastern portion of the plume, has shown increased EDB levels to above the DWS since 2007. The maximum EDB detection well 000-500 in 2008 was 0.49 µg/L. Prior to this, the last detection that exceeded the DWS in this well was 0.087 µg/L in 2005. This portion of the plume is downgradient of well 000-178 and will be captured by EW-2E.
- Core well 000-507 has detected gradually increasing levels of EDB above the DWS since it was installed in 2005. This well is immediately upgradient of the extraction wells.
- Plume bypass well 000-508 has not contained any EDB since it was installed in 2004, except for one detection in 2005.
- As recommended in the *2007 Groundwater Status Report*, in March 2009 another plume bypass well was installed east of well 000-508 and slightly deeper, to verify that EDB is being captured by extraction well EW-2E.

As noted above, the southward migration of the plume can be observed by analyzing the trends on **Figure 3.5-3**. Over the past three years, the EDB concentration has increased in well 000-178, indicating that the core of the plume is located between the extraction wells and wells 000-283 and 000-284. Comparing the plume's distribution from 1999 to 2008 (**Figure 3.5-4**), as well as the EDB concentrations in monitoring wells just south of North Street**,** helps to illustrate the southward movement of the plume. Overall, peak EDB concentrations declined from 7.6 µg/L in 2001 (in well 000-283) to 1.5 µg/L in 2008 (also in well 000-283).

EDB was the only VOC detected above the MCL in any OU VI well in 2008 (**Appendix C**).

3.5.4 System Operational Data

The extraction wells are currently sampled monthly. In conformance with the SPDES equivalency permit, the sampling frequency for the influent and effluent is also monthly. All OU VI system samples were analyzed for VOCs and EDB, and the effluent sample was analyzed weekly for pH. **Table 3.5-1** provides the effluent limitations for meeting the requirements of the SPDES permit equivalency.

Table 3.5-1
OU VI EDB Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Measured Value
pH (range)	5.0 – 8.5 SU	5.6 – 7.9 SU
ethylene dibromide	5.0 µg/L	<0.50 µg/L
chloroform	7.0 µg/L	1.4 µg/L
1,1-dichloroethene	5.0 µg/L	<0.50 µg/L
1,1,1-trichloroethane	5.0 µg/L	<0.50 µg/L

Notes:
Required sampling frequency is monthly for VOCs and weekly for pH.
SU = Standard Units

January – September 2008

The system operated with EW-1E and EW-2E running at 180 and 150 gpm, respectively, for almost this entire period. In June the system was down for part of the month due to a lightning strike. The system was off again from July 24 to 31 due to electrical problems. From January through September approximately 113 million gallons of water were pumped and treated.

October – December 2008

EW-1E was off from November 12 to December 1 for repairs. The system operated normally for the remainder of this period. Approximately 40 million gallons of water were pumped and treated this quarter.

Extraction Wells

During 2008, 153 million gallons were pumped and treated by the OU VI EDB System, with an average flow rate of approximately 330 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells, and **Table 3.5-2** shows the pumping rates. VOC concentrations for EW-1E (000-503) and EW-2E (000-504) are provided on **Table F-49** in **Appendix F**. Low levels of EDB were detected monthly in extraction well EW-1E during 2008, with a maximum of 0.06µg/L in July. Only two of the detections of EDB in EW-1E (0.054 and 0.06 µg/L) were above the federal DWS of 0.05 µg/L. There were two EDB detections in EW-2E in 2008, with a maximum concentration of 0.14 µg/L. No other VOCs were detected in the extraction wells above the MCLs.

System Influent and Effluent

During 2008, OU VI EDB system discharge parameters were below the regulatory limit specified in the SPDES equivalency permit. Influent and effluent results are reported on **Tables F-50** and **F-51**, respectively. EDB was detected monthly in the influent throughout 2008, with a maximum concentration of 0.042 µg/L.

Cumulative Mass Removal

No cumulative mass calculations were performed, based on the low detections of EDB below the federal DWS in the system influent. Several low-level VOCs not attributable to BNL were detected; the results are potentially due to analytical lab contamination and were all below the DWS.

3.5.5 System Evaluation Data

The OU VI EDB System was designed to capture and remediate the EDB plume as it travels off site south of BNL with the regional groundwater flow. Start-up of the system was initiated in August 2004, and it is planned to run for approximately 10 years. The system is operating as designed; no operating difficulties were experienced beyond normal maintenance, and no permit equivalencies have been exceeded.

The OU VI EDB System performance can be evaluated based on the four major decisions identified in the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the OU VI EDB plume treatment system.

2. If not, has the plume been controlled?

Yes. An analysis of data from the plume perimeter and bypass wells shows no detections of EDB above the DWS in 2008 except in perimeter well 000-500, located just upgradient and slightly east of extraction well EW-2E. As noted above, this well had two detections of EDB in 2008, with a maximum of 0.49 µg/L. Extraction well EW-2E is expected to capture this portion of the plume.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

The hydraulic capture of the system is operating as designed. In 2007 and 2008 EDB was detected in the system influent monthly. These detections were at concentrations just below the federal DWS. Based on the location of the trailing edge of the plume, the aquifer is being restored at the planned rate.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements.

4a. Have asymptotic EDB concentrations been reached in plume core wells?

No. Asymptotic conditions have not yet been achieved.

4b. Are there individual plume core wells above 0.05 µg/L EDB ?
In the fourth quarter of 2008, seven of eight plume core wells had concentrations greater than the 0.05 µg/L federal DWS.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?
To date, the OU VI EDB system has not been pulsed.

4d. Have the groundwater cleanup goals been met? Are MCLs expected to be achieved by 2030?
No. The federal DWS has not been achieved for EDB in plume core wells. It is expected to be achieved by 2030, as required by the OU VI ROD.

3.5.6 Recommendations

The following recommendations are made for the OU VI EDB Pump and Treat System and groundwater monitoring program:

- Maintain routine operations of the treatment system.
- Since there have been no historical detections of EDB above the DWS, except on one occasion for well 000-180 in 2001, sampling of monitoring wells 000-180, 000-285, 058-02, 089-13, 089-14, 099-06, 099-10, and 100-14 will be eliminated.
- For the remainder of the wells, maintain the routine operation and maintenance monitoring frequency.

3.6 SITE BACKGROUND MONITORING

Background water quality has been monitored since 1990. Historically, low levels of VOCs were routinely detected in several background wells that are screened in the deeper portions of the Upper Glacial aquifer.

3.6.1 Groundwater Monitoring

Well Network

The 2008 program included 10 wells in the northwestern portion of the BNL property (**Figure 1-2**). Background quality is defined as the quality of groundwater that is completely unaffected by BNL operations.

Sampling Frequency and Analysis

The samples were collected annually and analyzed for VOCs (**Table 1-5**).

3.6.2 Monitoring Well Results

The complete groundwater analytical data for 2008 are provided in **Appendix C**. There were detections of low levels of several VOCs in the site background wells, all of which were below NYS AWQS. The highest concentration detected was 2.3 µg/L of methyl tertiary-butyl ether in well 017-03.

While radionuclides are no longer analyzed in background wells, historic results are presented for reference purposes. **Table 3.6-1** summarizes the range of radionuclide values detected in background wells from 1996 through 2001.

3.6.3 Monitoring Program Evaluation

The program can be evaluated using the decision rule developed as part of the groundwater DQO process.

1. Is groundwater quality at BNL being impacted by off-site, upgradient source(s) of contamination?

No. There were no VOCs detected in site background wells above NYS AWQS during 2008. Based on these results, there is no current impact to BNL groundwater quality from upgradient contaminant sources.

3.6.4 Recommendation

No changes to the monitoring program are warranted at this time.

Table 3.6-1.
Radiological Background Monitoring, 1996 – 2001

Parameter	Activity Range (pCi/L)	Contract-Required Detection Limit
Cesium-137	<MDA to 7.24	12
Gross alpha	<MDA to 2.66	1.5
Gross beta	<MDA to 6.41	4.0
Strontium-90	<MDA to 3.84	0.8
Tritium	<MDA	1,000

Note:
<MDA = Less than minimum detectable activity

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3.7 CURRENT AND FORMER LANDFILL GROUNDWATER MONITORING

Groundwater monitoring data from both the Current and Former Landfills are discussed in detail in the *BNL 2008 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2009a). The complete groundwater monitoring results for these programs are included in **Appendix C**.

3.7.1 Current Landfill Summary

Data show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. By the end of 2008, the landfill had been capped for 13 years. Groundwater quality has been slowly improving. The trend in the data suggests that the cap is effective in mitigating contamination. The following is a summary of the results from the samples collected during 2008:

- VOCs, such as benzene and/or chloroethane, continue to be detected in downgradient wells 087-11, 087-23, 088-109, and 088-110 at concentrations above groundwater standards (**Figure 3.2-1**). The maximum chloroethane concentration was 80.8 µg/L in well 088-109. Benzene was detected at a maximum of 3.02 µg/L in well 088-110. TVOC concentrations in these four wells have ranged from 1.5 to 90 µg/L over the past several years indicating that low-level VOCs continue to emanate from the landfill. However, an analysis of the trends of VOCs indicated the concentrations are stable to decreasing.
- Landfill water chemistry parameters and metals evaluated during the year suggest that leachate continues to emanate from the landfill, but at low levels.
- Tritium and Sr-90 continue to be detected in the wells downgradient of the Current Landfill, but at concentrations well below groundwater standards. These concentrations were consistent with those observed in 2007.
- Since 1998, there have been no detections of VOCs, water chemistry parameters, or radionuclides exceeding groundwater standards in wells 087-24, 088-22, and 088-23. These wells are all screened in the mid to deep Upper Glacial aquifer to monitor the vertical extent of contamination from the Current Landfill.
- Although low levels of contaminants continue to be detected, the landfill controls are effective as evidenced by the improving quality of groundwater downgradient of the landfill.
- In 2008, the average concentrations of the metals of concern in the Wooded Wetlands sediments in either pond did not exceed BNL background concentrations. However, mercury was above the benchmark concentration in the north pond.
- In 2008, the averages for the water samples collected from each pond indicate that iron was present above BNL critical water concentrations in the South Pond. However, the average iron concentration in both ponds was below the BNL background levels. No significant changes have occurred compared to previous year's data. Since metals in water are the primary source of absorption by tiger salamanders, and there was no significant increase in dissolved metals in 2008, this indicates that the wooded wetland is not experiencing an increase in metals concentrations.

3.7.2 Current Landfill Recommendations

The following recommendations are made for the Current Landfill groundwater monitoring program:

- The sampling frequency for organic and inorganic compounds be reduced from quarterly to semiannual, except for VOCs in wells 088-22 and 088-23. Based on the lack of VOC detections in these wells, the VOC analyses in wells 088-22 and 088-23 should be reduced from semiannual to annual. Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium, and gamma spectroscopy will continue on an annual basis.

- The sampling of both surface waters and sediments within the wooded wetland complex will be reduced to once every two years, since 10 years of data indicate a stable pattern in the concentration of metals.

3.7.3 Former Landfill Summary

Data show that contaminant concentrations have been decreasing following the capping of the landfill in 1996. Contaminant concentrations downgradient of this landfill were relatively low prior to capping, primarily due to it being approximately 50 years old. The trend in the data suggests that the cap is effective in mitigating the remaining contamination from entering the groundwater. Based on the declining VOC and Sr-90 concentration trends in downgradient wells, it appears that the landfill cap is performing as planned. The following is a summary of the results from the samples collected during 2008:

- The Former Landfill Area is not a significant source of VOC contamination. No VOCs were detected above groundwater standards in 2008. VOC concentrations in the downgradient wells were at or near the method detection limits.
- Landfill-leachate indicators in downgradient wells were detected at concentrations approximating those in the background monitoring wells, indicating that leachate generation is minimal to nonexistent.
- The Former Landfill Area no longer appears to be a source of Sr-90 contamination. Only trace amounts of Sr-90 were detected near the Former Landfill Area (well 097-64). The Sr-90 detected in wells 106-43, 106-44, 106-45, and 106-64 have been decreasing with time and are currently not above groundwater standards.
- The implemented landfill controls are effective, as evidenced by the improving quality of groundwater downgradient of the landfill.

3.7.4 Former Landfill Recommendations

The following recommendations are made for the Former Landfill groundwater monitoring program:

- Based on the lack of detections above background levels, the monitoring frequency of all non-radiological parameters will be reduced from semiannual to annual.
- Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium, and/or gamma spectroscopy will continue.

4.0 FACILITY MONITORING PROGRAM SUMMARY

During 2008, the Facility Monitoring Program at BNL monitored the groundwater quality at 10 active research and support facilities. New York State operating permits require groundwater monitoring at two support facilities (the Major Petroleum Facility and the Waste Management Facility); the remaining eight research and support facilities are monitored in accordance with DOE Order 450.1, *Environmental Protection Program*. This Order requires the Laboratory to establish environmental monitoring programs at facilities that can potentially impact environmental quality, and to demonstrate compliance with DOE requirements and the applicable federal, state, and local laws and regulations. BNL uses these data to determine whether current engineered and administrative controls effectively protect groundwater quality and whether additional corrective actions are needed.

During 2008, approximately 240 individual samples were collected from 125 groundwater monitoring wells. BNL also installed 29 temporary wells to supplement the network of permanent monitoring wells. Information on groundwater quality at each of the monitored research and support facilities is described below. **Table 1-6** summarizes the Facility Monitoring Program by project. Complete analytical results from groundwater samples collected in 2008 can be found in **Appendix D**.

4.1 Alternating Gradient Synchrotron (AGS) Complex

The structures that constitute the AGS Complex include the AGS Ring, Linear Accelerator (Linac), Building 912, AGS Booster Beam Stop, 914 Transfer Tunnel, g-2 experimental area, E-20 Catcher, former U-Line Beam Target, and the J-10 Beam Stop. Activated soil has been created near a number of these areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. A number of radionuclides can be produced by the interaction of secondary particles with the soil that surrounds these experimental areas. Once produced in the soils, some of these radionuclides can be leached from the soils by rainwater, and carried to the groundwater. Of the radionuclides formed in the soil, only tritium (half-life = 12.3 years) and sodium-22 (half-life = 2.6 years) are detected in groundwater. Of these two radionuclides, tritium is more easily leached from the activated soils by rainwater and does not bind to soil particles. When tritium enters the water table, it migrates at the same rate as groundwater flow (approximately 0.75 feet per day). Sodium-22 does not leach out of the soil as readily as tritium, and migrates at a slower rate in the aquifer. The drinking water standard (DWS) for tritium is 20,000 pCi/L, and for sodium-22 is 400 pCi/L.

To prevent rainwater from leaching these radionuclides from the soil, impermeable caps have been constructed over many of the soil activation areas. Specifications for evaluating potential impacts to groundwater quality and the need for impermeable caps over beam loss areas are defined in the Standards Based Management System (SBMS) subject area entitled *Accelerator Safety*. BNL uses 56 groundwater monitoring wells to evaluate the impact of current and historical operations at the AGS beam stop and target areas. The locations of permanent monitoring wells are shown on **Figure 4-1**. During 2008, all 56 AGS monitoring wells were used to evaluate groundwater quality within the AGS Complex. The wells are routinely monitored for tritium.

Following the 1999 installation of an improved monitoring well network at the AGS, BNL detected three tritium plumes that originated from activated soil shielding at the g-2 experimental area, the former U-Line beam stop, and the former E-20 Catcher. The subsequent installation of impermeable caps over these soil activation areas has resulted in a reduction of tritium levels to less than the 20,000 pCi/L DWS in the former U-Line beam stop and E-20 Catcher areas. As discussed below, tritium concentrations greater than 20,000 pCi/L continue to be detected downgradient of the g-2 (VQ-12 magnet) soil activation area (**Section 4.2**).

Historical surface spills and discharges of solvents to several cesspools and recharge basins near the AGS contaminated the groundwater with VOCs. VOC contaminated groundwater within the AGS complex is monitored under the CERCLA Monitoring Program's Operable Unit III Central Monitoring Program (**Section 3.2.12**).

4.1.1 AGS Building 912

Building 912 consists of five interconnected structures that have been used to house as many as four experimental beam lines (A, B, C, and D lines). A typical beam line consists of bending and focusing electromagnets, vacuum pipes, instrumentation, high-voltage electrostatic devices, beam targets, radiation shielding, cooling water systems, and experimental detectors. Although these beam lines stopped operations in 2002, plans are being developed to reconfigure the experiment area for new experiments.

Beam loss and the production of secondary particles at proton target areas result in the activation of adjacent equipment, the floor, and probably the soil beneath the floor. The highest levels of soil activation beneath Building 912 are expected at the former C-Line target cave. Stormwater infiltration around the building is controlled by paving and stormwater drainage systems that direct most of the water to recharge basins north of the AGS complex. Therefore, it is believed that the potentially activated soil underlying the beam targets and stops is adequately protected from surface water infiltration.

4.1.1.1 AGS Building 912 Groundwater Monitoring

Well Network

Seventeen shallow Upper Glacial aquifer wells are positioned upgradient and downgradient of Building 912 (**Figure 4-1**). Upgradient wells are positioned to monitor potential tritium contamination from sources such as the g-2 area and the former U-Line experimental area. The downgradient wells are positioned to monitor significant beam stop and target areas in Building 912. Six of the downgradient wells are also used to track a section of the g-2 tritium plume that has migrated underneath Building 912 (**Section 4.2**).

Sampling Frequency and Analysis

During 2008, the six Building 912 wells that are used to track the g-2 tritium plume were sampled two times, whereas the remaining wells were sampled annually. The groundwater samples were analyzed for tritium (**Table 1-6**).

4.1.1.2 AGS Building 912 Monitoring Well Results

Other than low-level tritium contamination that is traceable to the g-2 source area, groundwater monitoring data for 2008 indicate that tritium is not being released from activated soil beneath the experimental floor of Building 912. The g-2 tritium plume has been tracked from the VQ-12 magnet source, beneath a portion of Building 912, to the HFBR facility (**Figure 4-8**). Tritium from this plume was detected in five wells downgradient of Building 912, with a maximum concentration of 16,500 pCi/L found in a sample from well 065-122. As described in **Section 4.2**, remedial actions for the g-2 source area and tritium plume are described in the ROD signed in May 2007 (BNL 2007b).

4.1.1.3 AGS Building 912 Groundwater Monitoring Program Evaluation

As noted above, in areas not impacted by the g-2 tritium plume, only low levels of tritium were detected in the Building 912 area groundwater monitoring wells. These results indicate that the building and associated stormwater management operations are effectively preventing rainwater from infiltrating activated soil below the experimental hall.

4.1.1.4 AGS Building 912 Recommendations

The following is recommended for the AGS Building 912 groundwater monitoring program.

- For 2009, the Building 912 wells used to track the g-2 tritium plume will continue to be sampled semiannually, whereas the remainder of the Building 912 monitoring wells will continue to be sampled annually.

4.1.2 AGS Booster Beam Stop

The AGS Booster is a circular accelerator with a circumference of nearly 660 feet. It is connected to the northwest portion of the main AGS Ring and to the Linear Accelerator (Linac). The AGS Booster, which has been in operation since 1994, receives either a proton beam from the Linac or heavy ions from the Tandem Van de Graaff generator. The booster accelerates protons and heavy ions before injecting them into the main AGS ring. In order to dispose of the beam during studies, a beam stop system was originally constructed at the 10 to 11 o'clock portion of the booster. In 1999, the beam stop was repositioned to the south side (6 o'clock section) of the Booster ring to accommodate the construction of the NASA Space Radiation Laboratory (NSRL) tunnel in the original beam stop location.

Although internal shielding around the beam stop was designed to keep secondary particle interactions with the soil to very low levels, a landfill-type geomembrane cap was constructed over the original beam stop region to prevent stormwater infiltration into the activated soil. When the beam stop was repositioned to the 6 o'clock region of the Booster, a coated concrete cap was constructed over the new beam stop area to prevent stormwater infiltration.

4.1.2.1 AGS Booster Groundwater Monitoring

Well Network

Two shallow Upper Glacial aquifer monitoring wells (064-51 and 064-52) are used to monitor the Booster beam stop area (**Figure 4-1**).

Sampling Frequency and Analysis

The Booster area wells were sampled one time during 2008, and the samples were analyzed for tritium (**Table 1-6**).

4.1.2.2 AGS Booster Monitoring Well Results

Tritium has not been detected in the Booster area wells since 2002 (**Figure 4-2**).

4.1.2.3 AGS Booster Groundwater Monitoring Program Evaluation

The low levels of tritium detected during 2001 and 2002 near the Booster beam stop were related to a short-term uncovering of activated soil shielding near the former booster beam stop area during the construction of the tunnel leading from the Booster to the NSRL facility. This work, which began in September 1999 and was completed by October 1999, allowed rainwater to infiltrate the low-level tritium activated soil shielding.[1] Tritium has not been detected in the Booster area monitoring wells since 2003.

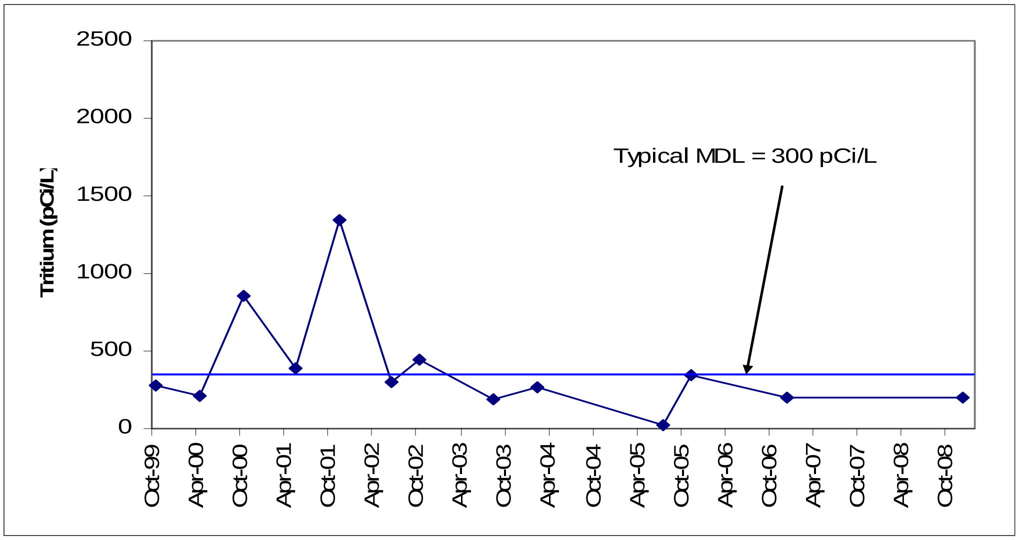
4.1.2.4 AGS Booster Recommendation

The following is recommended for the AGS Booster groundwater monitoring program:

- For 2009, the monitoring frequency for the Booster beam stop monitoring wells will continue to be annually.

[1] Before construction of the NSRL tunnel commenced, soil samples were collected by drilling through the tunnel wall near the booster beam stop to verify that the tritium and sodium-22 levels were within acceptable limits for worker safety and environmental protection.

Figure 4-2.
AGS Booster Beam Stop
Maximum Tritium Concentrations in Downgradient Wells 064-51 and 064-52



4.1.3 NASA Space Radiation Laboratory Facility (NSRL)

The NSRL is jointly managed by the U.S. Department of Energy's Office of Science and NASA's Johnson Space Center. The NSRL employs beams of heavy ions extracted from Brookhaven's Booster accelerator for radiobiology studies. NSRL became operational during summer 2003. Although the secondary particle interactions with the surrounding soil shielding are expected to result in only a minor level of soil activation, geomembrane caps were constructed over the entire length of the beam line and the beam stop region to prevent stormwater infiltration into potentially activated soil.

4.1.3.1 NSRL Groundwater Monitoring

Well Network

This facility is monitored by two shallow Upper Glacial aquifer monitoring wells (054-08 and 054-191) located immediately downgradient of the NSRL (**Figure 4-1**).

Sampling Frequency and Analysis

The NSRL area wells were monitored one time during 2008, and the samples were analyzed for tritium (**Table 1-6**).

4.1.3.2 NSRL Monitoring Well Results

Groundwater monitoring at the NSRL facility began in late 2002. Since that time, tritium has not been detected in any of the groundwater samples.

4.1.3.3 NSRL Groundwater Monitoring Program Evaluation

Based on monitoring conducted to date, NSRL beam line operations have not impacted groundwater quality.

4.1.3.4 NSRL Recommendation

The following is recommended for the NSRL groundwater monitoring program:

- For 2009, the monitoring frequency for the NSRL wells will continue to be annually.

4.1.4 AGS E-20 Beam Catcher

The E-20 beam catcher was used from 1984 to 1999, and was located at the 5 o'clock position of the AGS ring (**Figure 4-1**). The E-20 Catcher was a minimum aperture area of the AGS ring, and was used to pick up or "scrape" protons that move out of acceptable pathways. The E-20 Catcher picked up about 80 to 90 percent of all losses resulting from beam injection, transition, and ejection in the AGS Ring.

Like other beam loss areas in the AGS complex, the soil surrounding the E-20 Catcher became activated by the interaction with secondary particles. In late 1999 and early 2000, tritium and sodium-22 levels in groundwater were found to exceed the DWS, with concentrations of 40,400 pCi/L and 704 pCi/L, respectively. In April 2000, a temporary impermeable cap was installed over the E-20 Catcher soil activation area. A permanent cap was constructed by October 2000. Tritium and sodium-22 concentrations dropped to below their applicable DWS soon after the cap was installed.

4.1.4.1 AGS E-20 Catcher Groundwater Monitoring

Well Network

To verify the effectiveness of the impermeable cap over the E-20 Catcher, the area is monitored by three shallow Upper Glacial aquifer wells (064-55, 064-56, and 064-80). These wells are approximately 100 feet downgradient of the source area (**Figure 4-1**).

Sampling Frequency and Analysis

During 2008, the E-20 Catcher wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.4.2 AGS E-20 Catcher Monitoring Well Results

Following the installation of the cap in 2000, tritium and sodium-22 concentrations decreased to levels below applicable DWS (**Figure 4-3**). During 2008, the maximum observed tritium concentration was 430 pCi/L, detected in well 064-80.

4.1.4.3 AGS E-20 Catcher Groundwater Monitoring Program Evaluation

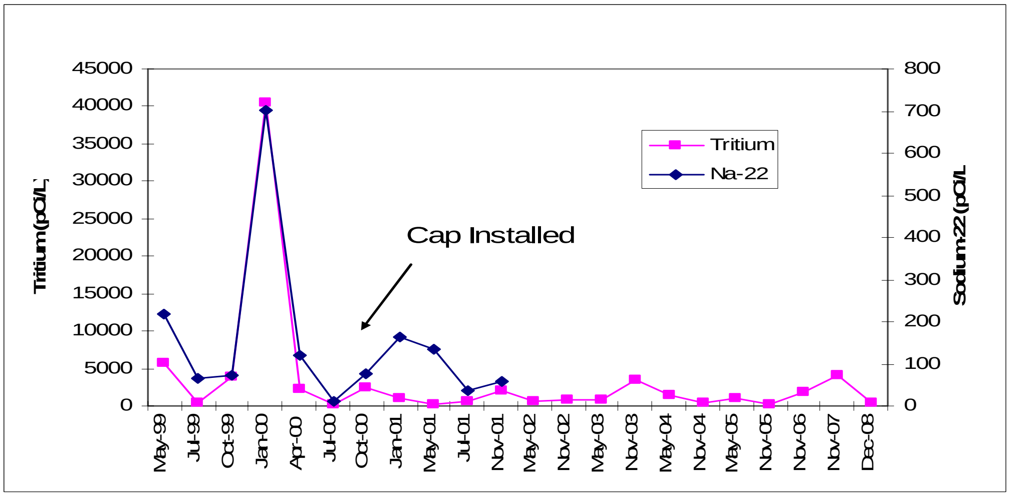
The reduction in tritium concentrations since the impermeable cap was constructed over the E-20 Catcher area in 2000 indicates that the cap has been effective in preventing rainwater infiltration into the activated soil that surrounds this portion of the AGS tunnel.

4.1.4.4 AGS E-20 Catcher Recommendation

The following is recommended for the AGS E-20 Catcher groundwater monitoring program:

- For 2009, the monitoring frequency for the E-20 Catcher wells will continue to be annually.

Figure 4-3.
AGS E-20 Catcher
Maximum Tritium and Sodium-22 Concentrations in Downgradient Temporary and Permanent Monitoring Wells.



4.1.5 AGS Building 914

Building 914 houses the transfer line between the AGS Ring and the Booster. Due to beam loss near the extraction (kicker) magnet, the extraction area of Building 914 is heavily shielded with iron. Because the extraction area is housed in a large building, most soil activation is expected to be below the floor of the building, where it is protected from rainwater infiltration.

4.1.5.1 AGS Building 914 Groundwater Monitoring

Well Network

Groundwater quality downgradient of the AGS Building 914 transfer line area is monitored by shallow Upper Glacial aquifer wells 064-03, 064-53, and 064-54 (**Figure 4-1**).

Sampling Frequency and Analysis

During 2008, the AGS Building 914 area wells were monitored one time and samples were analyzed for tritium (**Table 1-6**).

4.1.5.2 AGS Building 914 Monitoring Well Results

Low levels of tritium were detected intermittently in groundwater downgradient of the AGS Building 914 transfer tunnel during 2000 through 2005 (**Figure 4-4**). Although tritium was not detected in any of the groundwater samples during 2006 and 2007, in 2008 low-level tritium was once again detected in well 064-03 at a concentration of 620 pCi/L.

4.1.5.3 AGS Building 914 Groundwater Monitoring Program Evaluation

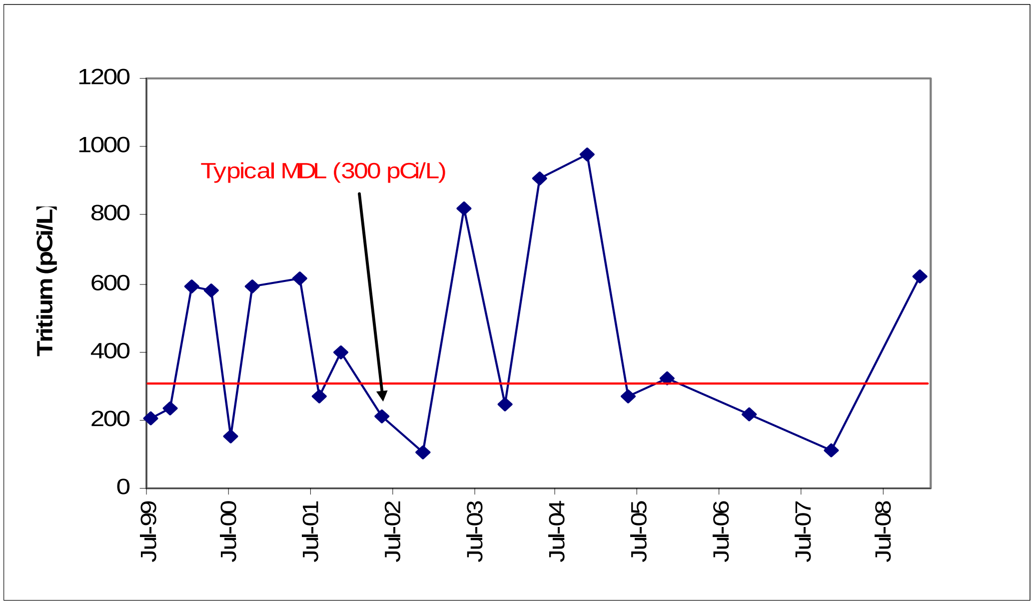
Groundwater monitoring downgradient of AGS Building 914 continues to indicate that the building structure and associated stormwater controls are effectively preventing significant rainwater infiltration into activated soil below the building. However, the periodic detection of trace levels of tritium since 2000 suggests that some rainwater may be infiltrating the activated soil. Continued monitoring is required.

4.1.5.4 AGS Building 914 Recommendation

The following is recommended for the AGS Building 914 groundwater monitoring program:

- For 2009, the monitoring frequency for the AGS Building 914 area wells will continue to be annually.

Figure 4-4.
AGS Building 914 Transfer Tunnel
Maximum Tritium Concentrations in Downgradient Wells 064-03, 064-53, and 064-54



4.1.6 AGS g-2 Beam Stop

The g-2 experiment operated from April 1997 until April 2001. The g-2 beam stop is composed of iron, and is covered by soil. Like other beam loss areas in the AGS complex, the g-2 beam stop was an area where the soil surrounding the stop would have become activated by the interaction with secondary particles. To prevent rainwater from infiltrating the soil surrounding the beam stop, BNL installed a gunite cap over the stop area before the start of beam line operations.

In November 1999, tritium and sodium-22 were detected in groundwater monitoring wells approximately 250 feet downgradient of the g-2 experimental area. A groundwater investigation conducted during November and December 1999 revealed a narrow plume of tritium with a maximum tritium concentration of 1,800,000 pCi/L. Sodium-22 was also detected, but at a concentration of only 60 pCi/L, or 15 percent of the 400 pCi/L DWS.

Following the discovery, an investigation into the source of the contamination revealed that the tritium originated from activated soil shielding adjacent to the g-2 experiment's VQ-12 Magnet. There was no evidence that any of the tritium originated from the beam stop area. The VQ-12 magnet section of the beam line was not a designed beam loss area, and the gunite cap installed over the nearby beam stop did not protect the VQ-12 area. In December 1999, an impermeable cap was installed over the VQ-12 soil activation area. This cap was joined to the existing beam stop cap. In September 2000, the activated soil shielding and associated tritium plume were designated as new sub-Area of Concern 16T. The selected remedial actions for the g-2 tritium source area and plume are documented in a ROD which was signed in May 2007 (BNL 2007b). The monitoring program for the VQ-12 source area and g-2 tritium plume are described in **Section 4.2**.

4.1.6.1 AGS g-2 Beam Stop Groundwater Monitoring

Well Network

Groundwater quality downgradient of the g-2 beam stop is monitored using wells 054-67, 054-68, 054-124, 054-125, and 054-126 (**Figure 4-1**). These wells are located immediately north, and cross gradient, of the VQ-12 source area monitoring wells described in **Section 4.2**..

Sampling Frequency and Analysis

During 2008, the g-2 beam stop wells were monitored annually, and the samples were analyzed for tritium (**Table 1-6**).

4.1.6.2 AGS g-2 Beam Stop Monitoring Well Results

During 2008, trace levels of tritium were detected in three of the four monitoring wells located downgradient of the g-2 beam stop: 290 pCi/L in well 054-125, 310 pCi/L in well 054-126, and 690 pCi/L in well 054-124.

4.1.6.3 AGS g-2 Beam Stop Groundwater Monitoring Program Evaluation

Monitoring of wells downgradient of the g-2 beam stop indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding.

4.1.6.4 AGS g-2 Beam Stop Recommendation

The following is recommended for the AGS g-2 Beam Stop groundwater monitoring program:

- During 2009, the g-2 beam stop area wells will continue to be monitored on an annual basis.

4.1.7 AGS J-10 Beam Stop

In 1998, BNL established a new beam stop at the J-10 (12 o'clock) section of the AGS Ring, replacing E-20 as the preferred repository for any beam that might be lost in the AGS Ring (**Figure 4-1**). The J-10 beam stop is subject to the same injection, transition, ejection, and studies losses that occurred at the former E-20 Catcher (**Section 4.1.4**). The J-10 stop area of the AGS Ring is covered by layers of soil-crete (a sand and concrete mixture), which reduce the ability of rainwater to infiltrate the potentially activated soil. BNL also constructed a gunite cap over a small section of the J-10 region that did not have a soil-crete cover before beam stop operations began.

4.1.7.1 AGS J-10 Beam Stop Groundwater Monitoring

Well Network

The monitoring well network for the J-10 beam stop consists of upgradient well 054-62 and downgradient wells 054-63 and 054-64 (**Figure 4-1**).

Sampling Frequency and Analysis

During 2008, the three J-10 beam stop wells were monitored one time and the samples were analyzed for tritium (**Table 1-6**).

4.1.7.2 AGS J-10 Beam Stop Monitoring Well Results

Since 2001, low levels of tritium have been routinely detected in groundwater downgradient of the J-10 beam stop (**Figure 4-5**). During 2008, these tritium concentrations were less than the MDA.

4.1.7.3 AGS J-10 Beam Stop Monitoring Program Evaluation

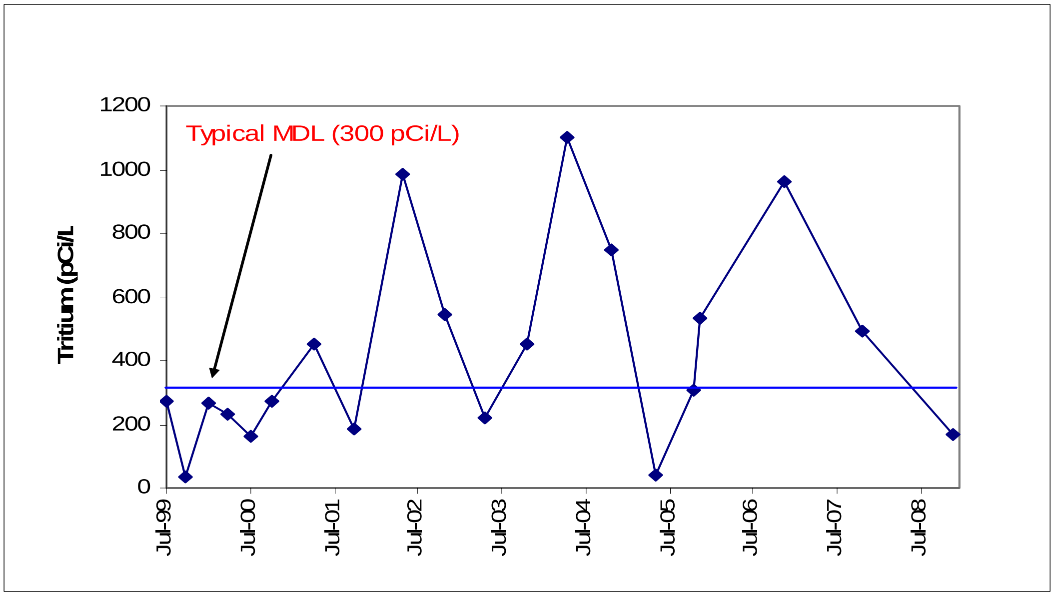
Groundwater monitoring data suggest that the engineered controls in place at J-10 are preventing significant rainwater infiltration into the activated soil shielding. However, the occasional detection of low levels of tritium (up to 1,000 pCi/L), suggests that some rainwater may be infiltrating the activated soil.

4.1.7.4 AGS J-10 Beam Stop Recommendation

The following is recommended for the AGS J-10 Beam Stop groundwater monitoring program:

- During 2009, the monitoring frequency for the J-10 Beam Stop area wells will continue to be annual.

Figure 4-5.
AGS J-10 Beam Stop
Maximum Tritium Concentrations in Downgradient Wells 054-63 and 054-64



4.1.8 Former AGS U-Line Beam Target and Stop Areas

The U-Line beam target area was in operation from 1974 through 1986. During its operation, a proton beam from the AGS would first strike a target and the resulting secondary particles would be selected by an arrangement of two magnetic "horns" and collimators immediately downstream of the target. The entire assembly was in a ground-level tunnel covered with an earthen berm. Internal shielding was stacked around the horns. Although the U-Line beam target has not been in operation since 1986, the associated tunnel, shielding, and overlying soil remain in place. The former U-Line beam target, horns, and beam stop are areas where the interaction of secondary particles with soil surrounding the tunnel resulted in production of tritium and sodium-22.

In late 1999, BNL installed monitoring wells downgradient of the target area to evaluate whether residual activated soil shielding was impacting groundwater quality. Subsequent monitoring found low levels of tritium and sodium-22, but at concentrations well below the applicable DWS. In early 2000, BNL installed four temporary wells downgradient of the former U-Line beam stop, which is approximately 200 feet north of the target area. Tritium was detected at concentrations up to 71,600 pCi/L. Sodium-22 was not detected in any of the samples. In May 2000, a temporary impermeable cap was installed over the U-Line beam stop soil activation area to prevent rainwater infiltration and the continued leaching of radionuclides out of the soil and into groundwater. By October 2000, a permanent geotextile cap was constructed over the U-Line beam stop area, and two additional permanent wells were installed to provide improved long-term monitoring of this source area.

4.1.8.1 Former AGS U-Line Groundwater Monitoring

Well Network

The former U-Line area is monitored by upgradient well 054-127 and downgradient wells 054-66, 054-128, 054-129, 054-130, 054-168, and 054-169. Three of the downgradient wells monitor the target area, and three wells monitor the beam stop area (**Figure 4-1**).

Sampling Frequency and Analysis

During 2008, the former U-Line area wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.8.2 Former AGS U-Line Groundwater Monitoring Well Results

U-Line Target Area

Low levels of tritium have been routinely detected in wells downgradient of the former U-Line beam target since monitoring began in 2000 (**Figure 4-6**). During 2008, the highest tritium concentration detected was 400 pCi/L in well 054-129, located approximately 200 feet downgradient of the target area.

U-Line Beam Stop Area

Since the cap was installed over the former U-line beam stop in 2000, tritium concentrations in downgradient wells have been well below the 20,000 pCi/L DWS (**Figure 4-7**). During 2008, only a trace level of tritium (670 pCi/L) was detected in one well downgradient of the U-Line target area.

4.1.8.3 Former AGS U-Line Groundwater Monitoring Program Evaluation

The significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soil.

4.1.8.4 Former AGS U-Line Recommendation

The following is recommended for the Former AGS U-Line groundwater monitoring program:

- For 2009, the U-line area wells will continue to be sampled for tritium on an annual basis.

Figure 4-6.
Former AGS U-Line Beam Target
Maximum Tritium Concentrations in Downgradient Well 054-129

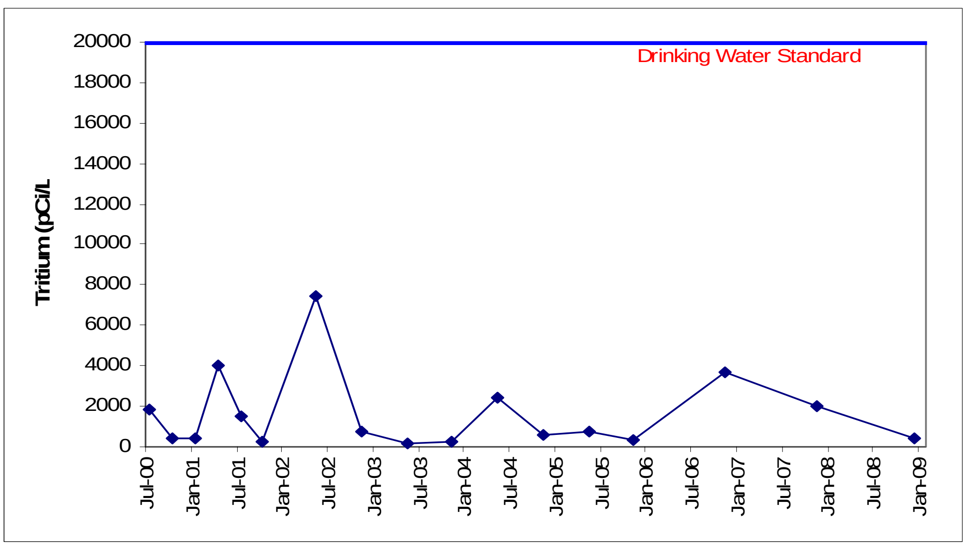
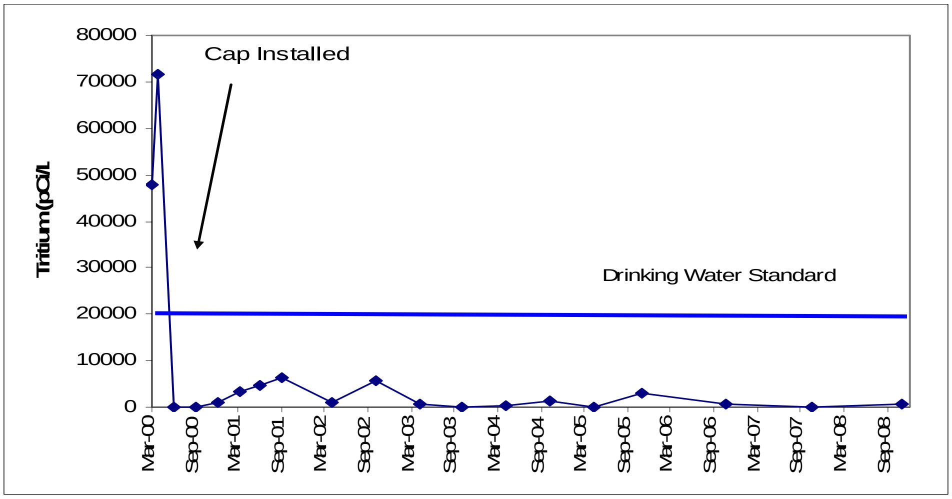


Figure 4-7.
Former AGS U-Line Beam Stop
Maximum Tritium Concentrations in Downgradient Temporary and Permanent Wells



4.2 g-2 Tritium Source Area and Groundwater Plume

In November 1999, tritium was detected in the groundwater near the g-2 experiment at concentrations above the 20,000 pCi/L DWS. Sodium-22 was also detected in the groundwater, but at concentrations well below the 400 pCi/L DWS. An investigation into the source of the contamination revealed that the tritium and sodium-22 originated from activated soil shielding located adjacent to the g-2 target building, where approximately 5 percent of the beam was inadvertently striking one of the beam line magnets (magnet VQ-12). Rainwater was able to infiltrate the activated soils and carry the tritium and sodium-22 into the groundwater. To prevent additional rainwater infiltration into the activated soil shielding, a concrete cap was constructed over the area in December 1999. Other corrective actions included refocusing the beam and improved beam loss monitoring to reduce additional soil activation, stormwater management improvements, and additional groundwater monitoring.

Following the concurrence from the NYSDEC, a ROD was signed by the DOE and EPA in early 2007 (BNL 2007b). This ROD requires continued routine inspection and maintenance of the impermeable cap, groundwater monitoring of the source area to verify the continued effectiveness of the stormwater controls, and monitoring the tritium plume until it attenuates to less than the 20,000 pCi/L DWS. Monitoring of the source area will continue for as long as the activated soils remain a threat to groundwater quality. Contingency actions have been developed if tritium levels exceeding 1,000,000 pCi/L are detected within the plume, or if the tritium plume does not attenuate as predicted by the groundwater model.

4.2.1 g-2 Tritium Source Area and Plume Groundwater Monitoring

Well Network

The g-2 tritium plume is currently monitored in two general areas: the source area (including the area to the east of Building 912), and the downgradient segments of the plume. Monitoring of the source area is accomplished using six wells immediately downgradient of the VQ-12 source and 12 wells east of Building 912. Monitoring of the downgradient sections of the tritium plume located in the vicinity of the HFBR is accomplished using a combination of permanent and temporary wells (**Figures 4-8 and 4-9**).

Sampling Frequency and Analysis

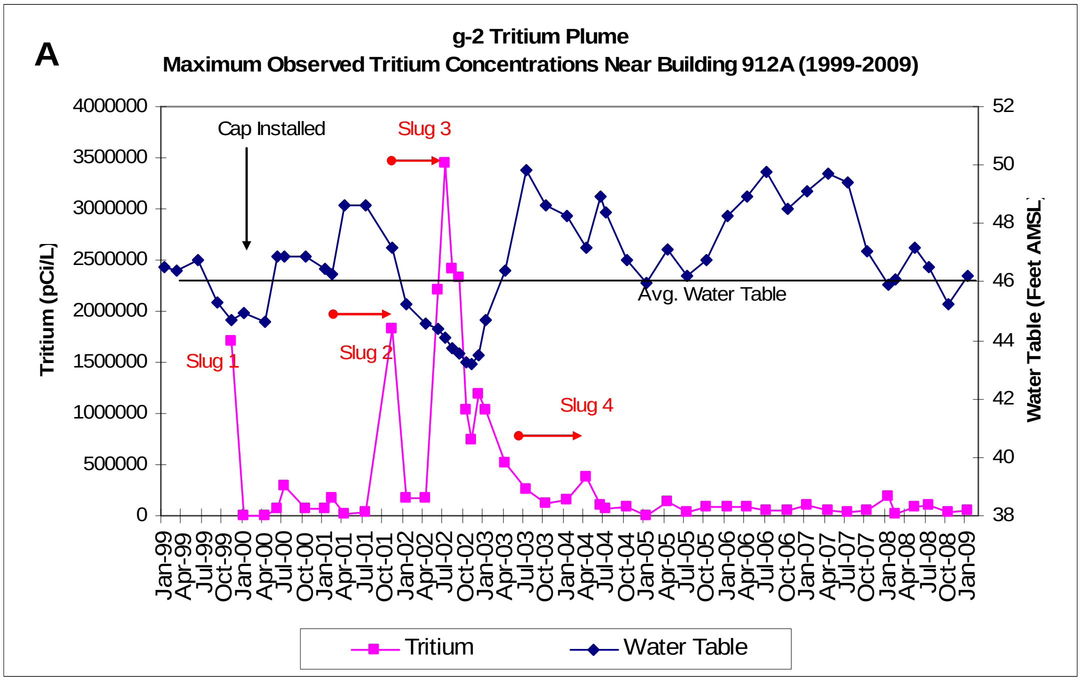
During 2008, the g-2 VQ-12 source area monitoring wells were monitored quarterly, and the samples were analyzed for tritium (**Table 1-6**). One set of quarterly samples was also analyzed for sodium-22. The wells located east of Building 912 were sampled two times during the year. From September 2008 to March 2009, 29 temporary wells were installed along five east-west transects to track the leading edge of the g-2 tritium plume (**Figure 4-8**). Sample results for the temporary wells are summarized on **Tables 4.2-1** through **4.2-5**.

4.2.2 g-2 Tritium Source Area and Plume Monitoring Well Results

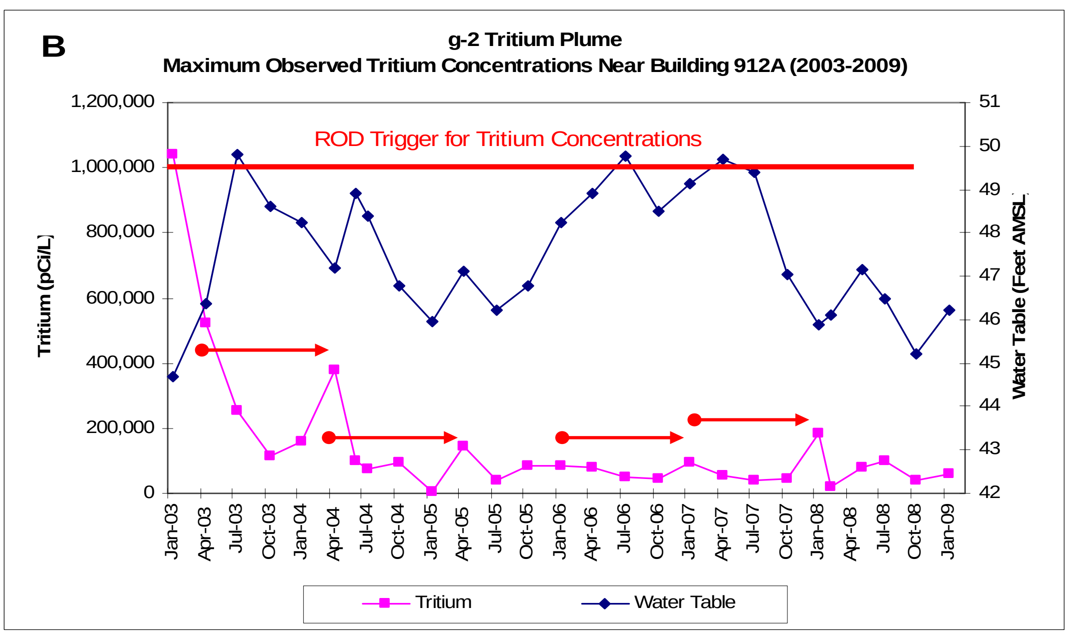
Source Area Monitoring Results

Monitoring data indicate that the high levels of tritium have entered the groundwater as a series of slug releases (**Figure 4-10**). Following the initial releases of tritium that occurred prior to cap installation in December 1999, subsequent periodic slug releases, characterized by short-term spikes in tritium concentrations, appear to be related to changes in the water-table elevation. As the water table rises, residual tritium is flushed from the vadose (unsaturated) zone close to the water table. Water levels in the central BNL area in mid-2000, mid-2001, and mid-2003 were near the highest observed in almost 50 years of record for the BNL site, to a level of approximately 49 feet above mean sea level. Approximately one year after each of these periods of high water-table elevations, elevated tritium concentrations were observed in the first set of source area monitoring wells (e.g., tritium concentrations increased to 1.8 million pCi/L in November 2001, and 3.4 million pCi/L in July 2002). Over time, the amount of tritium remaining in the vadose zone near the water table is expected to decrease by this flushing mechanism and by natural radioactive decay. Although the water table increased to nearly 49 feet above mean sea level during two periods since 2003, tritium levels in all but three sets of quarterly samples from source area monitoring wells have been less than 100,000 pCi/L. During this time period, tritium concentrations increased to a maximum 186,000 pCi/L in January 2008 (**Figure 4-10**). The overall reductions in tritium concentrations suggest that the amount of residual tritium that is available to be flushed out of the deep vadose zone is decreasing. Samples were analyzed for sodium-22 during the fourth-quarter 2008. The maximum sodium-22 concentration was 74 pCi/L detected in the sample from well 054-185. The DWS for sodium-22 is 400 pCi/L.

Figure 4-10. g-2 Tritium Source Area
Maximum Tritium Concentrations in Downgradient Wells
A: Maximum tritium concentrations observed from 1999 through January 2009 in groundwater downgradient of the VQ-12 source area. Red arrows represent approximately 1 year of travel time from the source area to the first set of downgradient monitoring wells.



B: Comparison of January 2003–January 2009 results to the ROD trigger level. Red arrows represent approximately 1 year of travel time from the source area to the first set of downgradient monitoring wells.



Downgradient Areas of the Plume

The extent of the g-2 tritium plume during the first quarter of 2009 is depicted on **Figure 4-8**. **Figure 4-9** provides a cross-sectional view of the plume. Monitoring of the downgradient areas of the plume is accomplished using a combination of permanent and temporary wells. Since June 2007, 39 temporary well locations have been established along five east–west transects (Transects A, B, C, D and E). Over this period, 18 temporary wells have been installed at the same locations twice to evaluate changes in tritium concentrations over time; with the most recent wells installed between September 2008 and April 2009 (**Tables 4.2-1** through **4.2-.5**). During the September 2008 through April 2009 sampling events, samples were also collected for Sr-90 to assist in defining the extent of the WCF Sr-90 Plume (**Section 3.2.15**). The downgradient segment of the tritium plume (as defined by concentrations >20,000 pCi/L) appears to be breaking up into discrete segments. Based upon the most recent sampling of the temporary wells, the downgradient portion of the g-2 plume extends from the Building 801 parking lot (Transect A) to Temple Place (Transect E). The highest tritium concentrations were observed along Transect D, located immediately south of the HFBR, where a maximum concentration of 80,700 pCi/L was detected in temporary well G2-GP-84. The southernmost extent of the tritium plume extends to the Temple Place area (Transect E), where a maximum tritium concentration of 33,300 pCi/L was detected in temporary well G2-GP-94. The observed tritium concentrations have been consistent with g-2 Engineering Evaluation/Cost Analysis (EE/CA) model predictions of decay and dispersion effects on the high concentration plume segments (i.e., slugs) with distance from the source area.

4.2.3 g-2 Tritium Source Area and Plume Groundwater Monitoring Program Evaluation

Although tritium continues to be detected in the groundwater downgradient of the g-2 (VQ-12) source area at concentrations that exceed the 20,000 pCi/L DWS, the reduction in tritium concentrations since 2003 indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding. As discussed previously, a comparison of tritium levels in the source area monitoring wells and water-table elevation data suggests that the periodic natural fluctuations in the water table have released residual tritium from the deep vadose zone (i.e., unsaturated soil immediately above the water table). It is believed that this tritium was mobilized to the soil close to the water table before the cap was constructed in December 1999. Once the cap was in place, the lack of additional rainwater infiltration kept the tritium in the vadose zone from migrating into the groundwater until the significant rise in water table mobilized it. There appears to be good correlation between high tritium concentrations detected in monitoring wells immediately downgradient of the source area, and the water-table elevation about one year before the sampling (**Figure 4-10**). Over time, the amount of tritium remaining in the vadose zone near the water table is expected to decrease by this flushing mechanism and by natural radioactive decay. To fulfill the monitoring requirements defined in the ROD, BNL will continue to monitor groundwater quality in the source area until the activated soils are no longer a threat to groundwater quality.

4.2.4 g-2 Tritium Source Area and Plume Recommendations

The following are recommended for the g-2 Tritium Source Area and Plume groundwater monitoring program:

- During 2009, the source area monitoring wells will continue to be sampled quarterly, and the downgradient sections of the tritium plume will continue to be monitored using a combination of permanent and temporary wells.
- During the summer/fall of 2009, additional temporary wells will be installed along Transect D and Transect E to track the leading edge of the g-2 plume.
- To fulfill the monitoring requirements defined in the ROD, BNL will continue to track the plume until the tritium concentrations drop below the 20,000 pCi/L DWS.

4.3 Brookhaven Linac Isotope Producer (BLIP)

When the Brookhaven Linac Isotope Producer (BLIP) is operating, the Linac delivers a beam of protons that strike a series of targets in the BLIP target vessel, positioned at the bottom of a 30-ft underground tank. The targets rest inside a water-filled, 18-inch- diameter shaft that runs the length of the tank, and are cooled by a 300-gallon, closed-loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and soil immediately outside the tank is activated by the production of secondary particles at the target.

As part of a 1985 redesign of the vessel, leak detection devices were installed and the open space between the water-filled shaft and the vessel's outer wall became a secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements, and is registered with the SCDHS. The BLIP facility also has a 500-gallon UST for storing liquid radioactive waste (change-out water from the BLIP primary system). The waste tank and its associated piping system conform to Article 12 requirements and are registered with SCDHS.

In 1998, BNL conducted an extensive evaluation of groundwater quality near the BLIP facility. Tritium concentrations of 52,000 pCi/L and sodium-22 up to 151 pCi/L were detected in the groundwater approximately 50 feet downgradient of the BLIP target vessel. Due to the activation of the soil shielding surrounding the BLIP target vessel and the detection of tritium and sodium-22 in groundwater, the BLIP facility was designated as sub-AOC 16K under the IAG.

In 1998, BNL made improvements to the stormwater management program at BLIP in an effort to prevent additional rainwater infiltration into the activated soil below the building. The BLIP building's roof drains were redirected away from the building, existing paved areas on the south side of the building were resealed, and a gunite cap was installed on the remaining three sides of the building. In May and June 2000, BNL undertook additional protective measures by injecting colloidal silica grout (also known as a Viscous Liquid Barrier) into the activated soil. The grout reduces the permeability of the soil, thus further reducing the ability of rainwater to leach tritium and sodium-22 from the activated soils should the stormwater controls fail.

In late 2004, BNL also constructed a new protective cap over the beam line that runs from the Linac to the BLIP facility. The new cap was installed because direct soil measurements and beam loss calculations indicated that the tritium and sodium-22 concentrations in soils surrounding these beam lines could result in stormwater leachate concentrations that exceed the "5 percent" criteria described in the *Accelerator Safety* SBMS (Standards Based Management System) subject area.[2]

Following concurrence from the NYSDEC, a ROD was signed by the DOE and EPA in early 2007 (BNL 2007b). This ROD requires continued routine inspection and maintenance of the impermeable cap, and groundwater monitoring to verify the continued effectiveness of the stormwater controls. Maintenance of the cap and groundwater monitoring will continue for as long as the activated soils remain a threat to groundwater quality.

4.3.1 BLIP Groundwater Monitoring

Well Network

The monitoring well network for the BLIP facility consists of two upgradient and five downgradient wells. These wells provide a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality (**Figure 4-1**).

[2] The BNL *Accelerator Safety* SBMS subject area requires stormwater controls where rainwater infiltration into activated soil shielding could result in leachate concentrations that exceed 5 percent of the drinking water standard (i.e., >1,000 pCi/L for tritium and 20 pCi/L for sodium-22).

Sampling Frequency and Analysis

During 2008, the three wells located immediately downgradient of BLIP were monitored quarterly (064-47, 064-48, and 064-67). The two upgradient wells and remaining two downgradient wells were sampled semiannually. All BLIP groundwater samples were analyzed for tritium, and one set of samples from the three immediately downgradient wells were analyzed for sodium-22 by gamma spectroscopy (**Table 1-6**).

4.3.2 BLIP Monitoring Well Results

Monitoring data collected from January 1999 to July 2000 indicated that the initial corrective actions taken during 1998 were highly effective in preventing the release of tritium and sodium-22 from the activated soil surrounding the BLIP target vessel. Prior to May 2000, tritium and sodium-22 concentrations in wells directly downgradient of BLIP were <3,000 pCi/L and <5 pCi/L, respectively. However, significant increases in tritium concentrations were observed in groundwater samples collected after the silica grout injection took place in late May and early June 2000 (**Figure 4-11**). It was determined that tritium in the soil pore water near the target vessel was displaced by the grout. Tritium concentrations in the groundwater immediately downgradient of BLIP increased to 56,500 pCi/L by October 2000. By December 2000, tritium concentrations dropped to below 20,000 pCi/L, and remained below this level throughout 2001 and 2002. From 2003 through 2006, there were several short-duration periods when tritium concentrations once again exceeded 20,000 pCi/L (**Figure 4-12**). Since January 2006, tritium levels have remained below the 20,000 pCi/L DWS. During 2008, the maximum tritium concentration was 5,630 pCi/L. Sodium-22 was not detected in the samples collected from downgradient wells 064-47, 064-48, and 064-67 during the third quarter 2008.

Figure 4-11.
BLIP Target Vessel
Maximum Tritium Concentrations in Wells 40 feet Downgradient

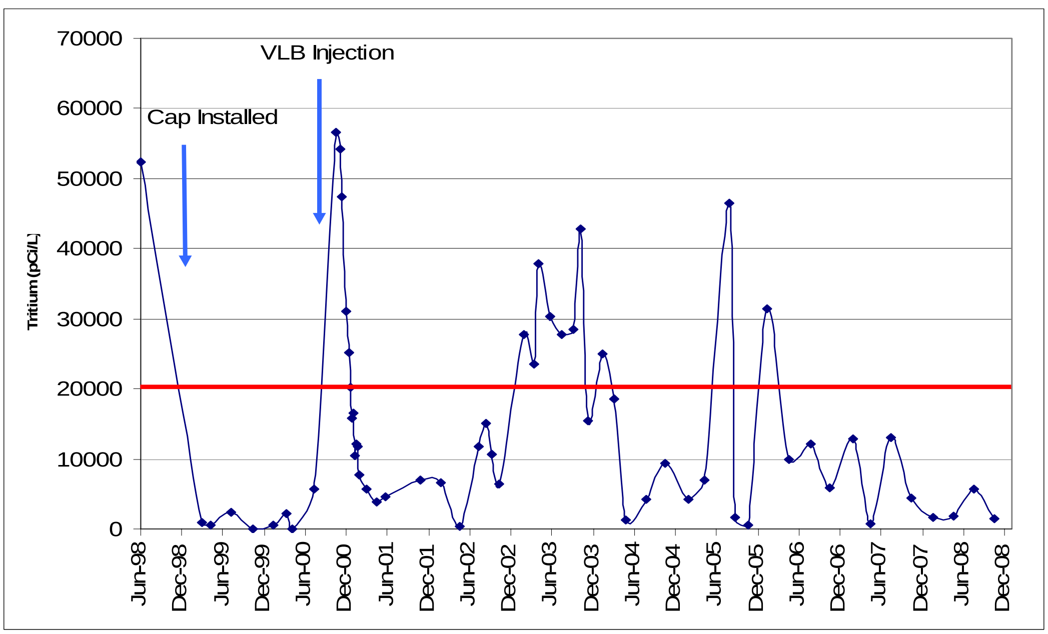
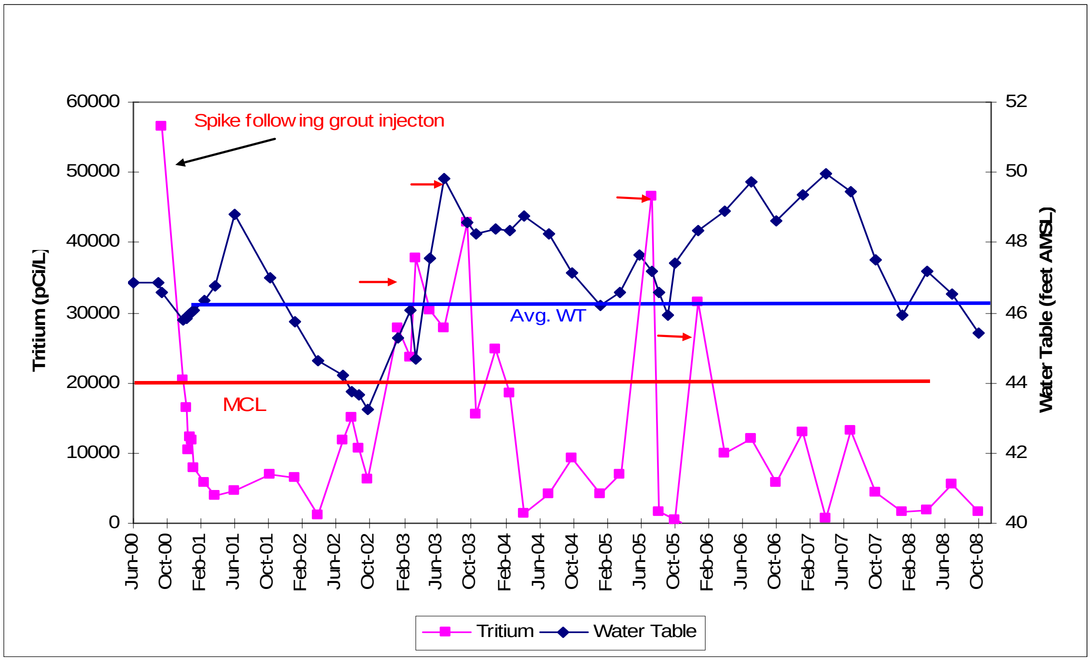


Figure 4-12.
BLIP Target Vessel
Tritium Concentrations vs. Water-Table Position, in Wells 40 Feet Downgradient,



Note 1: Arrows indicate approximate groundwater travel time from directly below the BLIP target to the first set of monitoring wells (e.g., well 064-67). Travel time is approximately 89 days, based on a distance of 40 feet and groundwater velocity of 0.45 ft/day.

4.3.3 BLIP Groundwater Monitoring Program Evaluation

The BLIP cap is in good condition, and is effectively controlling stormwater infiltration. Although direct inspection of the silica grout is not possible, it is expected to be in good condition and would be effective in preventing significant leaching of tritium from the activation zone should the primary stormwater controls fail. A comparison of tritium concentrations to changes in water-table position suggests that the periodic increases in tritium concentrations are probably associated with increases in water-table elevation (**Figure 4-12**). As the water table rises, older tritium that had leached from the soil before the cap was installed in 1998 or that was released during the grout injection project is flushed from the soil close to the water table. The amount of tritium remaining in the vadose zone close to the water table is expected to decline over time, due to this flushing mechanism and by natural radioactive decay. The short-term concentration increases observed in 2005 and 2006 also appear to be correlated to increases in the elevation of the water table.

4.3.4 BLIP Recommendation

As required by the ROD, BNL will continue to conduct routine inspections of the cap, and to monitor groundwater quality downgradient of the BLIP facility. The following is recommended for the BLIP groundwater monitoring program:

- Because tritium levels in groundwater have been continuously below the 20,000 pCi/L DWS since January 2006, BNL proposes reducing the monitoring frequency for the downgradient monitoring wells 064-47, 064-48, and 064-67 from quarterly to semiannually starting in 2009.
- Sampling frequency for the two upgradient and two downgradient wells will be changed from semiannual to annual.

4.4 Relativistic Heavy Ion Collider (RHIC)

Beam line interaction with the Relativistic Heavy Ion Collider (RHIC) collimators and beam stops produces secondary particles that interact with soil surrounding the 8 o'clock and 10 o'clock portions of the RHIC tunnel and the W-Line stop (**Figure 4-13**). These interactions result in the production of tritium and sodium-22, which can be leached out of the soil by rainwater. Although the level of soil activation was expected to be minor, before RHIC operations began in 2000 BNL installed impermeable caps over these beam loss areas to prevent potential impact to groundwater quality.

4.4.1 RHIC Groundwater Monitoring

Well Network

Thirteen shallow wells are used to verify that the engineered impermeable caps and operational controls implemented at the RHIC beam stops and collimators are effective in protecting groundwater quality. Six of the monitoring wells are located in the 10 o'clock beam stop area, six wells are in the collimator area, and one well is downgradient of the W-Line beam stop (**Figure 4-13**). As an extension to the groundwater monitoring program, surface water samples are also collected from the Peconic River, both upstream (location HY) and downstream (location HV) of the beam stop area, to verify that potentially contaminated groundwater is not being discharged into the Peconic River stream bed during high water-table conditions.

Sampling Frequency and Analysis

During 2008, groundwater samples were collected from the RHIC monitoring wells on a semiannual schedule, and the samples were analyzed for tritium (**Table 1-6**). Routine analysis for sodium-22 was dropped from the groundwater monitoring program in 2002 because tritium is the best indicator of possible cap failure (i.e., tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater). Surface water samples were collected quarterly and analyzed for tritium and sodium-22.

4.4.2 RHIC Monitoring Well Results

As in past years, no tritium was detected in the RHIC groundwater samples. No tritium or sodium-22 was detected in surface water samples from downstream location HV.

4.4.3 RHIC Groundwater Monitoring Program Evaluation

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps installed over the RHIC beam stop and collimator areas are effectively preventing rainwater infiltration into the activated soil shielding.

4.4.4 RHIC Recommendation

The following is recommended for the RHIC groundwater monitoring program:

- During 2009, groundwater samples will continue to be collected on a semiannual basis. Surface water samples will also continue to be collected as part of the monitoring program.

4.5 Brookhaven Medical Research Reactor (BMRR)

The Brookhaven Medical Research Reactor (BMRR) was a 3-megawatt light water reactor that was used for biomedical research. Research operations at the BMRR stopped in December 2000. All spent fuel was removed in 2003 and the primary cooling water system has been drained. BNL is preparing plans to permanently decommission the facility.

The BMRR primary cooling water system consisted of a recirculation piping system that contained 2,550 gallons of water. The cooling water contained approximately 5 Curies (Ci) of tritium. Unlike the HFBR, the BMRR does not have a spent fuel storage canal or pressurized imbedded piping systems that contained radioactive liquids. Historically, fuel elements that required storage were either stored within the reactor vessel, or they were transferred to the HFBR spent fuel canal. The BMRR primary cooling water system piping is fully exposed in the containment structure and is accessible for routine visual inspections. When the BMRR was operational, excess heat was transferred by means of heat exchangers with once-through (secondary) cooling water, which was obtained from nearby process supply wells or the BNL Chilled Water System. This secondary water was discharged to recharge basin HP, 800 feet south of the Medical Department complex, and was monitored as part of the SPDES program. All cooling water discharges from the BMRR stopped in December 2000.

In 1997, tritium was detected in wells installed directly downgradient (within 30 feet) of the BMRR. The maximum tritium concentration observed during 1997 was 11,800 pCi/L, almost one-half of the 20,000 pCi/L DWS. The highest observed tritium concentration since the start of groundwater monitoring was 17,100 pCi/L in October 1999. The tritium currently detected in groundwater 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. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (non-radioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any accidental future releases to the underlying soil.

4.5.1 BMRR Groundwater Monitoring

Well Network

The monitoring well network for the BMRR facility consists of one upgradient and three downgradient wells (**Figure 4-14**). Samples collected from the four groundwater monitoring wells are used to determine whether residual tritium in the soils below the BMRR is impacting groundwater quality.

Sampling Frequency and Analysis

Starting in 2007, the sampling frequency for the BMRR wells was changed from annual to once every two years. One set of samples was collected in 2008, and the samples were analyzed for tritium, gamma emitting radionuclides, gross alpha, and gross beta (**Table 1-6**).

4.5.2 BMRR Monitoring Well Results

Monitoring results for 2008 indicated that tritium concentrations continued to be well below the 20,000 pCi/L DWS. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 1,130 pCi/L detected in well 084-27 (**Figure 4-15**). As in past years, gamma, gross alpha, and gross beta analyses did not indicate the presence of any other reactor-related radionuclides.

4.5.3 BMRR Groundwater Monitoring Program Evaluation

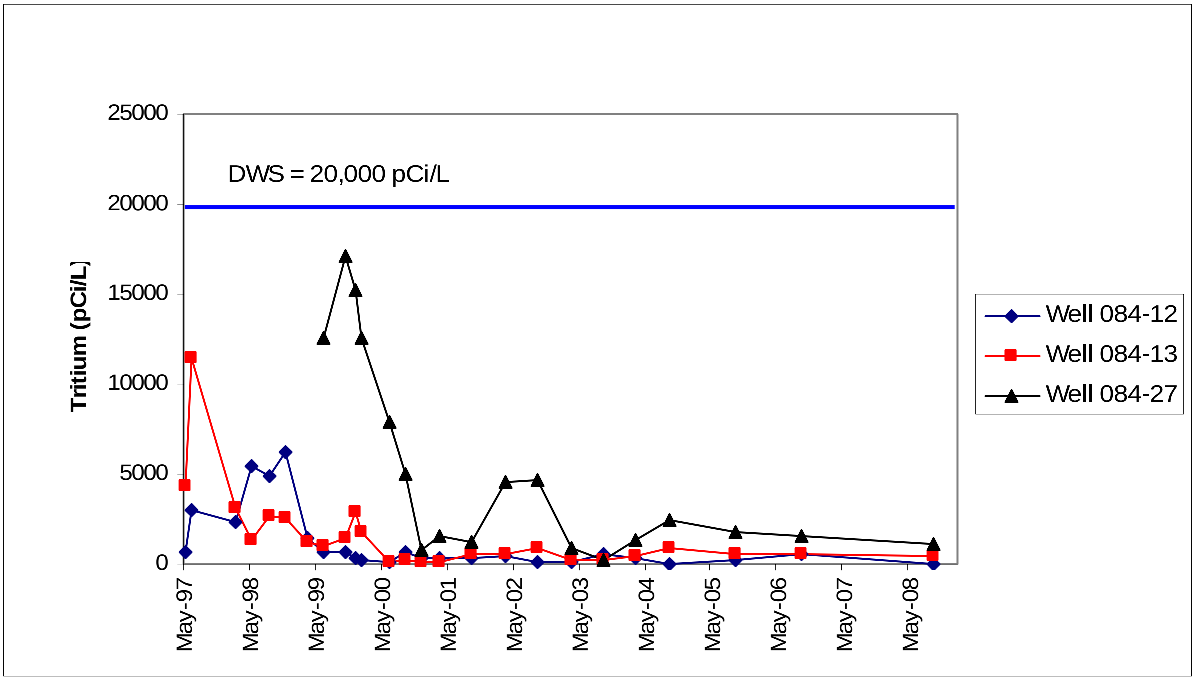
Tritium concentrations in groundwater from the BMRR well network have never exceeded the 20,000 pCi/L DWS, and have remained <5,000 pCi/L since September 2000. The BMRR structure is effectively preventing rainwater infiltration into the underlying soils, and therefore reducing the movement of any residual tritium from the soil to the groundwater.

4.5.4 BMRR Recommendation

The following is recommended for the BMRR groundwater monitoring program:

- The monitoring frequency for the BMRR wells will continue to be once every two years, with the next set of samples being collected in 2010.

Figure 4-15.
BMRR
Tritium Concentrations in Downgradient Wells



4.6 Sewage Treatment Plant (STP)

The STP processes sanitary wastewater from BNL research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit (NY-0005835). On average, 1.25 million gallons per day (MGD) are processed during the summer and 0.72 MGD are processed daily during the rest of the year. Before discharge into the Peconic River, the sanitary waste stream is fully treated by 1) primary clarification to remove settleable solids and floatable materials, 2) aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia, 3) secondary clarification, 4) sand filtration for final effluent polishing, and 5) ultraviolet disinfection for bacterial control. Oxygen levels are regulated during the treatment process to remove nitrogen biologically, using nitrate-bound oxygen for respiration.

Wastewater from the STP clarifier is released to the sand filter beds, where water percolates through 3 feet of sand before being recovered by an underlying clay tile drain system, which transports the water to the discharge point at the Peconic River (SPDES Outfall 001). Approximately 15 percent of the water released to the filter beds is either lost to evaporation or to direct groundwater recharge. At the present time, six sand filter beds are used in rotation.

Two emergency hold-up ponds are located east of the sand filter bed area. The hold-up ponds are used to store sanitary waste in the event of an upset condition or if the influent contains contaminants in concentrations exceeding BNL administrative limits and/or SPDES permit effluent release criteria. The hold-up ponds have a combined holding capacity of nearly 8 million gallons of water, and provide BNL with the ability to divert all sanitary system effluent for approximately one week. The hold-up ponds are equipped with fabric-reinforced plastic liners that are heat-welded along all seams. As part of the Phase III Sewage Treatment Plant Upgrades project in 2001, the liners were enhanced by the addition of new primary liners and a leak detection system. The older liners now serve as secondary containment.

4.6.1 STP Groundwater

Well Network

In addition to the comprehensive influent and effluent monitoring program at the STP, the groundwater monitoring program is designed to provide a secondary means of verifying that STP operations are not impacting environmental quality. Six wells are used to monitor groundwater quality in the filter bed area and three wells are monitored in the holding pond area (**Figure 4-16**).

Sampling Frequency and Analysis

During 2008, the six STP filter bed area wells were monitored semiannually and the three holding pond area wells were sampled annually. The samples were analyzed for VOCs, anions, metals, tritium, gross alpha, gross beta, and gamma emitting radionuclides (**Table 1-6**).

4.6.2 STP Monitoring Well Results

Radiological Analyses

During 2008, radioactivity levels in samples collected from most of the STP wells were generally typical of ambient (background) levels. As in previous years, the samples from filter bed area monitoring well 038-02 had higher than normal gross alpha and gross beta levels, with maximum concentrations of 24 pCi/L and 110 pCi/L, respectively. This well is screened in fine-grained material above a localized low permeability (silt and clay) deposit, and the elevated gross alpha and gross beta values are believed to be related to the naturally occurring radionuclides common to these deposits. Tritium was not detected in any of the STP area wells. No BNL-related gamma emitting radionuclides were detected in any of the STP groundwater monitoring wells.

Non-Radiological Analyses

During 2008, all water quality and most metals concentrations were below the applicable NYS AWQS or DWS. In filter bed area well 039-86, sodium was detected at a concentration of 27 milligrams per liter (mg/L), slightly above the 20 mg/L NYS AWQS. In four of six filter bed area wells, iron and aluminum exceeded applicable standards, with the highest levels of 7.4 mg/L and 5.8 mg/L, respectively, detected in well 038-02. The NYS AWQS for iron is 0.3 mg/L, and the DWS (secondary MCL for aesthetic quality) for aluminum is 0.2 mg/L. Low levels of nitrates continue to be detected in many of the STP filter bed area wells, with a maximum concentration of 5.2 mg/L detected in filter bed area monitoring well 039-08. The NYS AWQS for nitrate is 10 mg/L. No VOCs were detected above the NYS AWQS in any of the STP monitoring wells.

4.6.3 STP Groundwater Monitoring Program Evaluation

Monitoring results for 2008 indicate that STP operations are not having a significant impact on groundwater quality, and that the BNL administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system continues to be effective.

4.6.4 STP Recommendation

No changes to the monitoring frequency are proposed for 2009.

4.7 Motor Pool Maintenance Area

The Motor Pool (Building 423) and Site Maintenance facility (Building 326) are attached structures located along West Princeton Avenue (**Figure 4-17**). The Motor Pool area consists of a five-bay automotive repair shop, which includes office and storage spaces. The Site Maintenance facility provides office space, supply storage, locker room, and lunchroom facilities for custodial, grounds, and heavy equipment personnel. Both facilities have been used continuously since 1947.

Potential environmental concerns at the Motor Pool include 1) the historical use of USTs to store gasoline, diesel fuel, and waste oil, 2) hydraulic fluids used for lift stations, and 3) the use of solvents for parts cleaning. In August 1989, the gasoline and waste oil USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes two 8,000-gallon USTs used to store unleaded gasoline, one 260-gallon above ground storage tank used for waste oil, and one 3,000-gallon UST for No. 2 fuel oil. The Motor Pool facility has five vehicle-lift stations. The hydraulic fluid reservoirs for the lifts are located above ground.

Since 1996, several small-scale hydraulic oil and diesel oil spills have been remediated at the Motor Pool. The only known environmental concern associated with the Site Maintenance facility (Building 326) was the December 1996 discovery of an old oil spill directly south of the building. In an effort to investigate the potential impact that this spill had on groundwater quality, four wells were installed downgradient of the spill site. Although the solvent TCA was detected in the groundwater at concentrations above NYS AWQS, petroleum hydrocarbons were not detected.

4.7.1 Motor Pool Maintenance Area Groundwater Monitoring

Well Network

The Motor Pool facility's groundwater monitoring program for the UST area is designed to confirm that the engineered and institutional controls are effective in preventing contamination of the aquifer, and to evaluate continued impacts from historical spills. Two shallow Upper Glacial aquifer wells (102-05 and 102-06) are used to monitor for potential contaminant releases from the UST area (**Figure 4-17**).

Groundwater quality downgradient of Building 423 and Building 326 is monitored using four wells (102-10, 102-11, 102-12, and 102-13). The program is designed to periodically assess existing solvent contamination that resulted from historical vehicle maintenance operations, and to confirm that the current engineered and institutional controls are effective in preventing additional contamination of the aquifer.

Sampling Frequency and Analysis

During 2008, the UST area wells were monitored semiannually and the samples were analyzed for VOCs (**Table 1-6**). The wells were also checked for the presence of floating petroleum hydrocarbons during these sample periods. The Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs.

4.7.2 Motor Pool Monitoring Well Results

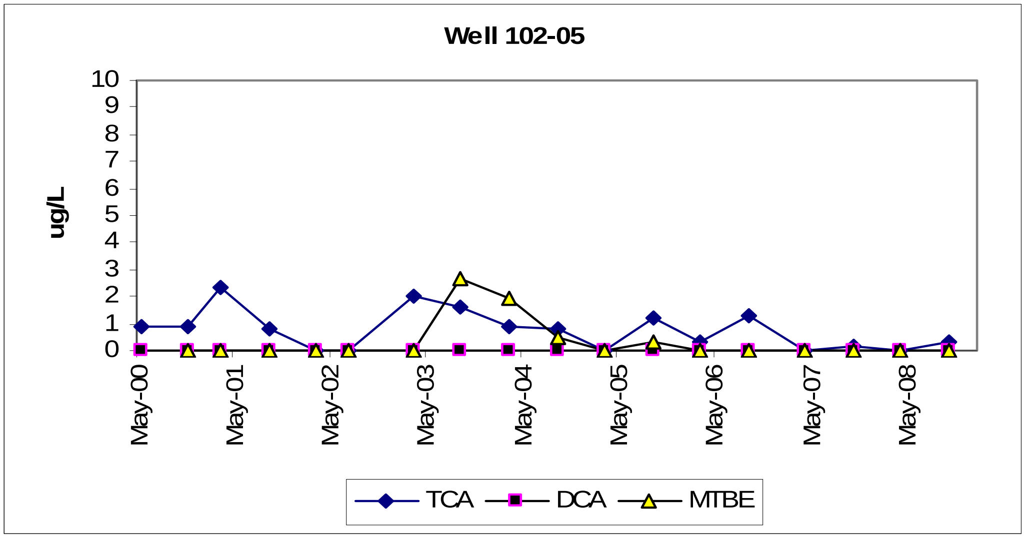
Underground Storage Tank Area

During 2008, no gasoline-related products were detected in groundwater downgradient of the gasoline UST area (**Figure 4-18**). Although the former gasoline additive MTBE concentrations had reached a maximum of nearly 34 µg/L (NYS AWQS is 10 µg/L) in 2003, MTBE has not been detected in any samples since 2006. As in past years, trace levels of the solvent TCA were also detected, but at concentrations that continued to be well below the NYS AWQS of 5 µg/L. Wells 102-05 and 102-06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating product was observed.

Building 423/326 Area

During 2008, the solvent TCA was detected in well 102-12 at a concentration of 6.7 µg/L, slightly above the 5 µg/L NYS AWQS (**Figure 4-19**). As in 2007, DCA levels remained less than the 5 µg/L standard. Although trace levels (< 0.3 µg/L) of the former gasoline additive MTBE continue to be occasionally detected in some of the Motor Pool wells, the MTBE levels have been less than the 10 µg/L NYS AWQS since 2005. It is believed that the TCA, DCA, and MTBE originated from historical vehicle maintenance operations.

Figure 4-18.
Motor Pool Gasoline UST Area
VOC Concentration Trends in Downgradient Wells



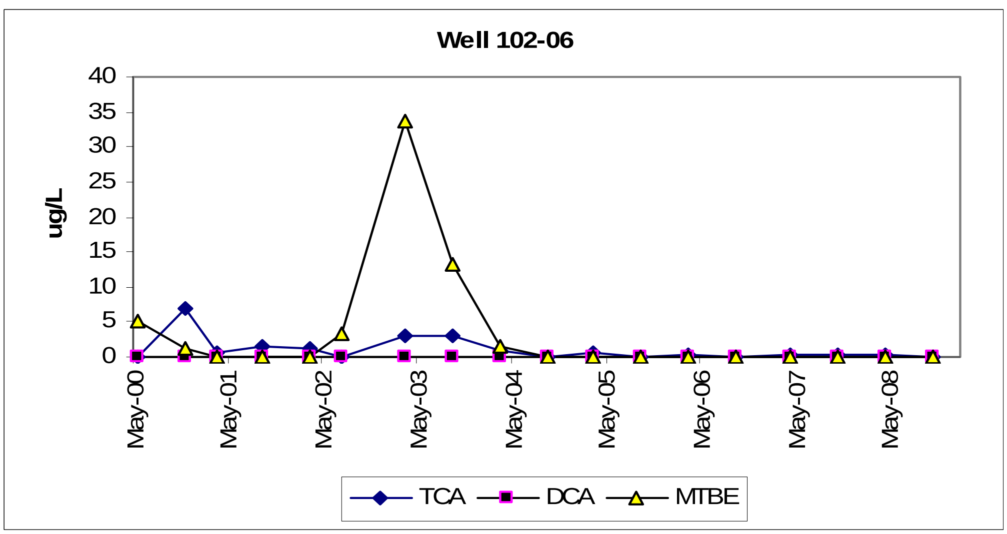
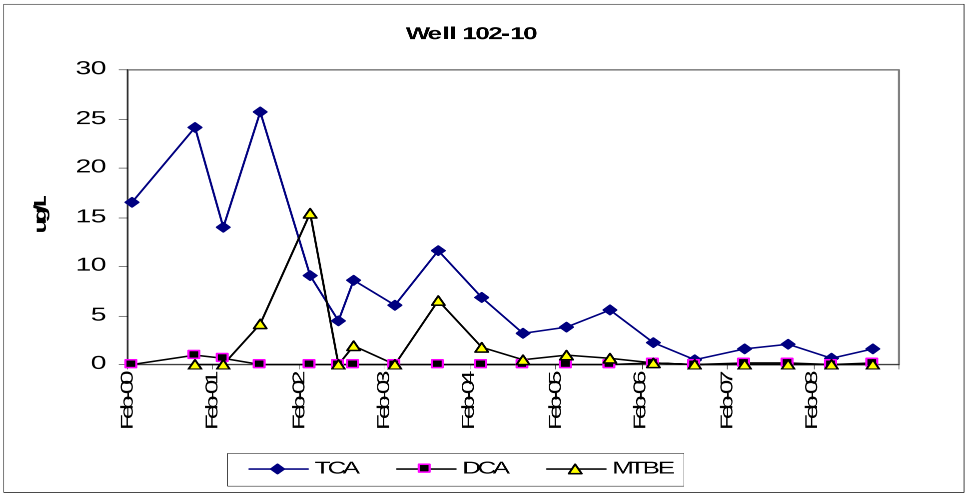
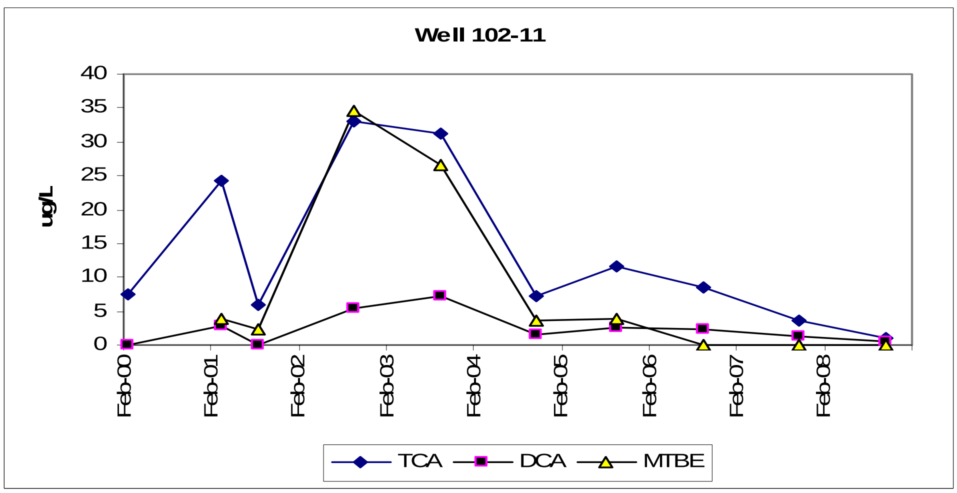
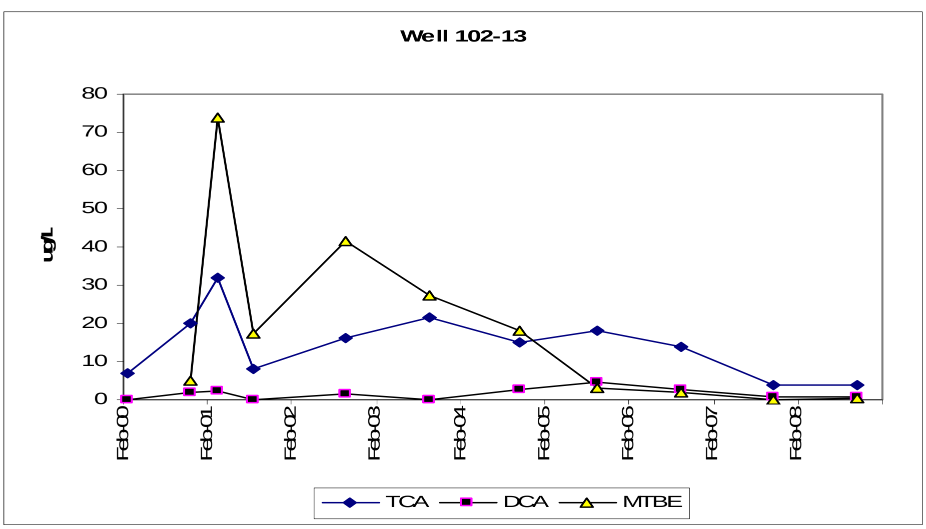


Figure 4-19.
Motor Pool Building 423/326 Area
VOC Concentration Trends in Downgradient Wells







4.7.3 Motor Pool Monitoring Program Evaluation

Although small-scale solvent and gasoline releases from vehicle maintenance operations have impacted groundwater quality in the Motor Pool area, there has been a steady decrease in VOC concentrations over the past several years. During 2008 there were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). The MTBE and TCA that is periodically detected in the groundwater near the UST area are likely to have originated from historical spills.

4.7.4 Motor Pool Recommendation

No changes to the monitoring program are proposed for 2009.

4.8 On-Site Service Station

Building 630 is a commercial automobile service station, privately operated under a contract with BNL. The station was built in 1966, and is used for automobile repair and gasoline sales.

Potential environmental concerns at the service station include the historical use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. When the service station was built in 1966, the UST inventory consisted of one 6,000-gallon and two 8,000-gallon tanks for storing gasoline, and one 500-gallon tank for used motor oil. In August 1989, the USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. During the removal of the old USTs, there were no obvious signs of soil contamination.

The current tank inventory includes three 8,000-gallon USTs for storing unleaded gasoline, and one 500-gallon UST used for waste oil. The facility has three hydraulic vehicle-lift stations.

Groundwater quality in the service station area has been impacted by historical small-scale spills of oils, gasoline, and solvents, and by carbon tetrachloride contamination associated with a nearby UST that was used as part of a science experiment conducted in the 1950s. In April 1998, BNL removed a UST from an area approximately 200 feet northwest (upgradient) of the service station. Although there are indications that the tank was releasing small quantities of carbon tetrachloride before its removal, a significant increase in carbon tetrachloride concentrations in groundwater indicated that additional amounts of this chemical were inadvertently released during the excavation and removal process. BNL started to remediate the carbon tetrachloride plume in October 1999 (**Section 3.2.1**).

4.8.1 Service Station Groundwater Monitoring

Well Network

The service station's groundwater monitoring program is designed to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer and to evaluate continued impacts from historical spills. Five wells are used to monitor for potential contaminant releases (**Figure 4-20**).

Sampling Frequency and Analysis

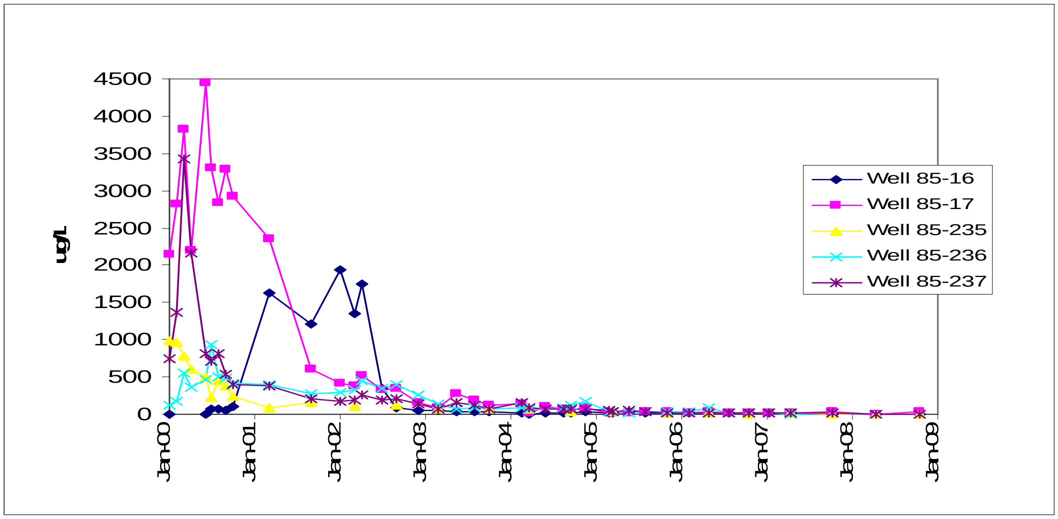
During 2008, the service station facility wells were monitored two times, primarily by the CERCLA program as part of the Carbon Tetrachloride plume monitoring project. The samples were analyzed for VOCs (**Tables 1-5** and **1-6**). Three of the wells near the gasoline USTs were also checked semiannually for the presence of floating petroleum hydrocarbons.

4.8.2 Service Station Monitoring Well Results

During 2008, carbon tetrachloride (and its breakdown product, chloroform) continued to be detected in the service station monitoring wells (**Figure 4-21**). The maximum carbon tetrachloride and chloroform concentrations were 36 µg/L and 5.9 µg/L, respectively. The levels of carbon tetrachloride currently detected in the groundwater are considerably less than those observed during 2000, when carbon tetrachloride concentrations approached 4,500 µg/L. The reduction in carbon tetrachloride levels reflects the effectiveness of the groundwater remediation system, which achieved its cleanup objectives and was shut down and placed in standby mode in August 2004 (**Section 3.2.1**).

Historically, groundwater quality at the Service Station has been affected by a variety of VOCs that appeared to be related to historical service station operations. During 2008, high levels of VOCs (with a TVOC concentration of 1,575 µg/L) continued to be detected in well 085-17. The contamination consisted primarily of xylenes (total) at 720 µg/L, ethylbenzene at 29 µg/L, 1,2,4-trimethylbenzene at 250 µg/L, 1,3,5-trimethylbenzene at 93 µg/L, and the solvent PCE at a concentration of 35 µg/L (**Figure 4-22**). For the past two years, VOC concentrations in wells 085-235, 085-236, and 085-237 have remained at low to trace levels (**Figures 4-23** and **4-24**). As in previous years, no floating product was detected in the wells. It is important to note that the petroleum-related compounds detected in the Motor Pool wells have not been detected in Carbon Tetrachloride project wells located downgradient of the facility. This is consistent with studies that have demonstrated that many petroleum-related compounds breakdown in aquifer systems within a short distance from a source area.

Figure 4-21.
Service Station
Carbon Tetrachloride Concentration Trends in Monitoring Wells.



4.8.3 Service Station Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the service station facility during 2008 indicates that VOCs continue to be detected at concentrations greater than the applicable NYS AWQS. There were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). It is believed that the petroleum hydrocarbon-related compounds and solvents that have been detected in groundwater originated from historical vehicle maintenance operations before improved chemical storage and handling controls were implemented in the 1980s.

Figure 4-22.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-17
Carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.

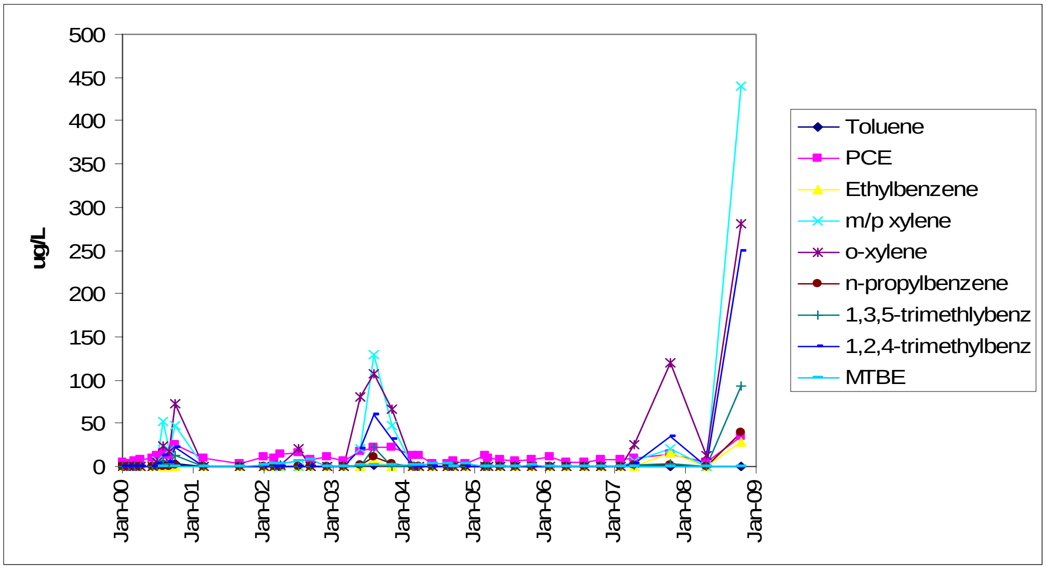
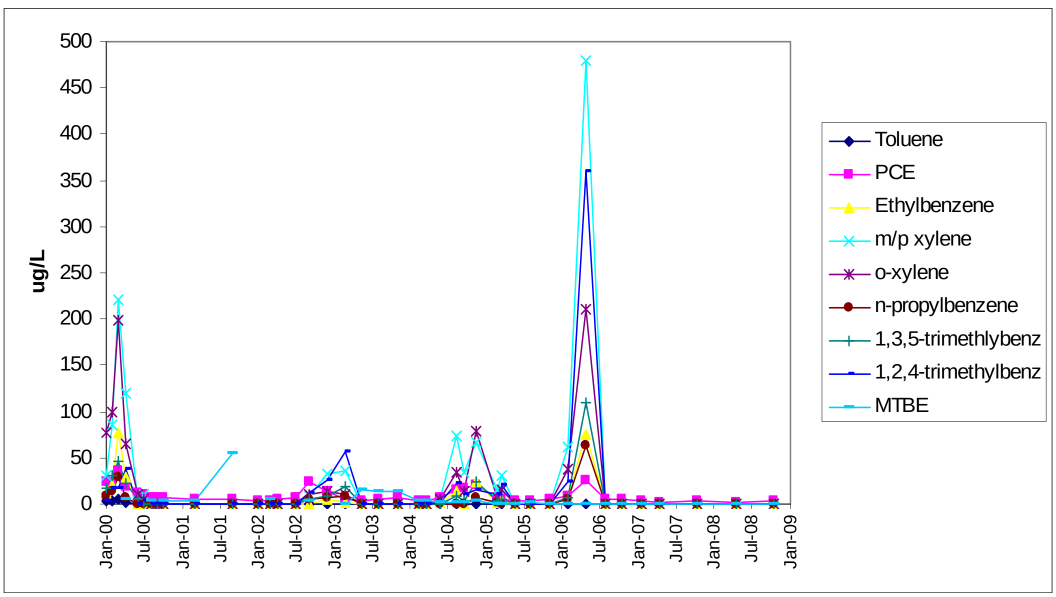


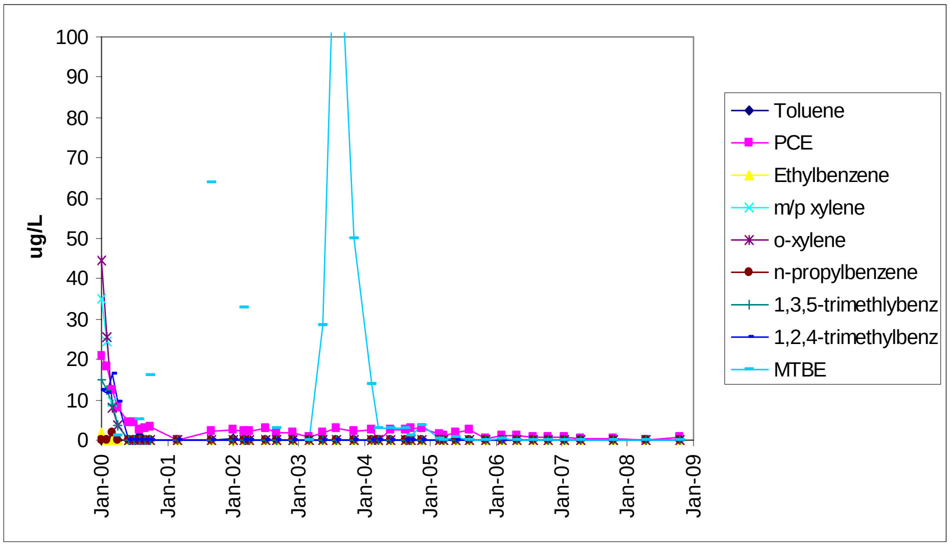
Figure 4-23.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-236
Carbon tetrachloride from the upgradient carbon tetrachloride UST source area is not included.



4.8.4 Service Station Recommendation

No changes to the monitoring program are proposed for 2009.

Figure 4-24.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-237
Carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.



4.9 Major Petroleum Facility (MPF) Area

The MPF is the holding area for fuel oil used at the Central Steam Facility (CSF). The fuel oil is held in a network of seven above ground storage tanks, which have a combined capacity of up to 1.7 million gallons of No. 6 fuel oil and 60,000 gallons of No. 2 fuel oil. The tanks are connected to the CSF by above ground pipelines that have secondary containment and leak detection devices. The fuel storage tanks are positioned in bermed containment areas that have a capacity to hold >110 percent of the volume of the largest tank located there. The bermed areas have bentonite clay liners consisting of either Environmat™ (bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soil to form an impervious soil/clay layer. As of December 1996, the fuel-unloading operations were consolidated to one centralized building that has secondary containment features. The MPF is operated under NYSDEC Permit #1-1700 and, as required by law, a Spill Prevention Control and Countermeasures (SPCC) Plan and a Facility Response Plan have been developed for the facility. Groundwater quality near the MPF has been impacted by several oil and solvent spills: 1) the 1977 fuel oil/solvent spill east of the MPF that was remediated under the IAG (**Section 3.3.1**); and 2) solvent spills near the CSF.

4.9.1 MPF Groundwater Monitoring

Well Network

Eight shallow Upper Glacial aquifer wells are used to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer (**Figure 4-25**).

Sampling Frequency and Analysis

Groundwater contaminants from the fuel oil products stored at the MPF can travel both as free product and in dissolved form with advective groundwater flow. Historically, the Special License Conditions for the MPF required semiannual sampling for SVOCs and monthly monitoring for floating petroleum. Samples were also periodically tested for VOCs as part of the Facility Monitoring Program. In 2002, NYSDEC expanded the required list of routine analyses to include VOCs, including testing for

MTBE (**Table 1-6**). MTBE was a common gasoline additive until January 2004, and it was occasionally introduced to fuel oil as a contaminant during the storage and transportation process.

4.9.2 MPF Monitoring Well Results

The MPF wells were sampled in April and October 2008. The wells were also tested monthly for the presence of floating petroleum. The samples were tested for SVOCs and VOCs. As in the past, no SVOCs were detected, and no floating product was observed. A number of VOCs not associated with fuel storage activities continued to be detected in the MPF area wells. Low levels of TCA (up to 0.6 μg/L), PCE (up to 3.2 μg/L), and chloroform (up to 0.9 μg/L) were detected in upgradient well 076-25. These compounds are related to historical spills near building 650. In the downgradient wells, the highest VOC concentrations continue to be detected in well 076-380, where PCE was detected at concentrations up to 66 μg/L, well above the NYS AWQS of 5 μg/L. Low levels of TCE (7.7 μg/L) and TCA (up to 3.5 μg/L) were also detected in this well. Levels of the PCE breakdown product trans-1,2-dichloroethylene dropped to non-detectable levels by the end of 2005, and was only detected at a trace level during 2008 (**Figure 4-26**). Elevated levels of VOCs were also detected in OU IV monitoring well 076-185, located approximately 300 feet downgradient of well 076-380, with PCE concentrations of 9 μg/L and PCE breakdown product cis-1,2-DCE at a concentration of 10 μg/L. These solvents are believed to have originated from documented historical spills near the CSF building; their presence in groundwater is not the result of recent CSF or MPF operations.

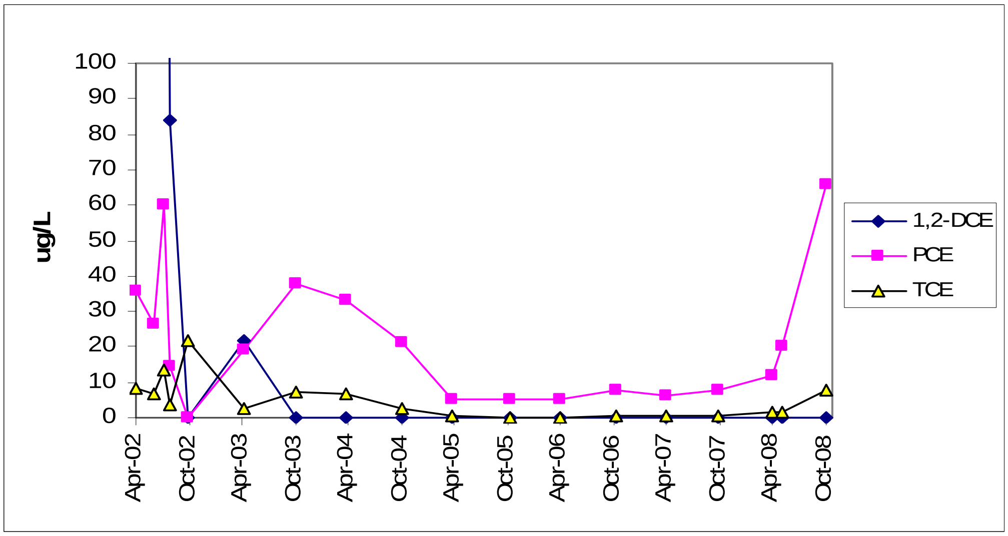
4.9.3 MPF Groundwater Monitoring Program Evaluation

Groundwater monitoring at the MPF continues to show that fuel storage and distribution operations are not impacting groundwater quality. The low levels of PCE and TCE detected in the groundwater in 2008 originated from historical solvent spills near Building 610. The historical nature of this contamination is supported by: 1) degreasing agents such as PCE have not been used at the CSF in many years, 2) PCE has been detected in several MPF area wells since the early 1990s, and 3) breakdown products of PCE have been detected. A number of historical spill sites near the CSF were identified in the late 1990s, and the contaminated soil was excavated in accordance with regulatory requirements.

4.9.4 MPF Recommendation

For 2009, monitoring will continue as required by the NYS operating permit.

Figure 4-26.
Major Petroleum Facility
VOC Concentrations in Downgradient Well 076-380.



4.10 Waste Management Facility (WMF)

The WMF is designed to safely handle, repackage, and temporarily store BNL-derived wastes prior to shipment to off-site disposal or treatment facilities. The WMF is a state-of-the-art facility, with administrative and engineered controls that meet all applicable federal, state, and local environmental protection requirements. The WMF consists of four buildings: the Operations Building, Reclamation Building (for radioactive waste), RCRA Waste Building, and the Mixed Waste Building.

Groundwater monitoring is a requirement of the RCRA Part B permit issued for WMF operations. The groundwater monitoring program for the WMF is designed to supplement the engineered and institutional controls by providing additional means of detecting potential contaminant releases from the facility. Because of the close proximity of the WMF to BNL potable supply wells 11 and 12, it is imperative that the engineered and institutional controls implemented at the WMF are effective in ensuring that waste handling operations do not degrade the quality of the soil and groundwater in this area.

4.10.1 WMF Groundwater Monitoring

Well Network

Groundwater quality at the WMF is currently monitored using seven shallow Upper Glacial aquifer wells. Five new downgradient monitoring wells were installed in late 2007 and incorporated into the monitoring program in February 2008. The new wells were positioned downgradient of the buildings based on the current southeast groundwater flow direction. Two wells (055-03 and 055-10) are used to monitor background water quality, and the five newly installed wells monitor groundwater quality downgradient of the three main waste handling and storage facilities. Wells 066-220 and 066-221 are located downgradient of the RCRA Building, wells 066-222 and 066-223 are located downgradient of the Reclamation Building, and well 066-224 is located downgradient of the Mixed Waste Building. The rest of the older wells are being maintained for the collection of water-level data, and the possible future collection of groundwater samples. Locations of the monitoring wells are shown on **Figure 4-27**.

Sampling Frequency and Analysis

During 2008, the WMF wells were sampled in February and August. Groundwater samples were analyzed twice for VOCs, tritium, gamma spectroscopy, gross alpha, and gross beta, and one time for metals and anions (e.g., chlorides, sulfates, and nitrates) (**Table 1-6**). A complete set of monitoring data and groundwater flow maps were provided to the NYSDEC in the *2008 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2009d).

4.10.2 WMF Monitoring Well Results

Radiological Analyses

Gross alpha and beta levels in samples from both upgradient and downgradient monitoring wells were consistent with background concentrations, and no BNL-related, gamma-emitting radionuclides were identified. Tritium was not detected in any of the WMF wells during 2008.

Non-radiological Analyses

The anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable NYS AWQS. Sodium was detected at a concentration of 44 mg/L in downgradient well 066-220, above the 20 mg/L NYS AWQS. The elevated sodium concentrations detected in both upgradient and downgradient wells since 1999 are likely due to nearby road salting operations. No VOCs were detected at concentrations above NYS AWQS during 2008. However, as in past years, trace levels of chloroform were detected in some of the upgradient and downgradient monitoring wells, with a maximum concentration of 0.57 μg/L detected in upgradient well 055-03. Trace levels of methyl chloride were also reported for some of the upgradient and downgradient wells, at concentrations up to 0.14 μg/L. This compound is infrequently detected in WMF area monitoring wells.

4.10.3 WMF Groundwater Monitoring Program Evaluation

Groundwater monitoring results for 2008 were consistent with previous years' monitoring, and continued to show that WMF operations are not affecting groundwater quality. There were no outdoor or indoor spills at the facility that could have impacted soil or groundwater quality. Except for elevated levels of sodium, the concentrations of chemicals and radionuclides analyzed were below NYS AWQS. Although there continue to be periodic detections of trace levels of tritium in the groundwater, a thorough review of waste management operations suggests that the tritium was not released from the WMF.

4.10.4 WMF Recommendation

For 2009, monitoring will continue as required by the RCRA Part B Permit.

4.11 Building 801

In early December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the floodwater indicated that the water contained Cs-137 (up to 784 pCi/L), Sr-90 (594 pCi/L), and tritium (25,000 pCi/L). It is believed that the floodwater became contaminated when it came into contact with the basement floor, which contains significant residual contamination from historical radiological spills. When the floodwater was pumped from the basement on March 8, 2002, approximately 4,950 gallons of contaminated water were removed. Taking into account possible losses due to evaporation, estimates were that between 1,350 and 2,750 gallons of contaminated floodwater might have seeped into the soil below Building 801. To evaluate the potential impact of such a release to groundwater quality, BNL installed a new monitoring well immediately downgradient of the building and monitored several nearby wells.

4.11.1 Building 801 Groundwater Monitoring

Well Network

Four downgradient wells are used to evaluate potential impacts to groundwater from the 2001 floodwater event. Well 065-169 is approximately 10 feet south of Building 801, whereas wells 065-37 and 065-170 are approximately 80 feet downgradient of the building (**Figure 3.2.15-1**). These wells were installed in 1999 to monitor historical releases from the Waste Concentration Facility and the former Pile Fan Sump area. Well 065-37 is screened close to the water table, whereas wells 065-169 and 065-170 are screened approximately 10 feet below the water table. In order to monitor groundwater quality at the water table directly downgradient of Building 801, well 065-325 was installed in October 2002.

Sampling Frequency and Analysis

During 2008, Building 801 monitoring well 065-325 was sampled two times under the Facility Monitoring Program (**Table 1-6**). The samples were analyzed for gross alpha, gross beta, Sr-90, Cs-137, and tritium. Monitoring wells 065-37, 065-169, and 065-170 were sampled one to two times under the CERCLA program, and the samples were analyzed for Sr-90 and Cs-137 (**Table 1-5**).

4.11.2 Building 801 Monitoring Well Results

The April and October 2008 samples from well 065-325 had Sr-90 concentrations of 42 pCi/L and 34 pCi/L, respectively (**Figure 4-28**). As in previous years, tritium and Cs-137 were not detected in this well. Sr-90 concentrations in well 065-37 decreased from a high of 73.3 pCi/L in October 2007 to a maximum of 47 pCi/L in 2008. Tritium was detected in well 065-37 at a concentration of 5,700 pCi/L, which is well below the 20,000 pCi/L standard. Tritium has not been detected in this well since 1997. As in previous years, only low levels of Sr-90 were detected in deeper wells 065-169 and 065-170, with maximum concentrations of 0.8 pCi/L and 1.1 pCi/L, respectively. Cs-137 was not detected in any of the wells.

4.11.3 Building 801 Groundwater Monitoring Program Evaluation

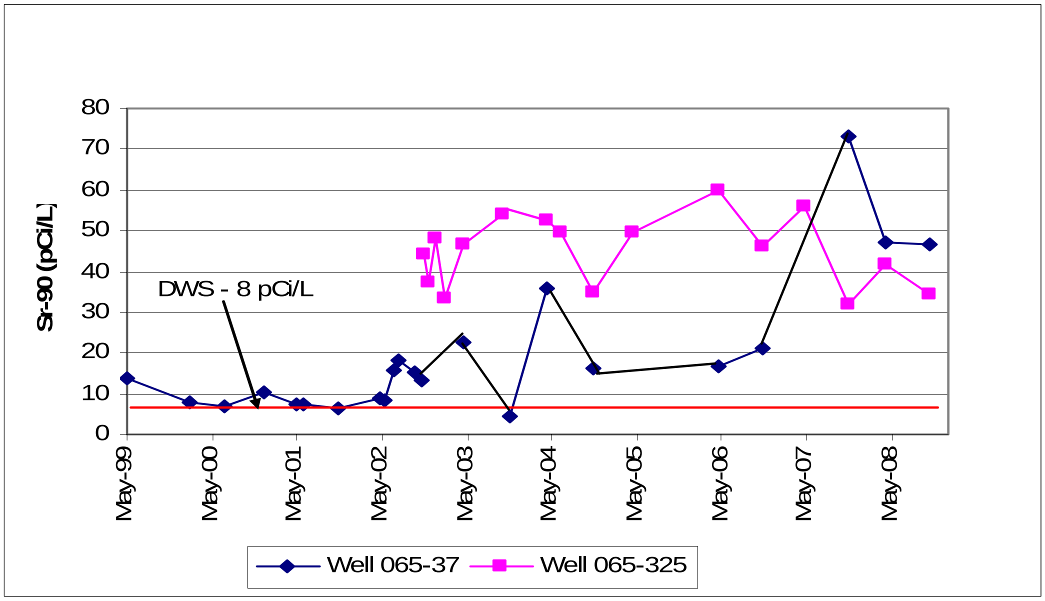
During 2008, Sr-90 concentrations in samples collected from shallow groundwater well 065-325 are consistent with pre-December 2001 values. Additionally, Cs-137 has not been detected in any of the groundwater samples since the floodwater event. It is estimated that from the December 2001 Building 801 floodwater release, it could take approximately 3 to 8 years for Sr-90 and approximately 100 years for Cs-137 to migrate to the closest downgradient well (065-325). Furthermore, detecting any new groundwater impacts from this release will be difficult to identify, as the local groundwater is already contaminated with radioactivity from legacy releases from Building 801 or the nearby former Pile Fan Sump (**Section 3.2.15**). Because tritium was not detected in shallower well 065-325, it is unclear whether the low levels of tritium detected in well 065-37 are indicative of water released during the 2001 basement flooding event.

4.11.4 Building 801 Recommendations

The following is recommended for the Building 801 groundwater monitoring program:

- For 2009, the monitoring frequency for well 065-325 will continue to be semiannual, and one sample round will be conducted as close as possible to the planned annual sampling of wells 065-37, 065-169, and 065-170 under the CERCLA program.

Figure 4-28.
Building 801
Sr-90 Concentration Trends in Downgradient Wells 065-37 and 065-325.



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5.0 SUMMARY OF RECOMMENDATIONS

This section is provided as a quick reference to all of the recommendations included in **Sections 3** and **4**. The recommendations are sequenced as they appear in **Sections 3** and **4**. **Table 5-1** summarizes the changes to the monitoring well sampling programs.

5.1 OU I South Boundary Pump and Treat System

The following are recommendations for the OU I South Boundary Pump and Treat System and groundwater monitoring program:

- Based on an elevated TVOC concentration in upgradient plume core well 107-40, the leading edge of the high concentration segment of the VOC plume is approaching the south boundary. As a result, full-time operation of extraction wells EW-1 and EW-2 will continue until further notice.
- Install up to nine shallow temporary wells using the Geoprobe® to characterize the current extent of the elevated area of Sr-90 contamination. These temporary wells will be installed in east-west transects beginning just south of monitoring well 107-35 and continuing to the north. Following review of the temporary well data, one or two monitoring wells may be installed.
- Add analysis of Sr-90 to system effluent sampling.
- Reduce and/or eliminate sample analyses for monitoring wells 098-33, 098-58, 098-59, 098-61, 107-10, 107-23, 107-24, 107-25, 107-26, 108-08, 108-12, 108-13, 108-14, 108-17, 108-18, 115-03, 115-30, 115-36 as described on **Table 5-1**. The frequencies have been reduced in these wells based on the lack of detections for given parameters over the past several years.
- The routine operation and maintenance monitoring frequency implemented in the fourth quarter of 2004 should be continued unless otherwise noted. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency. Maintain a quarterly sampling frequency for well 107-40 to monitor the hot spot.

5.2 Carbon Tetrachloride Pump and Treat System

The following are recommendations for the OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- Submit the Petition for Closure to the Regulators.
- Maintain the system in standby mode until the Petition for Closure is reviewed and approved.

5.3 Building 96 Air Stripping System

The following are recommendations for the OU III Building 96 groundwater remediation system and monitoring program:

- Maintain operation of treatment well RTW-1 and downgradient recirculation wells RTW-2, RTW-3, and RTW-4. Continue operation until TVOC concentrations <50 μg/L are seen in the influent and adjacent monitoring wells. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Maintain integrity of the plastic liner covering the PCE-contaminated soils. Following regulator approval of the OU III ESD, excavate the PCE-contaminated soils from the vadose zone source area. This also involves the removal of monitoring well 085-353 located in the center of the proposed excavation area. Following excavation, three additional monitoring wells will be installed to monitor the effectiveness of the excavation, including a replacement for well 085-353.

- Once hexavalent chromium concentrations drop below allowable discharge levels and all monitoring wells in the vicinity of the pumping well are below these levels, treatment for chromium will be eliminated.
- Due to low historical TVOC detections, the sampling frequency for the following monitoring wells will be reduced as follows:
  - Wells 085-97, 095-171, and 095-296 will change from quarterly to annual.
  - Wells 095-294, 095-295, 095-307, and 095-308 will change from quarterly to semiannual.
  - The remaining monitoring wells will remain at the quarterly sampling frequency.
- Continue to analyze for total chromium and hexavalent chromium in the monitoring wells.

5.4 Middle Road Pump and Treat System

The following recommendations are made for the OU III Middle Road Pump and Treat System and groundwater monitoring program:

- Maintain the routine operation and maintenance monitoring frequency that began in 2003. However, the following wells will be changed to an annual sampling frequency due to consistent low VOC concentrations 105-52, 105-54, 113-06, 113-07, 113-16, 113-18, 113-20, and 113-21.
- Maintain extraction wells RW-4, RW-5, and RW-6 in standby mode during 2009. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Install a temporary well approximately 100 feet west of well RW-1 to identify the vertical distribution of contaminants in this area. Based on the results of this temporary well evaluate the pumping rates and pump locations in extraction wells RW-1, RW-2 and RW-3.

5.5 OU III South Boundary Pump and Treat System

The following are recommendations for the OU III South Boundary Pump and Treat System and groundwater monitoring program:

- Maintain wells EW-6, EW-7, EW-8, and EW-12 in standby mode. The system's extraction wells will continue to be sampled on a quarterly basis. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Maintain the routine operations and maintenance monitoring frequency that began in 2003 except for the changes noted below.
- Stop sampling the following wells that have historically been below MCL's: 121-07, 121-19, 122-02, 122-15, and 122-16. The following wells are to be reduced to an annual sampling schedule due to low VOC concentrations: 122-04, 122-19, 122-18, 122-20, 122-31, 122-32, 122-33, 122-34, and 122-35.

5.6 Western South Boundary Pump and Treat System

The following are recommendations for the OU III Western South Boundary Treatment System and groundwater monitoring program:

- Continue full-time operation of extraction well WSB-1, and pulse pumping of WSB-2 at the schedule of one month on and two months off. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.
- If any of the three by pass detection w ells st arts showing increasing trends, the need to ta ke further action will be evaluated.

- Due to the elevated dichlorodifluoromethane detected at the deepest interval in WSB VP-7 between Middle Road and Princeton Avenue, a monitoring well will be installed in 2009. The data will be evaluated for approximately one year to determine if additional actions are necessary.
- Maintain the routine O&M monitoring frequency that began in 2005.
- Due to low historical detections of VOCs, the sampling frequency for monitoring wells 126-01 and 130-04 will be reduced from semiannual to annual.

5.7 Industrial Park In-Well Air Stripping System

The following are recommendations for the Industrial Park In-Well Air Stripping System and groundwater monitoring program:

- The current routine operations and maintenance monitoring frequency will be maintained during 2009.
- The system will continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. It is recommended that well UVB-7 be placed in standby as TVOC concentrations have dropped to below 5 µg/L in this well. Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, well UVB-1 or UVB-7 will be restarted.
- Wells 000-272 and 000-280 plume perimeter wells should be changed to an annual sampling schedule, as these wells have historically shown low VOC concentrations.

5.8 Industrial Park East Pump and Treat System

The following is the recommendation for the Industrial Park East Pump and Treat System and groundwater monitoring program:

- Submit Petition for Shutdown to the Regulators in July 2009. The system has met all shutdown requirements.

5.9 North Street Pump and Treat System

The following is recommended for the North Street Pump and Treat System and groundwater monitoring program:

- Maintain the operations and maintenance sampling frequency for monitoring wells.
- Due to historically low VOC concentrations, the sampling frequency for monitoring wells 000-108, 000-154, and 000-212 will be reduced from semiannual to annual.
- Due to the location of well 086-43 north of the Former Landfill and since groundwater samples have not exceeded DWS since it was installed, it is recommended that this well be dropped from the North Street monitoring program.
- VOCs have remained below DWS for wells 115-33, 115-34, and 115-35 since they were installed in 1996, and there have been no detections above DWS for well 115-32 since 2004. Additionally, tritium concentrations have been less than 400 pCi/L in each of these four wells since they were installed. As a result, it is recommended that these four wells be dropped from the North Street monitoring program.

5.10 North Street East Pump and Treat System

The following are the recommendations for the North Street East Pump and Treat System and groundwater monitoring program:

- Continue pulse pumping of both extraction wells. The pulse pumping consists of having the system on for one month, then off in standby mode for the next month. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction wells, the extraction well(s) will be put back into full-time operation.
- Following the review of additional monitoring well data, a Petition for Shutdown of the system will be prepared.
- Change the monitoring frequency for the monitoring wells from routine operations and maintenance to shutdown monitoring in the second quarter 2009. This calls for all NSE monitoring wells to be sampled quarterly.
- It is recommended that monitoring well 000-394 be added to the North Street East well network.

5.11 LIPA/Airport Pump and Treat System

The following are recommendations for the LIPA/Airport Groundwater Treatment System and groundwater monitoring program:

- Continue the airport extraction wells pulse-pumping schedule of pumping one week per month except for wells RTW-1A and RW-6A, which will continue with full-time operations. Discontinue full-time pumping of well RTW-3A since VOC concentrations in this well are now well below MCLs and have been for over six months. This well will revert back to the one week per month pumping schedule. If concentrations above the capture goal of 10 µg/L TVOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.
- Maintain LIPA wells EW-1L and EW-3L in standby mode. These extraction wells will be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.

5.12 Magothy Monitoring

The following is recommended for the Magothy groundwater monitoring program:

- Continue the current monitoring schedule for the Magothy monitoring program, except for wells 000-428 and 115-50. Well 000-428 will be changed from quarterly to semiannual and well 115-50 from quarterly to annual.

5.13 Central Monitoring

The following is recommended for the OU III Central groundwater monitoring program:

- Based on the lack of VOC detections above standards, wells 064-03, 066-08, 066-09, 075-01, 075-02, 105-05, and 105-06 should be dropped from the sampling program.

5.14 Off-Site Monitoring

No changes to the monitoring program are warranted at this time.

5.15 South Boundary Radionuclide Monitoring Program

The following are recommendations for the OU III South Boundary Radionuclide groundwater monitoring program:

- Due to the wells' locations and the lack of detections of radionuclides, it is recommended that the following wells be dropped from the sampling program: 119-03, 124-02, 125-01, and 099-10.

- Due to the lack of detections of radionuclides, it is recommended that gamma and tritium analyses be dropped from the well 107-10 sampling.

5.16 BGRR/WCF Strontium-90 Treatment System

The following are recommendations for the BGRR/WCF groundwater treatment system and monitoring program:

- Perform pre-design groundwater modeling for modifying the system to address the high concentration Sr-90 area in the vicinity of the HFBR. Utilize the fourth quarter 2008 permanent and temporary well data and the first-quarter 2009 temporary well data for model initialization. Determine the number and placement of extraction wells necessary to remediate this area and reduce Sr-90 concentrations to levels that will allow for achievement of OU III ROD cleanup goals.
- Install additional extraction wells to address the Sr-90 hot spot identified in the WCF plume. The modification to the existing Sr-90 treatment system will consist of several new extraction wells. The location and exact number of wells will depend on the distribution of the hot spot following the departure/attenuation of the g-2 tritium slug from this area. It is currently estimated that the modification will be implemented in 2010.
- For the BGRR Sr-90 plume, install temporary wells near 075-670 and 075-671 to determine the width of the downgradient portion of the plume.
- Install a temporary well adjacent to monitoring well 075-664 to determine if a permanent well screened at a shallower depth is necessary at this location.
- Eliminate sampling at monitoring wells 065-11 and 065-177. These wells are significantly outside of the current plume position and have not detected more than trace levels of Sr-90 over a number of years.
- Install a temporary well approximately 75 feet north of monitoring well 075-86 at the corner of Cornell Avenue to characterize the centerline of the PFS plume.

5.17 Chemical/Animal Holes Strontium-90 Treatment System

The following are the recommendations for the Chemical/Animal Holes Strontium-90 Treatment System and groundwater monitoring program:

- Due to the low influent concentrations, continue pulse pumping of EW-1 (one month on, one month off). If concentrations in this extraction well increase significantly, then EW-1 will be put back into full-time operation. Continue to operate extraction wells EW-1, EW-2 and EW-3 between 5 and 7 gpm.
- Maintain the operations and maintenance phase monitoring well sampling frequency started in 2007.
- Drop well 114-01 from the monitoring program since there have been no historical detections of Sr-90 in this well.
- Install temporary wells adjacent to monitoring well 106-48 to determine the extent of the Sr-90 contamination detected in this well. Following review of the temporary well data, a monitoring well may be installed.

5.18 HFBR Tritium Pump and Recharge System

The following are recommendations for the HFBR Tritium Pump and Recharge System and monitoring program:

- Reduce the sampling frequency for 11 wells along Cornell Avenue (075-225, 075-228, 075-231, 075-234, 075-237, 075-240, 075-244, 075-42, 075-43, 075-44, and 075-45) from monthly to quarterly. The sampling frequency for these wells was increased during the fall of 2006 in response to a water leak in the HFBR building. There is no need to continue data collection at a monthly frequency as this leak has had no impact on groundwater.
- Reduce the sampling frequency for tritium for a number of wells as noted on **Table 5-1**. It is now well documented that these wells are outside the plume perimeter and, in most cases, there is another well located between these wells and the plume.
- Continue to install and sample temporary wells twice per year over the next several years to characterize the location of the high tritium concentration area approaching EW-16. Results will be communicated to the regulators via the IAG conference call and quarterly/annual reports.
- Continue operating EW-16 and EW-11 in 2009. Monitor tritium concentrations in EW-16 on a weekly basis.
- The pump and recharge well(s) will be operated until the tritium concentrations from Weaver Drive to EW-16 drop below 20,000 pCi/L. The estimated operational duration of 2 to 4 years (2011 to 2013) is based on the length of the high concentration area slug and the time it would take to be completely captured by EW-16. The decision to turn the wells back to standby will be based on:
    - concentrations of tritium decreasing to less than 20,000 pCi/L in the monitoring wells at Weaver Drive as well as the extraction wells, and
    - verification that the new extraction well has captured concentrations of tritium in this area greater than 20,000 pCi/L. A decision to turn the wells back to standby will be supported with data from additional permanent and temporary wells, as needed.

5.19 OU IV AS/SVE System Post Closure Monitoring

The following is the recommendation for the OU IV AS/SVE Post Closure Monitoring program:

- Collect a sample from well 076-185 for VOC analyses during the second-quarter 2009 to confirm the detections of cis-1,2-dichloroethylene and tetrachloroethylene.

5.20 Building 650 (Sump Outfall) Strontium-90 Monitoring

The following recommendations are made for the Building 650 Strontium-90 Groundwater Monitoring Program:

- Reduce the sampling frequency for monitoring wells 076-167, 076-183, 076-20, and 076-262 from semiannual to annual. These are all perimeter wells that have not been detecting Sr-90 over the past several years. Eliminate sampling of monitoring wells 076-10, 076-182, 076-264, 076-265, and 076-27. After approximately ten years of monitoring these wells, BNL has established that they are outside of the plume and are no longer providing useful data. The sampling of wells can be resumed and sampling frequencies increased if warranted by future changes in groundwater flow conditions.

- Install two to three temporary wells approximately 150 feet south of monitoring well 076-24 to a depth of 60 feet bls. The data will help in characterizing the leading edge of the plume and the width of the plume in this area. A permanent monitoring well may be installed pending the results.

5.21 Operable Unit V

The following recommendation is made for the OU V plume groundwater monitoring program:

- It appears that the OU V VOC plume has largely attenuated. No individual VOC exceeded the NYS AWQS in 2008. It is recommended that the monitoring well network be sampled on an annual basis for one more year. If individual VOC concentrations and tritium remain below NYS AWQS during 2009, BNL may recommend reducing the number of wells being monitored.

5.22 Operable Unit VI EDB Pump and Treat System

The following recommendations are made for the OU VI EDB Pump and Treat System and groundwater monitoring program:

- Maintain routine operations of the treatment system.
- Since there have been no historical detections of EDB above the DWS, except on one occasion for well 000-180 in 2001, sampling of monitoring wells 000-180, 000-285, 058-02, 089-13, 089-14, 099-06, 099-10, and 100-14 will be eliminated.
- For the remainder of the wells, maintain the routine operation and maintenance monitoring frequency.

5.23 Site Background Monitoring

No changes to the monitoring program are warranted at this time.

5.24 Current Landfill Groundwater Monitoring

The following recommendations are made for the Current Landfill groundwater monitoring program:

- The sampling frequency for organic and inorganic compounds should be reduced from quarterly to semiannual, except for VOCs in wells 088-22 and 088-23. Based on the lack of VOC detections in these wells, the VOC analyses in wells 088-22 and 088-23 should be reduced from semiannual to annual. Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium and gamma spectroscopy will continue on an annual basis. .

5.25 Former Landfill Groundwater Monitoring

The following recommendations are made for the Former Landfill groundwater monitoring program:

- The monitoring frequency of all non-radiological parameters will be reduced from semiannual to annual.
- Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium, and/or gamma spectroscopy will continue.

5.26 Alternating Gradient Synchrotron (AGS) Complex

The following recommendations are made for the AGS Complex groundwater monitoring programs:

- For 2009, the Building 912 wells used to track the g-2 tritium plume will continue to be sampled semiannually, whereas the remainder of the AGS Complex monitoring wells will continue to be sampled annually.

5.27 g-2 Tritium Source Area and Groundwater Plume

In accordance with g-2/BLIP/UST ROD requirements, BNL will continue to monitor groundwater quality downgradient of the g-2 source area until the source is no longer a threat to groundwater quality. The following recommendations are made for the g-2 Tritium Source Area groundwater monitoring program:

- For 2009, BNL will continue to monitor the g-2 source area wells on a quarterly basis, and the g-2 wells located downgradient of Building 912 will continue to be monitored semiannually.
- During the summer/fall of 2009, additional temporary wells will be installed along Transect D and Transect E to track the leading edge of the g-2 plume.
- To fulfill the monitoring requirements defined in the ROD, BNL will continue to track the plume until the tritium concentrations drop below the 20,000 pCi/L DWS.

5.28 Brookhaven Linac Isotope Producer Facility

Because tritium levels in groundwater have been continuously below the 20,000 pCi/L DWS since January 2006, BNL proposes reducing the monitoring frequency for the downgradient monitoring wells 064-47, 064-48, and 064-67 from quarterly to semiannually starting in 2009. Sampling frequency for the two upgradient and two downgradient wells will be changed from semiannual to annual.

5.29 Relativistic Heavy Ion Collider Facility

For 2009, groundwater samples will continue to be collected on a semiannual basis.

5.30 Brookhaven Medical Research Reactor Facility

The monitoring frequency for the BGRR wells will continue to be once every two years, with the next set of samples being collected in 2010.

5.31 Sewage Treatment Plant

No changes to the STP groundwater monitoring program are proposed for 2009.

5.32 Motor Pool Maintenance Area

No changes to the Motor Pool groundwater monitoring program are proposed for 2009.

5.33 On-Site Service Station

No changes to the Service Station groundwater monitoring program are proposed for 2009.

5.34 Major Petroleum Facility Area

No changes to the MPF groundwater monitoring program are proposed for 2009.

5.35 Waste Management Facility

For 2009, monitoring will continue as required by the RCRA Part B Permit.

5.36 Building 801

For 2009, the monitoring frequency for well 065-325 will continue to be semiannual, and one sample round will be conducted as close as possible to the planned annual sampling of wells 065-37, 065-169, and 065-170 under the CERCLA program.

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Reference List

Arcadis Geraghty & Miller. 2003. *Final Magothy Aquifer Characterization Report*. Brookhaven National Laboratory, Upton, NY. May 2003.

Aronson, D.A., and Seaburn, G.E. 1974. *Appraisal of the operating efficiency of recharge basins on Long Island, NY in 1969.* USGS Supply Paper 2001-D.

BNL. 2000a. *Carbon Tetrachloride Groundwater Removal Action Operations and Maintenance Manual.* Brookhaven National Laboratory, Upton, NY. January 26, 2000.

BNL. 2000b. *Operations and Maintenance Manual for the OU III Offsite Removal Action.* Brookhaven National Laboratory, Upton, NY. February 11, 2000.

BNL. 2001a. *BNL Spill Prevention, Control and Countermeasures Plan*. Brookhaven National Laboratory, Upton, NY.

BNL. 2001b. *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort - Work Plan,* Brookhaven National Laboratory, Upton, NY, May 2001.

BNL. 2002a. *Building 96 Groundwater Source Control Treatment System Operations and Maintenance Manual*. Brookhaven National Laboratory, Upton, NY. April 2002.

BNL. 2002b. *Operations and Maintenance Manual for the Western South Boundary Treatment System*. Brookhaven National Laboratory, Upton, NY. December 2002.

BNL. 2002c. *Petition For Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System,* Brookhaven National Laboratory, Upton, NY, June 2002.

BNL. 2003a. *Operations and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1*. Brookhaven National Laboratory, Upton, NY. July 18, 2003.

BNL. 2003b. *Final CERCLA Five Year Review Report for OU IV.* Brookhaven National Laboratory, Upton, NY.

BNL. 2004a. *Petition to Shutdown the OU III Carbon Tetrachloride Treatment System*. Brookhaven National Laboratory, Upton, NY. April 2004.

BNL. 2004b. *OU III Building 96 Operations and Maintenance Manual Modification*. Brookhaven National Laboratory, Upton, NY. June 2004.

BNL. 2004c. *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System*. Brookhaven National Laboratory, Upton, NY. September 3, 2004.

BNL. 2004d. *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems*. Brookhaven National Laboratory, Upton, NY. August 24, 2004.

BNL 2004e. *Operations and Maintenance Manual for the OU IV EDB Groundwater Treatment System*. Brookhaven National Laboratory, Upton, NY. Sept. 16, 2004.

BNL 2005a. *OU III Explanation of Significant Differences*. Brookhaven National Laboratory, Upton, NY.

BNL. 2005b. *Operations and Maintenance Manual for the RA V Treatment Facility*. Brookhaven National Laboratory, Upton, NY. October 7, 2005.

BNL. 2005c. *2004 BNL Groundwater Status Report.* Brookhaven National Laboratory, Upton, NY. June 2004.

BNL 2005d. *Operations and Maintenance Manual for the Sr-90 BGRR/WCF/PFS Groundwater Treatment System.* Brookhaven National Laboratory, Upton, NY.

BNL. 2007a. *BNL Land Use Controls Management Plan*, Revision 2. BNL, July 25, 2007.

BNL 2007b. *Record of Decision for Area of Concern 16T g-2 Tritium Source Area and Groundwater Plume, Area of Concern 16K Brookhaven Linac Isotope Producer, and Area of Concern 12 Former Underground Storage Tanks.* Brookhaven National Laboratory, Upton, NY. May 10, 2007.

BNL. 2008a. BNL *2006 Environmental Monitoring Plan,* Brookhaven National Laboratory, Upton, NY. January 2008

BNL. 2008b. *2007 BNL Groundwater Status Report.* Brookhaven National Laboratory, Upton, NY. June 2008.

BNL. 2008c. Operations and Maintenance Manual for the LIPA/Airport Groundwater Treatment System, Revision 2. Brookhaven National Laboratory, Upton, NY. November 2008.

BNL. 2008d. *Chemical/Animal Holes Strontium-90 Groundwater Treatment System Operations and Maintenance Manual*. Brookhaven National Laboratory, Upton, NY. November 2008.

BNL. 2009a. *Final Report for Building 96 Recommendation for Source Area Remediation.* Brookhaven National Laboratory, Upton, NY, March 2009.

BNL. 2009b. *2008 Environmental Monitoring Report, Current and Former Landfill Areas.* Brookhaven National Laboratory, Upton, NY, March 2009.

BNL. 2009c. *Operations and Maintenance Plan for the High Flux Beam Reactor Tritium Plume Pump and Recharge System.* Brookhaven National Laboratory, Upton, NY, February 2009.

BNL. 2009d. *2008 Groundwater Monitoring Report for the Waste Management Facility*, Brookhaven National Laboratory, Upton, NY.

deLaguna, W. 1963. *Geology of Brookhaven National Laboratory and Vicinity*, *Suffolk County, New York.*

DOE. 1993**.** *Order 5400.5*, *Radiation Protection of the Public and the Environment***.** January 1993.

DOE. 2003. *Order 450.1, Environmental Protection Program*, 2003.

Franke, O.L. and McClymonds, P. 1972. *Summary of the hydrologic situation on Long Island, NY, as a guide to water management alternatives*. USGS Professional Paper 627-F.

Holzmacher. 2004. *LIPA/Airport Pump Test Report.*

Paquette, D.E.; Bennett, D.B, and Dorsch, W.R. 2002. *Brookhaven National Laboratory Groundwater Protection Management Description.* BNL Report 52664. May 31, 2002.

Scorca, M.P., W.R. Dorsch, and D.E. Paquette. 1999. *Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, NY, 1994-97*. U.S. Geological Survey Water Resources Investigations Report 99-4086.

U.S. Environmental Protection Agency (EPA). 1992. Interagency Agreement, Administrative Docket Number: II-CERCLA-FFA-00201, May 1992.