BROOKHAVEN NATIONAL LABORATORY

Site Environmental Report 2013

VOLUME 1

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the Laboratory site, including some that are New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern. A total of 216 species of birds have been identified at Brookhaven National Laboratory since 1948, and approximately 85 species are known to nest on site. The Red-tailed hawk, a bird of prey, is protected by the Migratory Bird Treaty Act.

Chapter 6 of this report discusses habitat management and protection efforts of the Laboratory's various bird populations.

The Brookhaven National Laboratory 2013 Site Environmental Report is a public document that is distributed to various U.S. Department of Energy sites, local libraries, and local regulators and stakeholders. The report is available to the general public on the internet at http://www.bnl.gov/ewms/ser/. A summary of the report is also available and is accompanied by a compact disk containing the full report. To obtain a copy of the report or summary, please write or call:

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2013
SITE ENVIRONMENTAL REPORT

BROOKHAVEN NATIONAL LABORATORY

Volume I

October 2014

Prepared by
Brookhaven Science Associates, LLC
For the U.S. Department of Energy
Under Contract No. DE-AC02-98CH10886

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EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

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Executive Summary

Brookhaven National Laboratory (BNL) prepares an annual Site Environmental Report (SER) in accordance with DOE Order 231.1B, Environment, Safety and Health Reporting of the U.S. Department of Energy (DOE). 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 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 personnel, regulators, and other technically oriented stakeholders. A brief summary of the information contained in Volume II is included in Chapter 7, Groundwater Protection, of this volume.

Both reports are available in print and as downloadable files on the BNL web page at http://www.bnl.gov/esh/env/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 Environmental, Safety, Security and Health Policy reflects the commitment of BNL's management to fully integrate environmental stewardship into all facets of its mission and operations.

ENVIRONMENTAL MANAGEMENT SYSTEM

The Laboratory's Integrated Safety Management System (ISMS) incorporates 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 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 [EMS]) 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.

An EMS was established at BNL in 2001 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 and health of 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.* It also is 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. BNL was also the first DOE Office of Science Laboratory to achieve registration under the OHSAS 18001 (Occupational Health & Safety) Standard. Each certification requires the Laboratory to undergo annual audits by an accredited registrar to assure that the systems are maintained and to identify evidence of continual improvement. In 2013, an EMS and OHSAS re-certification audit determined that BNL remains in conformance with both standards. In recommended continued EMS certification, auditors from NSF-International Strategic Registrations, Ltd., found one Minor Nonconformance regarding the need for more consistent communication of BNL's Environmental Policy to contractors. As a corrective action, contractors are now presented with a copy of BNL's current ESSH Policy.

Executive Order 13514, signed in 2009, sets sustainability goals for federal agencies and focuses on making improvements in environmental, energy, and economic performance. It requires federal agencies to set a greenhouse gas emissions reduction target, increase energy efficiency, reduce fleet petroleum consumption, conserve water, reduce waste, support sustainable communities, and leverage federal purchasing power to promote environmentally responsible products and technologies. The Laboratory's EMS objectives and targets have been established to mirror these requirements.

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 Brookhaven Science Associates 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. Three P2 proposals were funded in 2013, for a combined investment of approximately $6,000. The anticipated annual savings from these projects is estimated at $17,500, for an average payback period of approximately 4 months. Initiatives to reduce, recycle, and reuse 13.4 million pounds of industrial, sanitary, hazardous, and radiological waste through the P2 program resulted in more than $12.7 million in cost avoidance or savings in 2013.

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 2013 follow.

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, 12 equivalency permits for the operation of groundwater remediation systems, and several other binding agreements. In 2013, the Laboratory operated in compliance with most of the requirements, and any instance of noncompliance was reported to regulatory agencies and corrected expeditiously. Routine inspections conducted during the year found no significant instances of non-compliance.

In 2013, emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from BNL's Central Steam Facility (CSF) were all within permit limits. One unexpected opacity excursion occurred in August 2013 as a result of a localized short-term power outage that occurred during scheduled electrical system maintenance in Boiler 6. Halon portable fire extinguishers continue to be removed and replaced by dry-chemical or clean agent units as they are encountered.

Monitoring of BNL's potable water system indicated that all drinking water requirements were met during 2013. Most of the liquid effluents discharged to surface water and groundwater met applicable New York State Pollutant Discharge Elimination (SPDES) permit requirements. Six excursions above permit limits were reported for the year; five occurred at BNL's Sewage Treatment Plant (STP) for total nitrogen, ammonia nitrogen, and total nitrogen load. The permit excursions were reported to the New York State Department of Environmental Conservation (NYSDEC) and the Suffolk County Department of Health Services (SCDHS) and corrective actions were taken. Groundwater monitoring at the Laboratory's Major Petroleum Facility (MPF) continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

Efforts to reduce the number and minimize the severity of spills on site continued in 2013. There were nine reportable spills of petroleum products, antifreeze, or chemicals, which was less than reported in 2012. The severity of releases was minor and spills were promptly cleaned up to the satisfaction of NYSDEC.

External environmental inspections or reviews conducted in 2013 by federal, state, and local agencies that oversee BNL activities included:

- *Air Compliance*. BNL representatives accompanied NYSDEC on a site inspection in September 2013; there were no issues identified.
- *Potable Water*. In August 2013, SCDHS collected samples and conducted its annual inspection of the BNL potable water system. Corrective actions for all identified deficiencies were established and communicated with SCDHS and are being addressed by the Laboratory's Energy and Utilities Division.
- *Sewage Treatment Plant*. SCDHS conducts quarterly inspections of the Laboratory's STP to evaluate operations and sample the effluent. In 2013, no performance or operational issues were identified. NYSDEC performed an annual surveillance inspection in March; there were no issues identified.
- *Recharge Basins*. SCDHS inspected several on-site SPDES-regulated outfalls in 2013; there were no issues identified.
- *Major Petroleum Facility*. The annual NYSDEC inspection of the MPF was performed in March 2013. Five conditions that required corrective action were identified: one for faded/illegible color coding and tank identification labels and four instances where for electronic leak detectors or high-level alarm systems that were not fully functional. All conditions were corrected in accordance with NYSDEC directives.

- *Chemical Bulk Storage (CBS) Facilities*. The CBS facilities are inspected periodically by NYSDEC. An inspection was conducted in March 2013; there were no issues identified.
- *Resource Conservation and Recover Act Inspections*. NYSDEC and EPA performed RCRA inspections in 2013; there were no issues identified.

Each year, the DOE Brookhaven Site Office (BHSO) conducts several environmentally-related assessments, some of which are supported by the DOE Chicago Office. In 2013, BHSO conducted a follow-up surveillance on BSA's response to the Building 705 Stack Drain Tank High-Level Alarm, which occurred in July 2012, to verify the effectiveness of the corrective actions and participated in a peer assessment of BSA's NESHAP's Program along with a team of environmental professionals from Oak Ridge National Laboratory. The Stack Drain Tank follow-up surveillance verified that BSA has successfully implemented numerous corrective actions to prevent recurrence of the overflow of the HFBR stack drain tank and lack of timely alarm response. The National Emission Standards for Hazardous Air Pollutant (NESHAP) assessment yielded no non-conformances, five programmatic strengths, and 19 opportunities for improvement (OFIs). In May 2013, a team of BNL Subject Matter Experts were assembled to analyze the OFIs and identify actions needed to improve Rad-NESHAP program implementation. A final report was completed in June, and most of the corrections were completed by September 30, 2013.

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. 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.

During 2013, Laboratory facilities released a total of 4,919 curies of short-lived radioactive gases. BNL's Brookhaven Linac Isotope Producer (BLIP) is the only facility subject to EPA's continuous monitoring requirements. Oxygen-15 (half-life: 122 seconds) and carbon-11 (half-life: 20.4 minutes) emitted from the BLIP constituted more than 99.9 percent of radiological air emissions on site in 2013.

The Laboratory conducts ambient radiological air monitoring to verify local air quality and to assess possible environmental and health impacts from BNL operations. Samples collected from air monitoring stations around the perimeter of the site were analyzed for tritium and gross alpha and beta airborne activity. Results for 2013 continued to demonstrate that on-site radiological air quality was consistent with air quality measured at 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 (boilers 6 and 7) are equipped with continuous emission monitors to measure nitrogen oxide (NOx) emissions and opacity. NOx emissions cannot exceed 0.30 lbs/MMBtu when No. 6 fuel oil is burned or 0.20 lbs/MMBtu when natural gas or No. 2 fuel oil is combusted. Opacity levels cannot exceed 20 percent, except for one 6-minute period per hour of not more than 27 percent opacity. In 2013, there were no exceedances of the NOx emission standards for either boiler, and there was one excess opacity measurement recorded for Boiler 6 during routine operations, which was due to a localized short-term power outage caused by electrical maintenance work, as discussed in Compliance Monitoring Program above. Multiple opacity excursions were recorded during performance testing of the opacity monitors and were documented in quarterly Monitoring System Performance Reports submitted to NYSDEC.

Because natural gas prices were lower than residual fuel oil prices throughout 2013, BNL's CSF used natural gas to supply more than 97.4

percent of the heating and cooling needs of the Laboratory's major facilities. As a result, annual facility emissions of particulate matter and nitrogen oxides were slightly higher than 2012 levels, when natural gas use accounted for 99 percent of Laboratory major facilities heating and cooling needs.

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

Water Quality Surveillance Program

The Laboratory discharges treated wastewater into the headwaters of the Peconic River via BNL's 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.

In 2013, the average gross alpha and beta activity levels in the STP discharge were within the typical range of historical levels and well below New York State Drinking Water Standards (NYS DWS). Tritium was not detected above method detection limits throughout the year. There was also no detection of cesium-137 (Cs-137), strontium-90 (Sr-90), or other gamma-emitting nuclides attributable to BNL operations. The STP is also monitored for nonradiological contaminants. In 2013, monitoring of the STP effluent showed that, except for isolated incidents of noncompliance for metals, organic and inorganic parameters were within SPDES effluent limitations or other applicable standards.

Discharges to recharge basins are sampled throughout the year and analyzed for 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 2013, there were no reported gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins. Inorganics (i.e., metals) were detected; however, their presence is due primarily to sediment run-off in stormwater discharges.

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 west of BNL, is monitored as a geographical control location for comparative purposes, as it is not affected by Laboratory operations. Radiological data from Peconic River surface water sampling in 2013 show that the average concentrations of gross alpha and gross beta activity from off-site locations and control locations were indistinguishable from BNL on-site levels. In addition, and all detected levels were below the applicable NYS DWS. Tritium was detected in one water sample collected upstream of the STP discharge. Due to the low level of detection and high uncertainty with the measurement, the data may be a false positive. Inorganic data from Peconic River samples collected upstream, downstream, and at control locations demonstrated that elevated amounts of aluminum and iron detected in the river are associated with natural sources.

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 on site, 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. Activities to eliminate or minimize negative effects on sensitive or critical species (e.g., the eastern tiger salamander, banded sunfish, and northern long-eared bat) are incorporated into procedures or into specific programs or project plans. While most restoration efforts have been completed, minor actions continue to remove pollutant sources that could contaminate habitats. When possible, 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 or within 1 mile of the Laboratory 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 2013 in deer meat was 0.85 pCi/g, wet weight (wet weight is before a sample is dried for analysis and the form most likely to be consumed). The highest concentration of Cs-137 in deer meat was 1.39 pCi/g, wet weight, from a deer taken more than 5 miles south of BNL. 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 nor formal health advisories are warranted.

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Sampling is now alternated each year either as part of BNL's routine surveillance monitoring program or sampling performed as part of the post-cleanup monitoring for the Peconic River remediation project. In 2013, results from surveillance monitoring of fish showed low levels of Cs-137 from the Peconic River System and all samples from the Carmans River were non-detectable. Levels of Cs-137 in all fish species are within the range of results historically seen from the Peconic River.

Metals analysis of fish in 2013 focused on mercury due to its known health risk. In general, a trend of decreasing mercury content downstream from BNL's STP is evident with the highest concentration of 4.08 mg/kg measured in a chain pickerel from Area D on site. Polychlorinated biphenyl (PCB) analysis in fish was discontinued off site, but continued to be performed for fish on site. Very low levels of Aroclor 1254 and 1260 were detected in several samples.

Annual sampling of vegetation in the on-site portion of the Peconic River was conducted in 2013. Cs-137 was detected in a single on-site aquatic vegetation sample. Under the Peconic River remediation project, sediment from the Peconic River was excavated to remove mercury and associated contaminants from three locations in 2011. Post cleanup monitoring of the three locations indicated low levels of Cs-137 and no location had a mercury concentration above the 2.0 mg/kg goal set by the Peconic River remediation project. Water column sampling for mercury and methyl mercury was performed at 9 of 15 Peconic River sampling locations in June and 6 of 15 locations in July, including BNL's STP outfall. The general trend of total mercury in Peconic River water samples decreased with increasing distance downstream from the STP. Methyl mercury concentrations fluctuated between sampling periods and between both on- and off-site locations.

Cs-137 analysis in farm vegetable samples did not detect any Cs-137 in 2013, but was detected in soils at a very low level; this is consistent with levels seen from worldwide fallout from weapons testing. Farm vegetable monitoring will be discontinued after 2013, as historic monitoring of farm vegetables showed no impacts from BNL operations. Some grassy vegetation samples and associated soil samples contained very low levels of Cs-137, and are considered consistent within the range of historical levels.

The Laboratory 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 2013, research included radiotelemetry surveys to determine home range and resource use by box turtles, acoustic and mist net bat surveys, impact assessments related to the construction and operation of the Long Island Solar Farm on site, and statistical analysis of long-term ecological and environmental monitoring data.

The goal of BNL's Cultural Resource Management Program 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 2013 included the submission of BNL's Cultural Resource Management Plan to the New York State Historic Preservation Office for review and the preparation of loan papers for the loan of Camp Upton artifacts to the Long Island History Museum for a display on "Long Island at War."

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

Groundwater Protection Management Program

BNL has made significant investments in environmental protection programs over the past 20 years and continues to make progress in achieving its goal of preventing new groundwater impacts and remediating previously contaminated groundwater. No new impacts to groundwater quality were discovered during 2013. The Laboratory's extensive groundwater monitoring well network is used to evaluate progress in restoring groundwater quality, to comply with regulatory permit requirements, and to monitor active research and support facilities where there is a potential for environmental impact. In 2013, BNL collected groundwater samples from 780 permanent monitoring wells and 65 temporary wells during 2,815 individual sampling events.

BNL continues to make significant progress in restoring groundwater quality. During 2013, approximately 183 pounds of volatile organic compounds (VOCs) and approximately 1.3 mCi of Sr-90 were removed while treating almost 1.4 billion gallons of groundwater. With the treatment of approximately 22 billion gallons of groundwater since the start of active remediation, 7,133 pounds of VOCs and 29 mCi of Sr-90 have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in a number of on- and off-site areas.

Chapter 7 of this report provides an overview of this program, and the SER Volume II, *Groundwater Status Report*, provides detailed descriptions, data, and maps relating to all groundwater monitoring performed in 2013.

Radiological Dose Assessment Program

The Laboratory routinely reviews 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 to the Maximally Exposed Off-Site Individual (MEOSI), which is defined as the possible largest dose to a person at a residence, office, or school beyond 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 2013 was comparable to natural background radiation levels.

To measure direct radiation from Laboratory operations, 58 environmental thermoluminescent dosimeters (TLDs) were deployed, of which 9 were placed in known radiation areas and 11 off-site areas in 2013. An additional 30 TLDs were placed in a lead-shielded container for use as reference and control TLDs for comparison purposes. The average dose of all TLDs showed there was no additional contribution above the natural background radiation 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 estimated as 66 ± 8 mrem (660 ± 80 µSv) and the annual off-site external dose was estimated as 61 ± 7 mrem (610 ± 70 µSv).

The ingestion pathway dose was estimated as 2.02 mrem (20 µSv) from the consumption of deer meat and 1.64E-01 mrem (1.6 µSv) from consumption of fish caught in the vicinity of the Laboratory. The dose from the air inhalation pathway attributable to BNL operations was 3.65 E-01 (36 µSv), which less than 4 percent of EPA's annual regulatory dose limit of 10 mrem (100 µSv). The total dose to the MEI from all pathways was estimated as 2.55 mrem (26 µSv), which is less than 3 percent of DOE's 100-mrem limit. Doses to aquatic and terrestrial biota and also from short-term projects, such as remediation work and waste management disposal activities, were also evaluated and found to be well below the regulatory limits.

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 report 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 2013, the Laboratory used six off-site contract analytical laboratories to analyze environmental samples: General Engineering Lab, H2M Lab, Test America, Chemtex Lab, Caltest Analytical, and American Radiation Services. 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.

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

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

2013 SITE ENVIRONMENTAL REPORT TEAM

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

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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. The most up-to-date, accurate version of this report is online at *http://www.bnl.gov/ewms/ser/*.

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Introduction 1

Established in 1947, Brookhaven National Laboratory is a multi-program research institution primarily funded by the U.S. Department of Energy's Office of Science. The Laboratory is operated and managed by Brookhaven Science Associates, a limited-liability company founded by the Research Foundation for the State University of New York on behalf of Stony Brook University, the largest academic user of Laboratory facilities, and Battelle, a nonprofit applied science and technology organization. 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.

One of 10 national Laboratories, 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 produce excellent science and advanced technology 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 is to utilize its world-class facilities and expertise to:

- Advance energy and environment-related basic research and apply it to 21st Century problems of critical importance to the Nation.
- Advance fundamental research in nuclear and particle physics to gain a deeper understanding of matter, energy, space, and time.

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.

In 2001, BNL was the first DOE Office of Science National Laboratory to be registered under the prestigious International ISO 14001 environmental management standard. 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 the report. Registration to these standards was maintained throughout 2013.

1.2 RESEARCH AND DISCOVERIES

BNL conducts research in physics, chemistry, biology, medicine, applied science, and a wide range of advanced technologies. BNL's world-class research facilities are also available to university, industrial, and government personnel from around the world. Current research includes energy security to help address the world's need for new, more efficient, and sustainable energy sources such as solar, wind, hydrogen, and other renewable sources; photon sciences, using ultra-bright light to reveal the structures of materials critically important to biology, technology, and more; quantum chromodynamics (QCD) to recreate matter and study the force that gives shape to visible matter in the universe from the dawn of time to today, using colliding subatmoic particles; physics of the universe to explore cosmic mysteries across the smallest and largest scales imaginable, from neutrinos to dark energy; and climate, environment, and biosciences, to map climate change, greenhouse gas emissions, and plant biology to help protect our planet's future.

To date, researchers working at BNL have received seven Nobel Prizes, National Medals of Science, Enrico Fermi Awards, Wolf Foundation Prizes, R&D 100 awards, as well as other recognitions for discoveries made wholly or partly at BNL. Some significant discoveries and developments made at the Laboratory include new forms of matter, subatomic particles, technologies that fuel leading experimental progams around the world, and life-saving medical imaging techniques for diagnosis and treatment of disease.

1.3 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 decommissioning was completed in June 2012. The BGRR is currently undergoing long-term surveillance and maintenance.

The High Flux Beam Reactor (HFBR) was in operation from 1965 through 1996. The facility 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 late 1996, workers discovered that a leak in the HFBR spent fuel storage pool had been releasing tritium to the groundwater (see SER, Volume II, Groundwater Status Report, for further details). The reactor was shut down for routine maintenance at the time of the discovery and was never restarted. In November 1999, DOE decided that the HFBR would be permanently shut down. With input from the community, a final Record of Decision (ROD) was approved outlining the remedy for the HFBR's permanent decontamination and decommissioning (D&D). 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 ancillary buildings, including fan houses; removal and disposal of the reactor control rod blades and beam plugs; draining and isolation of all utility piping penetrating the reactor building; removal of the stack silencer baffles; and rendering all former hazardous material storage tanks permanently out of service. Demolition of the stack will be completed by 2020 in accordance with the ROD. Starting in 2010, the HFBR entered a period of long-term surveillance and maintenance. During this period, the building will remain unheated and electrical services will only be energized during periodic inspections and for leak detection monitoring. The HFBR will remain in this state for 65 years to permit sufficient decay of remaining radioactivity within the reactor. At the end of the low-energy period, D&D of the reactor will continue.

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 and has entered a period of surveillance and maintenance.

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.

Although the Laboratory no longer performs research associated with neuroimaging, BNL's Center for Translational Neuroimaging used brain-imaging tools, including positron emission tomography (PET) and magnetic resonance imaging (MRI) equipment, to research the 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 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 par- ticle accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Nobel Prize in 1957. After 14 years of service, the Cosmotron ceased operation and was dis- mantled due to design limitations. The Alternating Gradient Synchrotron (AGS), a much larger particle accelerator, became operational in 1960. The AGS has allowed scientists to accelerate protons to energies that have 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). In 2010, BNL began operating a new heavy ion beam source for use by RHIC and the NASA Space Radiation Laboratory, the Electron Beam Ion Source (EBIS). This source produces and accelerates intense and bright heavy ion beams, allowing studies with new types of ions previously unavailable from the Tandem Van DeGraaff accelerator.

RHIC began operation in 2000. Inside this two-ringed particle accelerator, two beams of gold ions, heavy metals, or protons circulate at nearly the speed of light and 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 rates 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 first electron and heavy ion collider.

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, construction of the NSLS-II, conceived as the next generation synchrotron light source, began in 2008. 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. The NSLS-II is expected to be operational in 2015.

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. This award is based on five categories: sustainability, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.

BNL's Center for Functional Nanomaterials (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 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 leader-ship in the development of advanced materials and processes for energy applications. The CFN building has also been awarded LEED Silver certification.

The new Interdisciplinary Science Building (ISB), completed in 2013, is an energy-efficient and environmentally sustainable building that provides labs, offices, and support functions to bring together a broad spectrum of researchers, including industry, universities, and other National Laboratories. The ISB fosters energy research, focusing on the effective uses of renewable energy through improved conversion, transmission, and storage. The ISB has been awarded LEED Gold certification.

Construction of a 32 megawatt Long Island Solar Farm (LISF) at BNL was completed in the fall of 2011. The LISF is the largest solar photovoltaic (PV) electric generating plant in the Northeast region. Its goal is to help Long Island be less reliant on fossil fuel-driven power generation and to meet peak load demands from summertime air conditioning use. It is generating enough renewable energy to power approximately 4,500 homes and is helping New York State meets its clean energy and carbon reduction goals. The LISF will be one of the most studied solar installations, as it will be a focal point of the Northeast Solar Energy Research Center (NSERC) at BNL. Construction for the NSERC will be complete in 2014. Research will include work done at the LISF, as well as a dedicated research array for testing solar panel modules, inverters, and other equipment being developed for the solar energy industry. Additional information on the LISF can be found in Chapters 2 and 6 of this report.

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 1,820 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
- 520 acres used for outlying facilities, such as the Sewage Treatment Plant, ecology field, housing facilities, and fire breaks
- 400 acres of roads, parking lots, and connecting areas
- 200 acres occupied by the Long Island Solar Farm

The balance of the site, approximately 3,400 acres, is mostly wooded and represents the native pine barrens ecosystem.

The location of the major scientific facilities at BNL are shown on Figure 1-1. Additional facilities, shown on 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 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 five on-site wells. Water pumped from three supply wells located along the western boundary of the site is treated at the WTP with a lime-softening process to remove naturally occurring iron and with 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. Two 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 2013.

Past operations and research at the BNL site, dating back to the early 1940s when it was Camp Upton, have resulted in localized

Figure 1-1. Major Scientific Facilities at BNL.

1. Relativistic Heavy Ion Collider (RHIC)
2. NASA Space Radiation Laboratory (NSRL)
3. Alternating Gradient Synchrotron (AGS)
4. AGS Booster
5. Brookhaven Linac Isotope Producer (BLIP) and Linear Accelerator (Linac)
6. Heavy Ion Transfer Line (HITL)
7. Radiation Therapy Facility (RTF)
8. Scanning Transmission Electron Microscope (STEM)
9. Interdisciplinary Science Building (ISB)
10. Center for Functional Nanomaterials (CFN)
11. National Synchrotron Light Source II (NSLS-II)
12. National Synchrotron Light Source (NSLS)
13. Tandem Van de Graff and Cyclotron

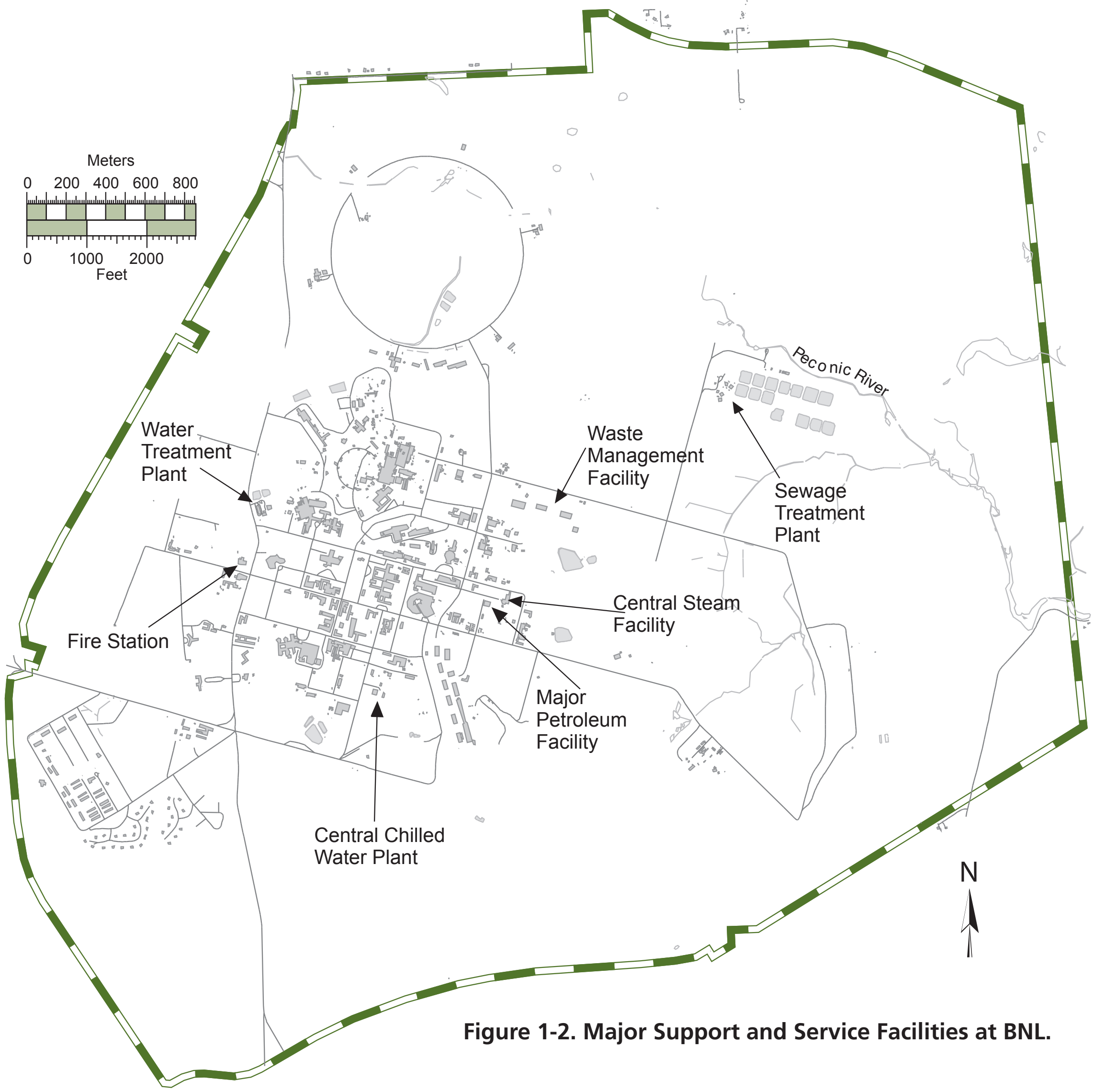


Figure 1-2. Major Support and Service Facilities at BNL.

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 40 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.

1.5 LOCATION, LOCAL POPULATION, AND LOCAL ECONOMY

BNL is located near the geographical center of Suffolk County, Long Island, New York. The Laboratory's 5,265-acre site is located in Brookhaven Township, the largest township in both area and population, and is approximately 60 miles east of New York City. BNL is one of the five largest high-technology employers on Long Island, with approximately 3,000 employees that include scientists, engineers, technicians, and administrative personnel. More than 75 percent of BNL employees live in Suffolk County. In addition, the Laboratory annually hosts almost 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.

BNL strengthens Long Island's position as a center of innovation in energy, the life sciences, and other fields crucial to the growth of New York State's economy. With an annual budget of over $652 million in 2013, the Laboratory had a significant economic impact on New York State. In fiscal year 2013, employee salaries, wages and fringe benefits accounted for over $399 million of its total annual budget. Supporting local and state businesses whenever possible, BNL spends million each year on goods and services. It is estimated that between 2012 and 2014, the Laboratory will generate, on an average annual basis, $947 million in economic output and approximately 7,000 jobs throughout New York State.

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.

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 approximately 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 deposites 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, approximately half of the annual precipitation is lost to the atmosphere through evapotranspiration, and the other half percolates through the soil to recharge the groundwater (Franke and McClymonds 1972, Aronson and Seaburn 1974).

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 2013, the Laboratory pumped approximately 434 million gallons of water for use on site. Approximately 70 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 3.8 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 years as it moves from the central, developed area of the site to the Laboratory's southern boundary.

1.7 CLIMATE

The Meteorological Services Group at BNL has been recording on-site weather data since 1949. The Laboratory is broadly influenced by continental and maritime weather systems. Locally, the Long Island Sound, Atlantic Ocean,

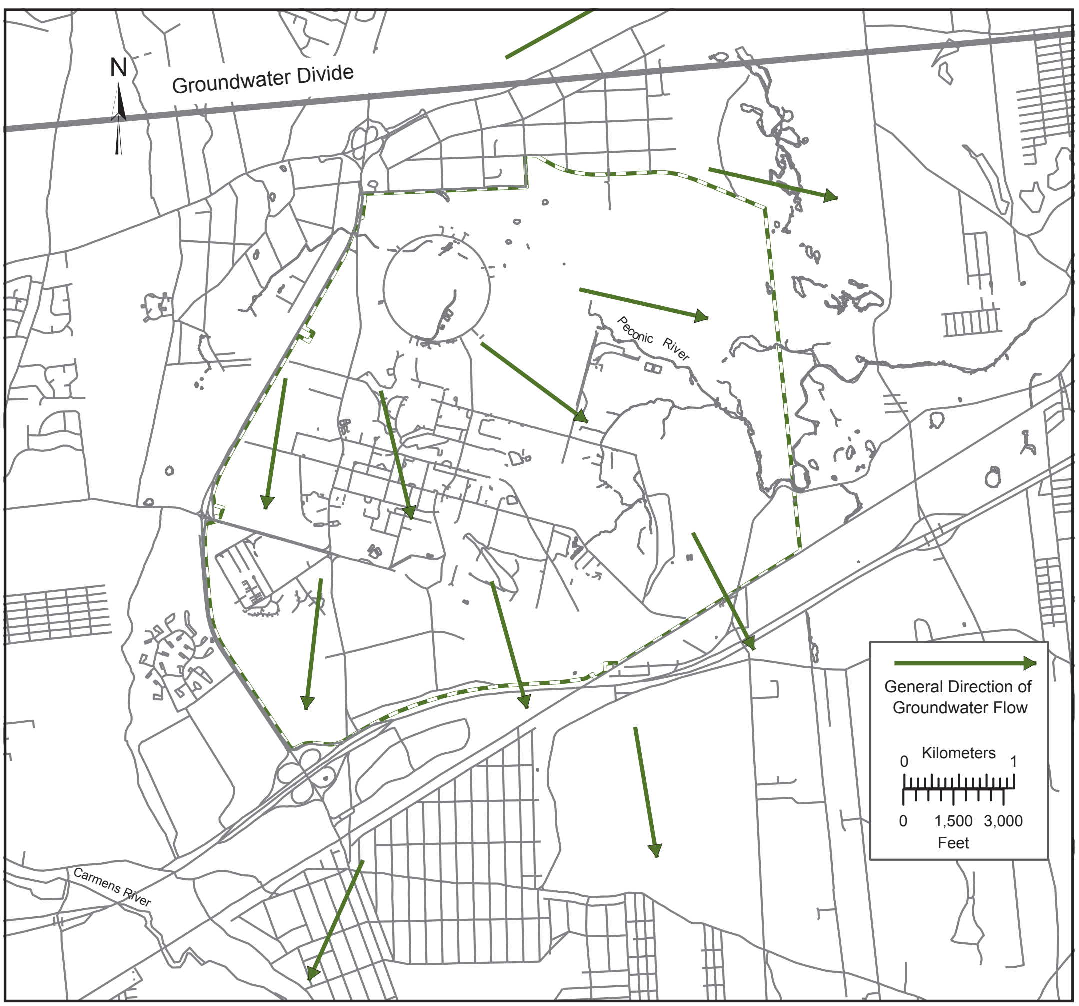


Figure 1-3. BNL Groundwater Flow Map.

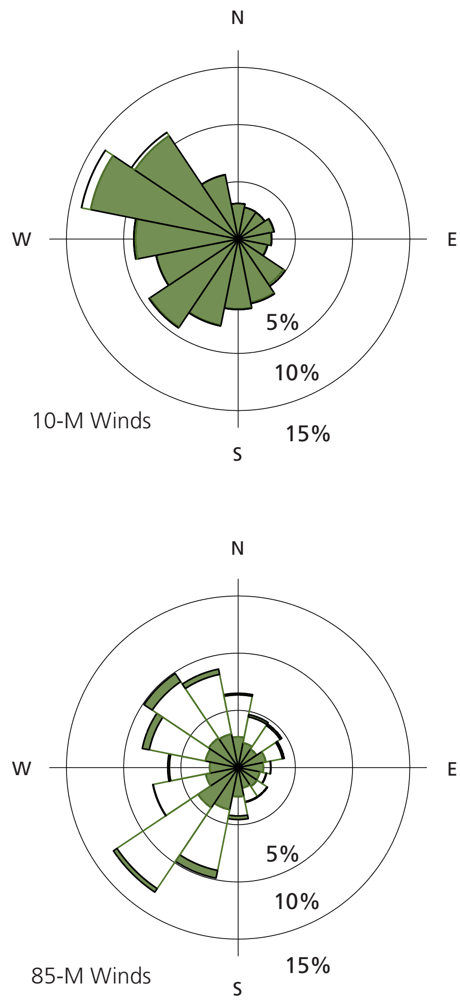
and associated bays influence wind directions and humidity and provide a moderating influence on extreme summer and winter temperatures. The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from those two directions during the spring and fall (Nagle 1975, 1978). Figure 1-4 shows the 2013 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 (85 meters) above land surface.

The average monthly temperature in the area for 2013 was 52 degrees Fahrenheit (°F). The average yearly temperature for the area was 50°F. Figures 1-5 and 1-6 show the 2013 monthly mean temperatures and the historical annual mean temperatures, respectively. The total annual precipitation in 2013 was 45.6 inches. Figures 1-7 and 1-8 show the 2013 monthly and the 64-year annual precipitation data. The average snowfall for2013 was 54.8 inches, well above the 31.7 inches average yearly snowfall for Long Island.

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



Explanation: Wind direction was measured at heights of 10 and 85 meters above the ground, for a total of 520,064 measurements at each height. The readings were plotted on the charts to indicate how often wind came from each direction. The concentric circles represent multi-percentage increases in the frequency. For example, at 10 meters above the ground, wind was from due south 5 percent of the time. The predominant wind direction in 2013 was from the northwest at the 10-m level, and from the southwest at the 88-m level.

Figure 1-4. BNL Wind Rose (2013).

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 200 plant, 15 animal, 85 bird, 13 amphibian, 12 reptile, and 10 fish species have been identified on site, some of which are New York State threatened, endangered, exploitably vulnerable, and species of special concern. To eliminate or minimize any negative effects that BNL operations might cause to these species, precautions are in place to protect habitats and natural resources at the Laboratory.

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 (BNL 2011). 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 (BNL 2012). These resources include

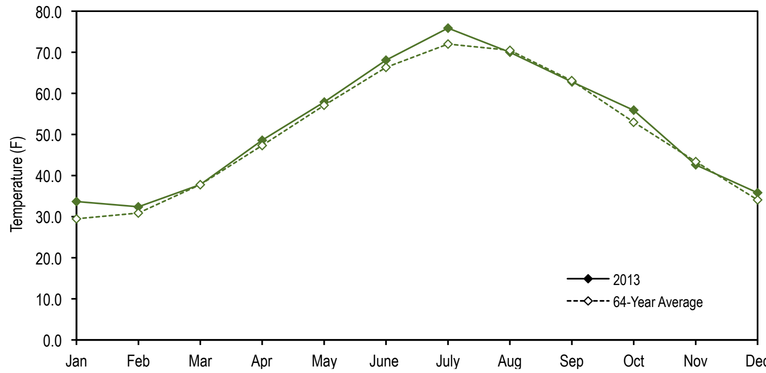


Figure 1-5. BNL 2013 Monthly Mean Temperature versus 64-Year Monthly Average.

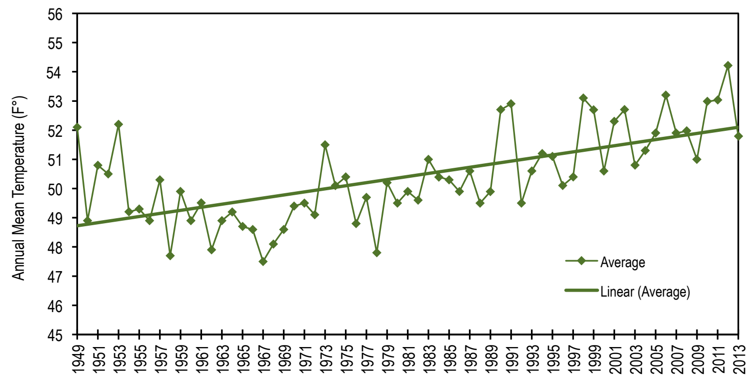


Figure 1-6. BNL 2013 Annual Mean Temperature Trend (64 Years).

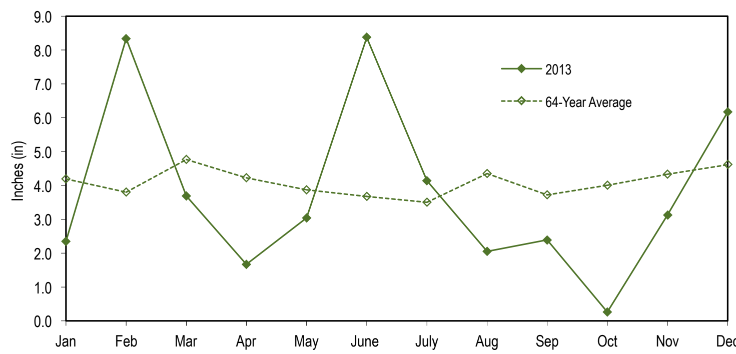


Figure 1-7. BNL 2013 Monthly Precipitation versus 64-Year Monthly Average.

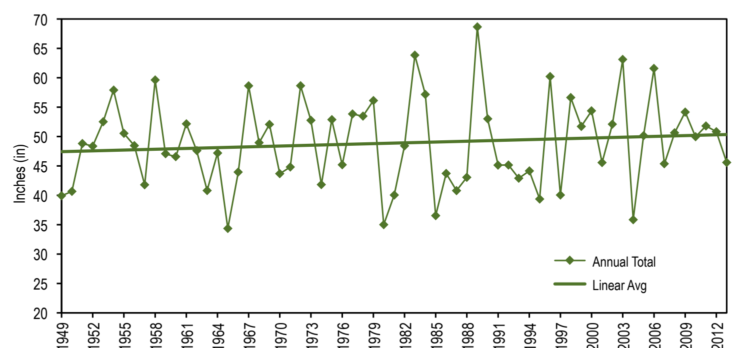


Figure 1-8. BNL 2013 Annual Precipitation Trend (64 Years).

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.

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Environmental Management System 2

One of Brookhaven National Laboratory's highest priorities is ensuring that its commitment to environmental protection is as strong as its passion for discovery. Brookhaven Science Associates (BSA), the contractor operating the Laboratory on behalf of DOE, takes environmental stewardship very seriously. As part of its commitment to environmentally responsible operations, BSA has established the BNL Environmental Management System (EMS).

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 an EMS registration, and recertification audits of the entire EMS occur every 3 years. In 2013, an EMS re-certification audit determined that BNL remains in conformance with the ISO 14001: 2004 Standard.

In 2013, BNL continued its strong support of its Pollution Prevention Program, which seeks ways to eliminate waste and toxic materials. Pollution prevention projects resulted in more than $12.7 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 13.4 million pounds of waste. Also in 2013, the BNL Pollution Prevention Council funded three new proposals, investing approximately $6,000. Anticipated annual savings from these projects are estimated at approximately $17,500, for an average payback period of approximately 4 months. 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 environmental issues, 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 and execution. The purpose of BNL's ISMS is to ensure that the way we do work integrates DOE's five Core Functions and seven Guiding Principles into all work processes.

The five Core Functions, as defined by DOE P 450.4, *Safety Management System Policy*, are:

- DEFINE THE SCOPE OF WORK: Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.
- IDENTIFY AND ANALYZE HAZARDS ASSOCIATED WITH THE WORK: Hazards associated with the work are identified, analyzed, and categorized.

- DEVELOP AND IMPLEMENT HAZARD CONTROLS: Applicable standards and requirements are identified and agreed upon, controls to prevent/mitigate hazards are identified, the safety envelope is established, and controls are implemented.
- PERFORM WORK WITHIN CONTROLS: Readiness is confirmed and work is performed safely.
- PROVIDE FEEDBACK ON ADEQUACY OF CONTROLS AND CONTINUE TO IMPROVE SAFETY MANAGEMENT: Feedback information on the adequacy of controls is gathered; opportunities for improving the definition and planning of work are identified and implemented; line and independent oversight is conducted; and, if necessary, regulatory enforcement actions occur.

The seven Guiding Principles, also defined by DOE P 450.4, are:

- LINE MANAGER CLEARLY RESPONSIBLE FOR SAFETY: Line management is directly responsible for the protection of the public, the workers, and the environment.
- CLEAR ROLES AND RESPONSIBILITIES: Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels.
- COMPETENCE COMMENSURATE WITH RESPONSIBILITIES: Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.
- BALANCED PRIORITIES: Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever activities are planned and performed.
- IDENTIFY STANDARDS AND REQUIREMENTS: Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of safety standards and requirements shall be established which, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.
- HAZARD CONTROLS TAILORED TO WORK BEING PERFORMED: Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work being performed and associated hazards.
- OPERATIONS AUTHORIZATION: The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.

The integrated safety processes within ISMS contributed to BNL achieving ISO 14001 and Occupational Health and Safety 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 for purposes of improving safety and providing a safe and healthy workplace, free from recognized hazards for all operations. 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.

The Laboratory'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 systems are maintained.

An ISO 14001 and OHSAS 18001 re-assessment audit was conducted by auditors from NSF International Strategic Registrations in May 2013 (OHSAS 18001 results are not included in this report). The Laboratory was recommended for continued certification to both standards. During the audit, one minor nonconformance was identified; the need for the Laboratory to consistently communicate BNL's Environmental, Safety, Security, and Health (ESSH) Policy to contractors. The Contractor Vendor Orientation (CVO) program training was updated to communicate the ESSH Policy.

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 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 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 impact 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.

Signed in 2009, Executive Order (EO) 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, establishes sustainability goals for federal agencies and focuses on improving their environmental, energy, and economic performance. In addition to guidance, recommendations, and plans, which are due by specific sustainability due dates, EO 13514 has set numerical targets for agencies.

Each governmental facility is required to have a Site Sustainability Plan (SSP) in place detailing the strategy for achieving these long-term goals, and to provide an annual status. The requirements will influence the future of BNL's EMS program and most have already been incorporated into BNL's SSP. Table 2-1 identifies the EO goal, the actions contained in the SSP, and BNL's performance in 2013.

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. BSA works closely with DOE to clearly define expectations and performance measures. Factors for selecting environmental priorities include:

- Meeting the intent and goals of EO 13514
- 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. For FY 2013, BNL's environmental objective included maintaining ISO 14001 and OHSAS 18001 certifications.

2.3.4 Environmental Management Programs

Each organization within BNL develops an action plan detailing how they will achieve their environmental objectives and targets, as well as 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 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 developed a Groundwater Protection Contingency Plan that defines an orderly process for quickly verifying the results and taking corrective actions in response to unexpected monitoring results (BNL 2013).

Table 2-1. EO 13514 Goals: Status Summary for Fiscal Year (FY) 2013.

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Goal 1: Greenhouse Gas Reduction and Comprehensive Greenhouse Gas Inventory		
28 percent Scope 1 and 2 greenhouse gas reduction by fiscal year 2020 from a fiscal year 2008 baseline (2013 status: 17 percent).	The fiscal year 2008 baseline was 205,542 $MtCO_2e$. In fiscal year 2013, BNL's Scope 1 and 2 greenhouse gas emissions totaled 80,466 $MtCO_2e$, a decrease of 60.9 percent against the fiscal year 2008 baseline.	Continuing efforts in fiscal year 2014 include hydropower, on-site Long Island Solar Farm, photo voltaic research and development, Renewable Energy Credit purchases, and energy intensity reduction through the Utility Energy Service Contract Phase 1. Planned actions include the Utility Energy Service Contract Phase II and consideration of small combined heat and power.
13 percent Scope 3 greenhouse gas reduction by fiscal year 2020 from a fiscal year 2008 baseline (2013 status: 4 percent).	Overall, Scope 3 greenhouse gas emissions have been reduced by 13 percent from the fiscal year 2008 baseline of 20,003 MtCO2e to 17,397 MtCO2e in fiscal year 2013. Emissions from employee business travel have increased 12.8 percent from 8,667 MtCO2e in fiscal year 2008 to 9,780 MtCO2e in fiscal year 2013.	Planned efforts include: consideration of options to reduce greenhouse gas from employee business travel; improving metrics for commuting greenhouse gas; amending domestic and foreign travel procedures to encourage use of hybrid vehicles; expanding user teleconferencing capabilities through the deployment of enhanced communication technologies during sitewide telephone replacement; conducting a survey about expanding shuttle services and possible introduction of a bussing service and on-site communal bicycles; and working with MetroPool on a BNL Rideshare Portal.
Goal 2: High Performance and Sustainable Buildings, Energy Saving Performance Contracts Initiative Schedule, and Regional and Local Planning		
30 percent energy intensity BTU/GSF (British Thermal Units Per Gross Square Foot) reduction by fiscal year 2015 from a fiscal year 2003 baseline (2013 status: 24 percent).	BNL's current level of energy intensity is 296,375 Btu/GSF. This level represents a cumulative reduction of 8.5 percent from the fiscal year 2003 baseline of 323,780 Btu/GSF.	The Utility Energy Services Contract was awarded on October 22, 2013. Phase I implementation will start in early 2014. It is estimated to result in an approximate 11 percent reduction in energy intensity. Energy conservation measures include improving the efficiency of supplying chilled water; lighting upgrades throughout the Laboratory, and installation of building controls with enhanced temperature setback. Further phases and other planned initiatives include providing free cooling, improving the steam system, and combined heat and power and/or biomass.
Energy Independence and Security Act Section 432 energy and water evaluations.	100 percent completed within last 4 years.	Green Energy Surveys will continue to be combined with Facility Condition Assessments to reduce audit costs.
Individual buildings metering for 90 percent of electricity (by October 1, 2012); for 90 percent of steam, natural gas, and chilled water (by October 1, 2015). (2013 status: 90 percent and 50 percent, respectively).	The status of individual building metering is as follows: electric: 97 percent; natural gas: 100 percent; steam: 85 percent; and chilled water: 100 percent. Several Ethernet-based Power Quality meters were installed throughout the Laboratory; several steam meters were upgraded to the advanced metering platform; chilled water metering in the National Synchrotron Light Source II includes segregated metering for the ring/process loads and the laboratory-office buildings cooling loads; and advanced potable water metering has been installed in the Interdisciplinary Science Building-1.	Data Center 459: An advanced dual channel ultrasonic chilled water meter will be installed to separate data center and office load, and an electric meter will be installed on UPS to meter data center electric load. Data Center 515: The small chilled water meter line serving perimeter offices will be meter-advanced, and two electric sub-meters will be installed to segregate office and data center electric load.
Cool roofs, unless uneconomical, for roof replacements unless project already has CD-2 approval. New roofs must have thermal resistance of at least R-30.	In fiscal year 2013, one cool roof was added to Building 734.	In October 2013, a reminder was sent to all roofing project managers to review potential projects against the DOE Cool Roof requirements.

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Table 2-1. EO 13514 Goals: Status Summary for Fiscal Year (FY) 2013 *(continued).*

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
15 percent of existing buildings greater than 5,000 gross square feet (GSF) are compliant with the Guiding Principles of High Performance and Sustainable Buildings by fiscal year 2015 (2013 status: 11 percent).	The Modernization Project Office continues to make progress towards the 15 percent requirement and received a High Performance and Sustainable Buildings recognition letter from DOE Headquarters. At the end of fiscal year 2013, BNL is 72 percent High Performance and Sustainable Buildings compliant for the nine buildings that will not achieve Leadership in Energy and Environmental Design (LEED) certification. Tasks completed in fiscal year 2013 include: replacement of the HVAC system at Building 438; installation of occupancy sensors in all High Performance and Sustainability Buildings; installation of night setback controls in Buildings 438 and 935; and HVAC, lighting, and hot water High Sustainability Buildings improvements in Building 817.	The Modernization Project Office has put together a schedule for the completion of the remaining High Performance and Sustainability Buildings projects in fiscal year 2014 and early fiscal year 2015. For fiscal year 2014, work planned includes HVAC, fume hood, and lighting upgrades in Building 599; roof replacement for Building 438; miscellaneous metering; and bid/award of Building 459 indoor air quality improvements and HVAC upgrade. In fiscal year 2015, work will include the completion of Building 459, data center improvements if required, and retrocommissioning. This work is planned for the first quarter of fiscal year 2015 to ensure completion well ahead of the milestone of September 30, 2015.
All new construction, major renovations, and alterations of buildings greater than 5,000 gross square feet must comply with Guiding Principles.	The Interdisciplinary Science Building-I was completed in fiscal year 2013 and achieved LEED Gold certification, indicating compliance with the Guiding Principles.	LEED Gold for the National Synchrotron Light Source II laboratory-office buildings was achieved in fiscal year 2013. No new major construction or renovation projects are expected in fiscal year 2014.
Goal 3: Fleet Management		
Achieve a 10% annual increase in fleet alternative fuel consumption by fiscal year 2015 relative to a fiscal year 2005 baseline (2013 status: 114 percent cumulative since 2005).	Fiscal year 2013 performance compared to fiscal year 2012 showed a 21 percent increase in alternative fuel consumption from 42,629 gallons in fiscal year 2012 to 51,713 gallons in fiscal year 2013. Alternative fueling infrastructure exists for compressed natural gas, 85 percent ethanol fuel, and biodiesel.	Continue to purchase alternative fuel vehicles and remove petroleum vehicles as much as practical.
Achieve a 2% annual reduction in fleet petroleum consumption by fiscal year 2020 relative to a fiscal year 2005 baseline (2013 status: 114 percent cumulative since 2005).	Fiscal year 2013 performance compared to 2012 showed an 18 percent decrease in petroleum consumption from 84,449 gallons in fiscal year 2012 to 69,263 gallons in fiscal year 2013. BNL is reducing petroleum consumption by replacing gasoline and diesel vehicles with alternative fuel vehicles, as budgets permit.	Continue to purchase alternative fuel vehicles and remove petroleum vehicles as much as practical.
Ensure that 100 percent of light duty vehicle purchases consist of alternative fuel vehicles by fiscal year 2015 and thereafter (75 percent by fiscal year 2000-2015).	In past several years, all light duty vehicles purchased were alternative fuel vehicles.	Continue to ensure that 100 percent of light duty vehicles are purchased as alternative fuel vehicles.
Reduce fleet inventory of non-mission critical vehicles by 35 percent by fiscal year 2013 relative to a fiscal year 2005 baseline.	Identified 253 mission-critical vehicles and reduced the fleet from a 2005 baseline of 298 vehicles to the current size of 259 vehicles.	This goal has been achieved.
Goal 4: Water Use Efficiency and Management		
Reduce potable water (gallons per square foot) by 26 percent by FY 2020 from a FY 2007 baseline (2013 status: 12 percent).	Annual water use intensity has decreased from 101 gallons per square foot to 85 gallons per square foot, a 15.5 percent water usage reduction since base year 2007. The Sewage Treatment Plant modification contract was awarded, and fieldwork commenced in the fourth quarter of fiscal year 2013.	A contractor is scheduled to complete the Sewage Treatment Plant modification in the second quarter of fiscal year 2014. The project will result in the recycling of approximately 70 percent of the potable water used at BNL. In fiscal year 2014, the Laboratory will continue with the replacement of existing water-related fixtures with low flow fixtures.

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Table 2-1. EO 13514 Goals: Status Summary for Fiscal Year (FY) 2013 *(concluded).*

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Reduce water consumption of industrial, landscaping, and agricultural water by 20 percent by fiscal year 2020 from a fiscal year 2010 baseline (2013 status: 6 percent).	No permanent landscaping or agricultural water use.	No actions are planned.
Goal 5: Pollution Prevention and Waste Reduction		
Divert at least 50 percent of non-hazardous solid waste, excluding construction and demolition debris by fiscal year 2015.	BNL's non-hazardous solid waste recycling rate was approximately 62 in fiscal year 2013.	Planned actions include revising training to educate employee on recycling programs; conducting a study to test the efficiency of remanufactured toner cartridges; and soliciting ideas for partial or full funding of projects that minimize waste and prevent pollution.
Divert at least 50 percent of construction and demolition debris by fiscal year 2015.	BNL recycles 95 percent of construction, demolition, and woody debris.	Continue to send material to Construction & Demolition transfer station for sorting and recycling. Continue to convert concrete, stone, and brick debris into recycled concrete aggregate for reuse on site.
Goal 6: Sustainable Acquisition		
Ensure procurements meet requirements by including necessary provisions and clauses (Sustainable Procurements/Bio-based Procurements).	All contract actions for construction and custodial products met sustainable acquisition requirements in fiscal year 2013.	Performance in sustainable acquisition will be documented in the fiscal year 2014 Pollution Prevention Tracking and Reporting System and the Consolidated Energy Data Report. The performance for the purchase of bio-based products will be documented in the System for Award Management for fiscal year 2014.
Goal 7: Electronic Stewardship and Data Centers		
Ensure all data centers are metered to measure a monthly Power Utilization Effectiveness (PUE) of 100 percent by fiscal year 2015 (2013 status: 80 percent).	Initial PUE study indicated current PUE to be above 1.6.	BNL is working to install additional metering so that a more accurate PUE for each data center may be measured and monitored. The meter is expected to be completed in the third quarter of fiscal year 2014.
Achieve maximum annual weighted average PUE of 1.4 by fiscal year 2015 (2013 status: 80 percent).	Initial PUE study indicated current PUE to be above 1.6.	Once all meters are in place, PUE will be monitored to evaluate the course of action needed to meet the goal of 1.4.
Ensure 100% of eligible PCs, laptops, and monitors have power management actively implemented and in use by FY 2012	▪ LANDesk power management implemented on all suitable systems.	▪ Continue to assess if any additional systems can use the power management systems.
Goal 8: Renewable Energy		
20 percent of annual electricity consumption from renewable sources by fiscal year 2020 (2013 status: 7.5 percent).	BNL purchased 40 million kWh of renewable energy credits, which equals approximately 9 percent of the Laboratory's total usage of electric and thermal energy. The on site Long Island Solar Farm began operations November 2011, and in fiscal year 2013, provided 54 million kWh/year of clean renewable energy to Long Island.	Construction of the Research and Development solar array began in the fourth quarter of fiscal year 2013 and will continue in fiscal year 2014. A CHP study was completed in August 2013, and evaluation of the potential benefits is ongoing. Renewable energy credit purchases will continue, and the quantity will need to be significantly increased due to the 20 percent requirement.

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 2013.

2.3.4.3 Waste Management

As a byproduct of the world-class research it conducts, BNL generates a wide range of wastes. These wastes include materials common to many businesses and industries, such as office wastes (e.g., paper, plastic, etc.), aerosol cans, batteries, paints, and oils. However, the

Laboratory's unique scientific activities also generate "specialized" waste streams that are subject to additional regulation and special handling, including radioactive, hazardous, and mixed waste. BNL's Waste Management Facility (WMF), operated by the Environmental Protection Division (EPD), is responsible for collecting, storing, transporting, and managing the disposal of these specialized wastes. This modern facility was designed for handling hazardous, industrial, radioactive, and mixed waste and is comprised of two staging areas: a facility for hazardous waste and mixed waste (both hazardous and radioactive) in Building 855, regulated by RCRA, and a reclamation building for radioactive material in Building 865. The RCRA building is 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 has reduced its waste storage footprint by consolidating hazardous and mixed wastes into its RCRA waste building.

In 2013, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 3.1 tons
- Mixed waste: 100 ft^3
- Radioactive waste: 2,526 ft^3

Hazardous waste from routine operations in 2013 decreased from 2012 generation rates, as shown in Figure 2-1a. Mixed waste generation increased from 2012 rates, as shown in Figure 2-1b, and can be attributed to increased activities at the Collider Accelerator Department (CAD) (i.e., dispositioning of unneeded lead). As shown in Figure 2-1c, radioactive waste for routine operations decreased from 2012 rates, and can be attributed to normal fluctuations in routine operations. Routine operations are defined as ongoing industrial and experimental operations.

Wastes generated by remediation projects, facility decommissioning activities, or one-time events (e.g., lab clean-out) are considered non-routine. In 2013, BNL continued to reduce the inventory of legacy waste materials through laboratory cleanouts. Wastes from facility decommissioning activities included primarily debris and equipment from the former Hot Shop and Hot Laundry buildings. Other non-routine wastes included the disposal of lead-contaminated debris, lead shielding, and polychlorinated biphenyl (PCB) wastes.

Figures 2-1d through 2-1f show wastes generated from non-routine operations. Waste generation from these activities has varied significantly from year to year. This is expected, as various decommissioning and remedial actions are conducted.

2.3.4.4 Pollution Prevention and Waste 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 national and DOE pollution prevention goals and policies, and represents an ongoing effort to make pollution prevention and waste minimization an integral part of BNL's operating philosophy.

Pollution prevention and waste reduction goals have been incorporated into the DOE contract with BSA, into BNL's ESSH Policy, the Performance Evaluation Management Plan associated with the Laboratory's operating contract with DOE, and BNL's SSP. 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"
- 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

Three Pollution Prevention proposals were funded in 2013, for a combined investment of approximately $6,000. The anticipated annual savings from these projects is estimated at $17,500, for an average payback period of approximately 4 months. 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 2013, 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 2013, these efforts resulted in more than $12.7 million in cost avoidance or savings and approximately 13.4 million pounds of materials being reduced, recycled, or reused annually.

In 2013, BNL's biggest pollution prevention project was the repurposing of its g-2 magnet. The magnet was shipped to Fermi National Accelerator Laboratory for the purpose of studying the properties of muons. The cost of moving this highly sensitive piece of equipment was $3 million, compared to the estimated $10 to $50 million to build a new one.

The Laboratory also has an active and successful solid waste recycling program, which involves all employees. In 2013, BNL collected approximately 160 tons of office paper for recycling. Cardboard, bottles and cans, construction debris, motor oil, scrap metals, lead, automotive batteries, electronic scrap, fluorescent light bulbs, and drill press/machining coolant were also recycled. Table 2-3 shows the total number of tons (or units) of the materials recycled in 2013.

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. Through an annual maintenance program, conventional plumbing fixtures are replaced with low-flow devices.

The Laboratory's 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 14-year trend of water consumption. Total water consumption in 2013 was approximately 1.2 million gallons less than in 2012. This decrease can be attributed to water conservation efforts and less water used for cooling. In each of the past 5 years, the water consumption total was approximately half the 1999 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 and implementing 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 efforts and assisting DOE in meeting the energy and sustainability goals in EO 13514; DOE Order 436.1, Departmental Sustainability; and the Secretary's initiatives. The Laboratory's SSP addresses all aspects of the DOE energy, water, transportation and other sustainability goals.

BNL has more than 4 million square feet of building space. Many scientific experiments at the Laboratory use particle beams generated and accelerated by electricity, with the particles controlled and aligned by large electromagnets. In 2013, BNL used approximately 271 million kilowatt hours (kWh) of electricity, 128,000 gallons of fuel oil, 16,000 gallons of propane, and 619 million ft^3 of natural gas.

Fuel oil and natural gas produce steam at the Central Steam Facility (CSF). Responding to market conditions, fuel oil and natural gas is historically used whenever each respective fuel is least expensive. However, given the current price disparity between natural gas and oil, BNL will continue to purchase natural gas over oil, further reducing greenhouse gas emissions (GHG). Additional information on natural gas and fuel oil use can be found in Chapter 4.

BNL continues to participate 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. BNL 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. In 2013, this scheduling reduced the electric demand at the Laboratory by 25 MW, saving approximately $1.5 million in electric costs and helping to maintain the

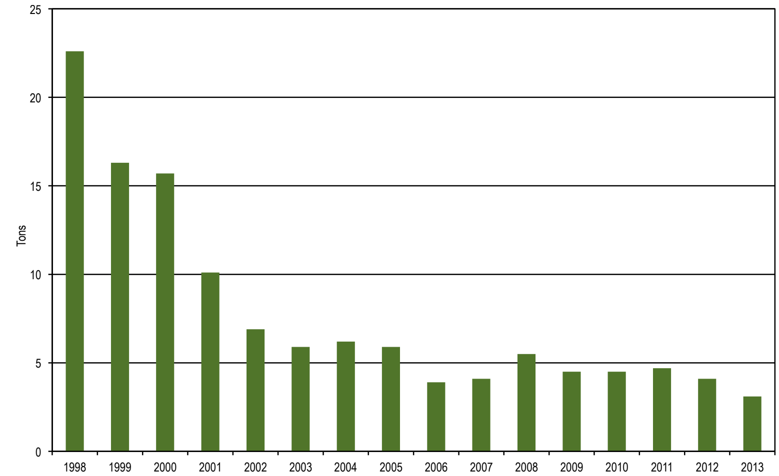

Figure 2-1a. Hazardous Waste Generation from Routine Operations, 1998 – 2013.

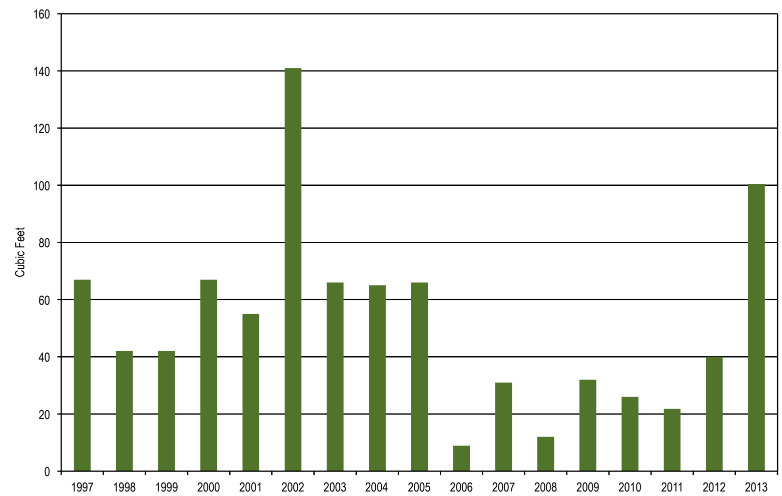

Figure 2-1b. Mixed Waste Generation from Routine Operations, 1998 – 2013.

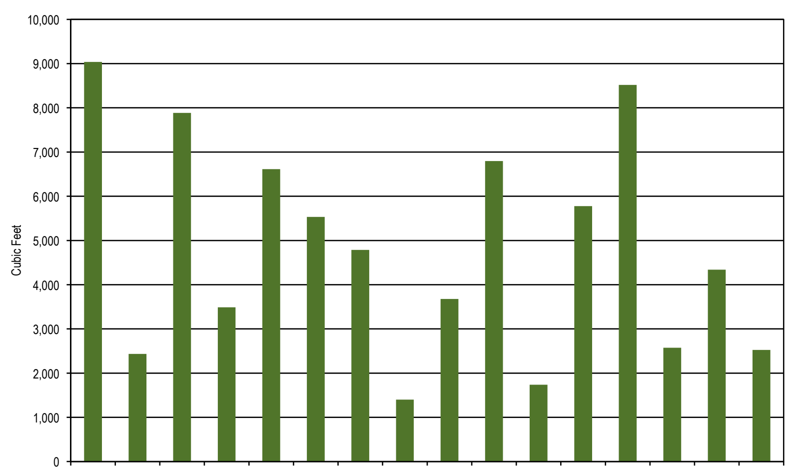

Figure 2-1c. Radioactive Waste Generation from Routine Operations, 1998 – 2013.

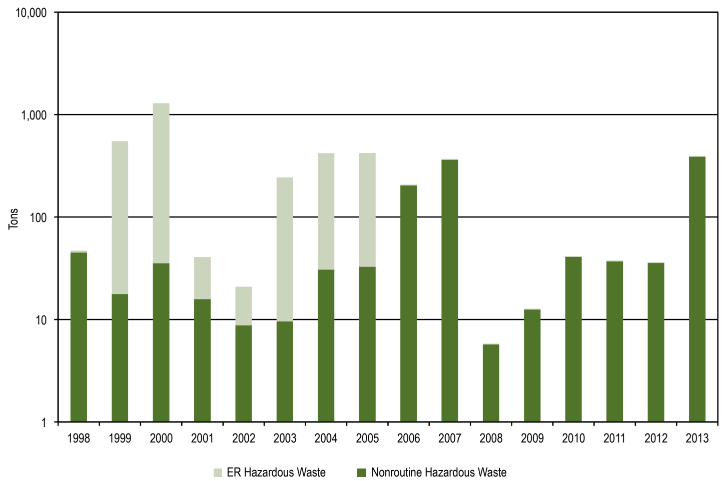

Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 1998 – 2013.

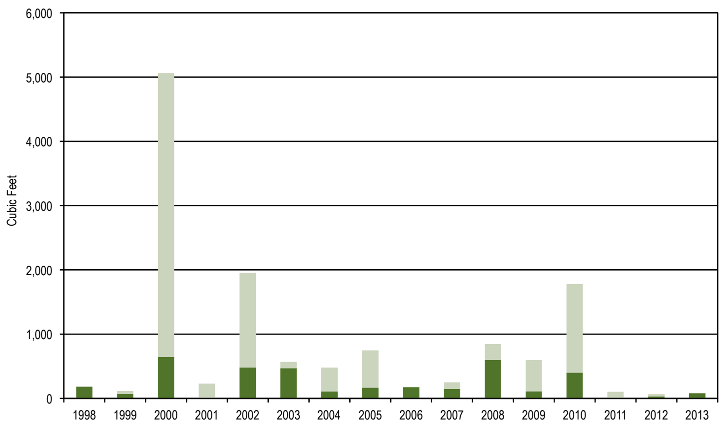

Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 1998 – 2013.

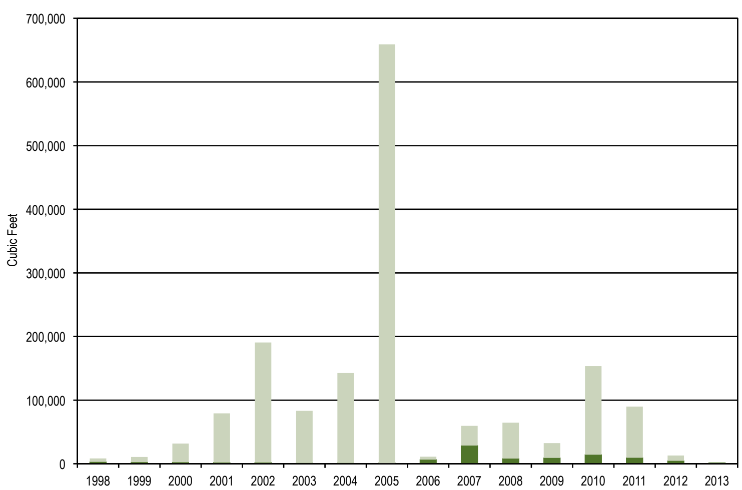

Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 1998 – 2013.

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 $26.8 million in 2013. The Laboratory will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs. Further, BNL's energy supply now includes approximately 118 million kWh of clean, renewable hydropower (received through the LISF).

In 2011, BP Solar completed construction of the Long Island Solar Farm (LISF) on DOE/BNL property. The array is currently the largest solar photovoltaic (PV) array (32 MW) in the Northeast and spans 195 acres with 164,000 panels. BNL worked extensively with LIPA, BP Solar, the State of New York, and other organizations to evaluate the site and develop the project, with LIPA purchasing the output through a 20-year Power Purchase Contract. The estimated annual output of 44 million kWh results in an avoidance of approximately 31,000 tons of carbon per year over its 30- to 40-year life span. The actual output for the first 3 operational years was an average of 52 million kWh/year, substantially above the estimated annual average value. As an outcome of constructing this large array on site, the Laboratory is developing

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2013	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
g-2 Magnet	Reuse	1,700,000	Metal/Scientific Equipment	$0	$3,000,000	$10,000,000	Collider Accelerator shipped its g-2 electromagnet to Fermi National Accelerator Laboratory. Cost estimates for building this piece of equipment from scratch range from 10-50 million dollars.
Mobile Fuel Oil Tank	Spill Prevention	N/A	Oil Spills	$7,000	$3,000	$5,000	Purchased a mobile fuel trailer for use with the satellite boilers; cost-shared project with the Utilities Group.
Lab Cleanouts	Chemical Disposal	600	Lab Chemicals	$15,000	$2,500	$12,500	Hired an experienced summer intern to aid the Waste Management Representative of the Biological Sciences buildings with chemical cleanouts.
Replacement of Small PCB Capacitors	Substitution	N/A	PCB	$4,000	$4,000	$0	Collider Accelerator Department removed and replaced 50 small capacitors containing PCBs and also removed an additional 25 capacitors containing PCBs from obsolete equipment.
Replacement of X-Ray Film Processing with Chemiluminicent Imaging	Substitution	835	Hazardous and Industrial Liquid Wastes	$27,000	$5,500	$179,000	Cost savings reflect: labor, waste disposal, and items (such as film) which will no longer need to be purchased.
Motion Sensors for Building 725	Energy Conservation	N/A	Greenhouse Gas/ Energy Conservation	N/A	$0	$6,000	Installation of motion sensored lighting in hallways, restrooms, and conference rooms in Building 725 during 2011.
LED Lighting in 490 Conference Room	Energy conservation	N/A	Greenhouse Gas/ Energy Conservation/ Manpower	$2,940	$0	$3,710	(40) 65-Watt incandecent bulbs were replaced with LED bulbs in Building 490 during 2011; savings of $1190/yearr in energy costs and $2520/yearr in manpower costs.
Motion Sensors for Building 820	Energy Conservation	N/A	Greenhouse Gas/ Energy Conservation	N/A	$0	$1,650	Installation of motion sensored lighting in Physics research area of Building 820.
Alkaline Batteries	Recycling	174	Industrial Waste	$10	$0	$10	150 pounds of alkaline batteries were collected and sent for recycling.
BioDiesel Tank, E-85, CNG	Alternative Fuels	0	Greenhouse Gas/ Energy Conservation	$0	$0	$0	BNL is utilizing alternative fuels to operate maintainance vehicles.
Motion Sensors for Labs*	Energy Conservation	N/A	Greenhouse Gas/ Energy Conservation	N/A	$0	$5,817	Installation of motion detector lighting in common areas of Buildings 490 and 463.

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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 2013	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
"Bio Circle Cleaner" Parts Washer	Substitution	640	Hazardous Waste	$10,000	$0	$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	$40,944	$0	$40,944	Empty aerosol cans are recycled as scrap, rather then sent to the Waste Management Division as hazardous waste. Eight units (Facilities & Operations=5, Collidar Accelerator=1, National Snchrotron Light Source=1, Basic Energy Sciences=1) each handle 66 lbs. of hazardous waste.
Electronic Reuse	Reuse	2,400	E-Waste	$6,000	$0	$6,000	BNL tracks electronic equipment and takes a reuse credit for transfer of equipment to another user.
Building Demolition Recycling	Recycling	10,000,000	Industrial Waste	$448,700	$25,000	$423,700	On-site demolition products (steel and concrete) are segregated, recycled, and reused.
System One Parts Washer	Substitution	1,280	Hazardous Waste	$12,000	$0	$12,000	Central Fabrications and Motor Pool each purchased 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.
Animal Bedding Conveying System	Composting	78,000	Low-Level Radiological Waste	$1,002,456	$0	$1,002,456	Animal bedding material is no longer sent to the sanitary sewer. It is now conveyed to a dumpster that is emptied and composted at the stump dump. The sanitary sludge was previously sent out as low-level radiological waste.
Lead Acid Batteries	Recycling	4,280	Universal Waste	$29,207	$0	$29,207	Avoids hazardous waste disposal costs for approximately 40 lbs. of lead per battery.
Cooling Tower Chemicals	Source Reduction	6,000	Industrial Waste	$12,000	$0	$12,000	Ozone water treatment units were installed on cooling towers at the National Space Radiation Laboratory (Building 957), the Special Ejection Magnet (Building 912A) and the Relativistic Heavy Ion Collider Reseach Facility (Building 1004) 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.

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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 2013	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Blasocut Machining Coolant	Recycling/ Reuse	45,200	Industrial Waste	$119,244	$0	$128,844	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it Laboratory-wide. In 2013, 5,650 gallons (45,200 lbs.) of Blasocut lubricant were recycled. Recycling involves aeration, centrifuge, and filtration and avoids cost of disposal as industrial waste and an avoided cost of buying 12 drums of concentrate ($800/drum) and 113 empty drums for shipping ($50/drum).
Fluorescent Bulbs	Recycling	13,540	Universal Waste	$473,900	$20,000	$453,900	Fluorescent bulbs are collected and sent to a recycling facility under the Universal Waste exemption rule.
Used Motor Oil	Energy Recovery	12,400	Industrial Waste	$32,426	$0	$32,426	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 2013, they collected 1,550 gallons of oil at no charge to BNL, which avoided the costs for disposal and 31 shipping drums ($50/drum).
Office Paper	Recycling	320,260	Industrial Waste	$16,814	$0	$23,219	Cost avoidance based on $105/ton for disposal as trash, plus $40/ton.
Cardboard	Recycling	193,360	Industrial Waste	$10,151	$0	$12,568	Cost avoidance based on $1055/ton for disposal as trash, plus $25/ton revenue.
Electronic Waste	Recycling	45,620	Industrial/Universal Waste	$114,050	$0	$134,112	Cost avoidance based on $105/ton for disposal as trash, plus $900/ton revenue.
Metals	Recycling	347,164	Industrial Waste	$18,226	$0	$170,897	Cost avoidance based on $105/ton for disposal as trash, plus $900/ton revenue.
Bottles/Cans	Recycling	32,920	Industrial Waste	$1,728	$0	$1,728	Cost avoidance based on $105/ton for disposal as trash.
Construction Debris	Recycling	608,360	Industrial Waste	$31,939	$0	$15,817	Cost avoidance based on $52/ton difference for disposal as trash.
	TOTALS	13,413,561		$2,435,735	$3,060,000	$12,723,505	

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

a solar research program that will look at impacts of climate change on large utility-scale PV systems, as well as research and development for solar power storage and inverter efficiencies. The Federal Energy Management Program (FEMP) recognizes the importance of the efforts of BNL and the DOE Brookhaven Site Office to host the LISF, and are providing credit toward BNL's SSP renewable energy goal.

In addition, the Laboratory has nearly completed the installation of the first phase of the 1 MW solar PV array for additional research. The 500 kW phase one array is estimated to become operational in the summer of 2014. The remaining 500 kW is expected to be completed in 2015-2016.

To reduce energy use and costs at non-research facilities, several additional activities were undertaken by the BNL Energy Management Group in 2013:

- *NYPA Power Contract*: Second full year of a 10-year contract that includes 15 MW of renewable (nearly zero GHG) hydropower. This contract is estimated to save in excess of $26 million per year compared to prevailing energy rates, with an option to renew for an additional 5 years. Actual savings for FY 2013 were $26.8 million.
- *DOE Sustainability Initiative*: The Energy Management Group continues to provide substantial support to the Federal/DOE-wide Sustainability Initiative, and has created a BNL Sustainability Leadership Team. The team is developing a formal site-wide sustainability program beyond DOE requirements, participates in one of three subcommittees for DOE on sustainability initiatives, and provides numerous evaluations and estimates on energy use, GHG, renewable energy, and energy-efficiency options.
- *Substantial Progress on Several Initiatives included in BNL's 2013 SSP*: New electric and steam meter installations; funding for energy conservation initiatives; new energy-efficient lighting installed in parking lots and offices; the purchase of Renewable Energy Credits (RECs) in meeting BNL's SSP goal; and training various parties on energy conservation initiatives.
- *Utility Energy Services Contract (UESC)*: Major support to DOE/BHSO in developing a UESC, which included a preliminary audit, completion of a follow-on Investment Grade Audit (IGA), and completion of the UESC contract terms and requirements. A contract was awarded in late October 2013 and construction began in late December. The UESC scope currently includes energy-efficient lighting, new building controls and commissioning, and an energy-efficient chiller project. The project is expected to be completed in July 2015.
- *Energy Conservation*: Energy and water evaluations are completed for 25 percent of the site each year. Cost-effective projects are identified and proposed for funding, as appropriate.
- *High Performance Sustainability Buildings (HPSB)*: Substantial completion of various energy and water conservation projects to achieve compliance in the EPA Portfolio Manager program. BNL is currently on target to substantially meet the HPSB goal.
- *Renewable Energy*: Continued project support for the LISF Project and the Research and Development (R&A) solar PV array (part of NSERC), and annual purchases of Renewable Energy Credits (REC's) to meet targeted goals.
- *Central Chilled Water Facility (CCWF)-Phase II*: The CCWF Phase-II project was completed in 2011 and is now providing chilled water to BNL buildings and processes such as the National Synchrotron Light Source (NSLS) and the data center, using modern energy-efficient chillers. The CCWF utilizes a 3.2 million gallon chilled water storage tank that is used to reduce peak electric demand by producing and storing chilled water during the night.
- *Natural Gas Purchase Contract*: BNL is currently saving approximately $7 million per year compared to oil and $500k compared to purchasing directly from National Grid.
- *Energy Savings*: 25 MW of demand is rescheduled each year to avoid coinciding with the utility summer peak, saving

Table 2-3. BNL Recycled Program Summary, 2002-2013.

Recycled Material	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Mixed paper	209	177	183	194	184	185	157	121	175	183	138	160
Cardboard	157	176	179	143	135	121	147	152	141	126	100	97
Bottles/Cans	19	23	22	22.1	27.7	24.4	19.6	23.7	24	22.5	18	16.5
Tires	3.5	12.3	11	12.8	32.5	19.9	34.5	15.5	10.1	9.2	10	7.1
Construction debris	304	334	367	350	297	287	302	312	416	256	380	304
Used motor oil (gallons)	1,920	3,920	3,860	4,590	2,780	2,020	1,500	1,568	1,700	1,145	1,585	1,550
Metals	48	193	128	559	158	382	460	91	131	84	228	174
Automotive batteries	6.3	4.6	5	4.6	5.5	2.5	2.7	4	1.6	2.1	2	2.1
Printer/Toner cartridges (units)	449	187	105	0	0	0	3,078	1,251	4,132	4,186	4,100	11,233
Fluorescent bulbs (units)	25,067	13,611	12,592	7,930	11,740	25,448	36,741	10,223	8,839	20,220	8,752	13,540
Blasocut coolant (gallons)	8,180	5,030	6,450	3,890	3,970	2,432	3,340	3,810	4,830	5,660	5,610	5,650
Antifreeze (gallons)	0	165	325	0	0	0	0	0	0	0	700	822
Tritium exit signs (each)	28	181	142	0	0	0	0	0	0	18	0	0
Smoke detectors (each)	40	0	0	0	0	0	0	0	0	0	0	0
Road base	2,016	0	2,666	0	0	0	0	0	0	0	0	0
Electronic reuse	0	0	0	0	0	0	16.3	11.4	12	11.6	3.2	1
Scrap electronics	0	0	0	6.1	70.3	40.5	48.9	17	16.7	19.9	30.9	23
Animal Bedding (composted)	0	0	0	0	6.3	19.6	42	41	52	54	3.3	39
Tyvek (lbs)	0	0	0	0	0	0	0	84	60	92	105	0
Metals (building demolition)	8	23	11	6	35	0	0	0	0	0	0	20
Concrete (building demolition)	891	590	3,000	328	5,505	6,175	0	0	4,050	0	0	5,000
Other construction and debris (building demolition)	790	388	1,200	157	818	0	0	0	0	0	0	0

Notes: All units are tons, except where noted.

over $1.5 million in electricity charges.

In addition, work continues in the replacement of aging, inefficient T-40 fluorescent lighting fixtures with new, high efficiency T-8 lighting fixtures (200 to 300 fixtures are typically replaced annually), saving tens of thousands of kWhs each year and reducing costs by several thousand dollars.

Due to continued conservation efforts, overall facilities energy usage for FY 2013 was approximately 8.8 percent less than in FY 2003, saving $930,000. In addition, approximately 16,207 gasoline gallon equivalents (gge) 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, as well as the Energy Independence and Security Act (EISA) of 2007, 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 FY 2006-FY 2015. Further, EO 13514 and associated orders have set even more stringent requirements, including increased use of renewable energy and reductions in transportation fuels that go significantly beyond the previous goal of a 30 percent reduction by FY 2015, compared to FY 1985.

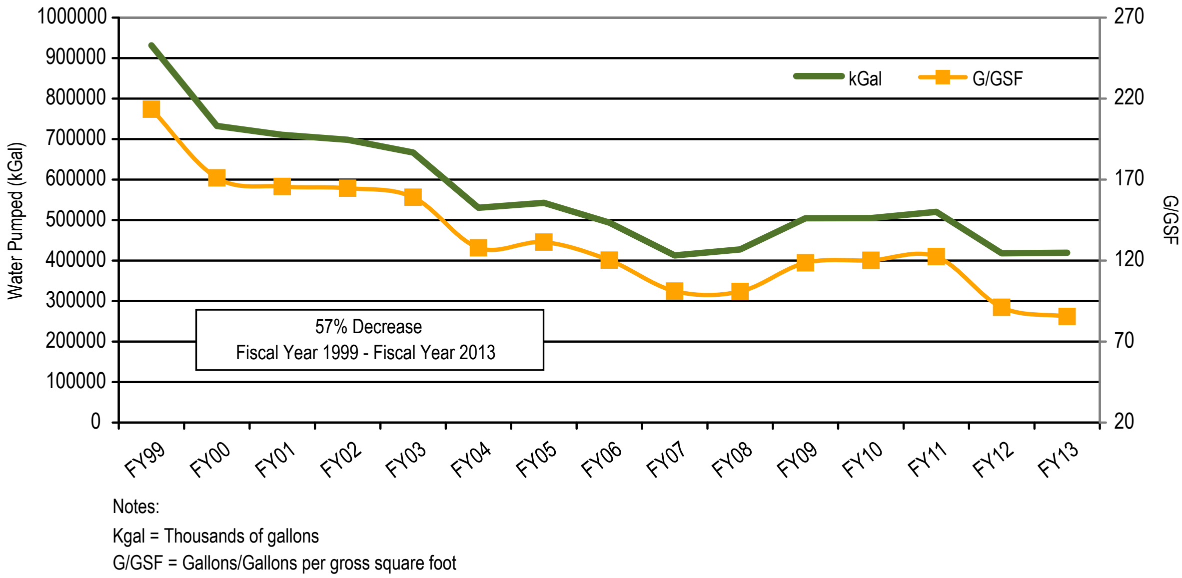

Figure 2-2. Annual Potable Water Use, 1999-2013.

As shown in Figure 2-3, BNL's energy use per square foot in 2013 was 30 percent less than in FY 1985 and 8.8 percent less than in FY 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

Through its Natural Resource Management Plan (BNL 2011), 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 (BNL 2013a) was 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 34 other Long Island sites, 15 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). 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 alternative
- Issue a Record of Decision (ROD), which is the remedy/corrective action agreed to by DOE, EPA, and NYSDEC

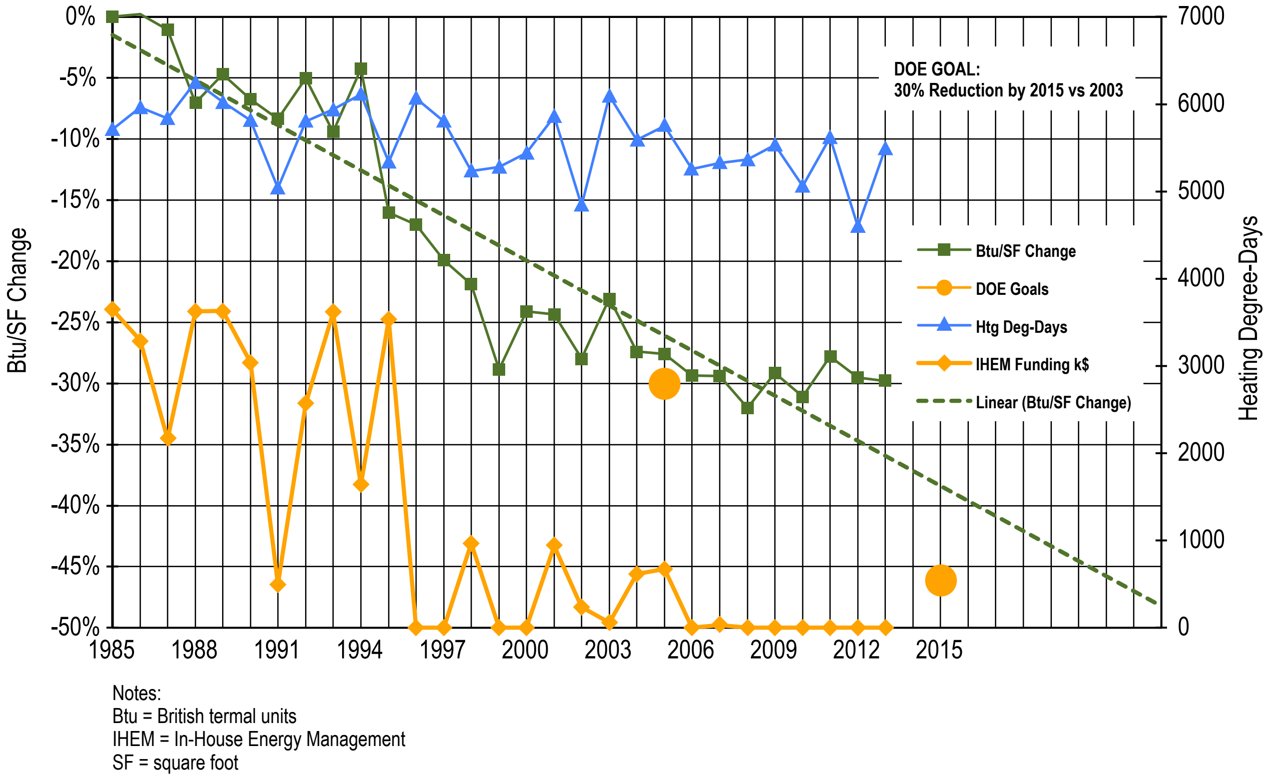

Figure 2-3. BNL Building Energy Performance, 2013 (Btu/SF Change Percent vs. Baseline Years).

- Perform the Remedial Design/Remedial Action, which includes final design, construction specifications, and carrying out the remedy selected

In 2013, BNL's 14 active groundwater treatment systems removed approximately 183 pounds of volatile organic compounds and 1.3 mCi of strontium-90 (Sr-90) from the sole source aquifer. Following approval from the regulators; four groundwater treatment systems were shut down and placed in an operationally-ready stand-by mode; one treatment system was partially decommissioned; and a new extraction well was installed for the Middle Road Treatment System. Also in 2013, long-term surveillance and maintenance (S&M) of the Laboratory's Brookhaven Graphite Research Reactor and the High Flux Beam Reactor continued. In accordance with the ROD, demolition of HFBR stack will be completed prior to 2020.

Post-cleanup monitoring of Peconic River surface water, sediment, fish, and wetland vegetation continued in 2013, and the results are reported in Chapter 6 of this report. Monitoring and control of invasive species was performed at three Peconic wetland areas that were remediated in 2011. This monitoring will continue through 2014 to satisfy federal requirements.

The groundwater systems operate in accordance with the Operations and Maintenance (O&M) manuals, while the Peconic and surface soil cleanup areas are monitored via the Soil and Peconic River Surveillance and Maintenance (S&M) Plan (BNL 2013c). 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 OU, and a summary of environmental restoration actions taken. See Chapter 7 and SER Volume II, *Groundwater Status Report*, for further details.

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

In support of BNL's EMS commitment to communication and community involvement, the Community, Education, Government and Public Affairs (CEGPA) Directorate develops best-in-class communications, science education, government relations, and community involvement programs that advance the science and science education missions of the Laboratory (BNL 2005). CEGPA contributes to public understanding of science and enhances the value of the Laboratory as a community asset and ensures that internal and external stakeholders are properly informed and have a voice in decisions of interest and importance to them. CEGPA also works to maintain relationships with BNL employees, key stakeholders, neighbors, elected officials, regulators, and other community members to provide an understanding of the Laboratory's science and operations, including environmental stewardship and restoration activities, and to incorporate community input into BNL's decision-making process.

To facilitate stakeholder input, CEGPA's Stakeholder Relations Office participates in or conducts on- and off-site meetings which include discussions, presentations, roundtables, and workshops. Stakeholder Relations staff attend local civic association meetings, canvass surrounding neighborhoods, conduct Laboratory tours, and coordinate informal information sessions and formal public meetings, which are held during public comment periods for environmental projects. BNL's Internal Communications Office manages programs to increase internal stakeholder awareness, understanding, and support of Laboratory initiatives, fosters two-way communications, and updates internal stakeholders on BNL priorities, news, programs, and events.

2.4.2.1 Communication Forums

To create opportunities for 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 their staff, regulators, and other government agencies on environmental and operational issues, as well as scientific discoveries and initiatives.
- The Community Advisory Council (CAC), established by BNL in 1998, advises Laboratory management primarily on environmental, health, and safety issues related to BNL that are of importance to the community. The CAC is composed of 27 member organizations and individuals representing civic, education, employee, community, environmental, and health interests. The CAC sets its own agenda in cooperation with the Laboratory and meets monthly. The CAC is one of the primary ways the Laboratory keeps the community informed. Meetings

are open to the public and are announced in the monthly community e-newsletter, *LabLink*, on the BNL homepage calendar and on the Community Relations website. An opportunity for public comment is provided at each meeting and organizations interested in participating on the CAC are encouraged to attend meetings and make their interest known.

- Monthly teleconference calls are held with parties to the Laboratory's Interagency Agreement and other federal, state, and local regulators to keep them up-to-date on project status. The calls also provide the opportunity to gather input and feedback and to discuss emerging environmental findings and initiatives.
- The Stakeholder Relations Office website is used to host links to the CAC webpage, which contains meeting agendas and past meeting presentations and minutes. Stakeholder Relations also manages several outreach programs that provide opportunities for stakeholders to become familiar with the Laboratory's facilities and research projects. Outreach programs include:
  - *Tour Program*: Opportunities to learn about BNL are offered to college, university, professional, and community groups. Tour groups visit the Laboratory's scientific machines and research facilities and meet with scientists who conduct research. Agendas are developed to meet the interests of the groups, and may include sustainability and environmental stewardship issues. Tours were provided for more than 2,250 visitors in 2013.
  - *The Speakers' Bureau*: Speakers are provided for educational institutions and community organizations, such as Rotary Clubs, civic organizations, school assemblies, and professional societies, to update them on Laboratory research and operations accomplishments, including environmental stewardship.
  - *Summer Sundays*: Held on four Sundays each summer, these open houses enable the public to visit BNL science facilities, experience hands-on activities, and learn about research projects and environmental stewardship programs. In 2013, more than 6,000 visitors participated in the program.

The Laboratory participates in various outreach events throughout the year that include festivals, workshops, BNL's Earth Day celebration, the Long Island Earth Summit, the Long Island Green Infrastructure Conference, Long Island Regional Economic Development Council, and the Suffolk County Planning Federation Conference. Brown bag lunch meetings for employees are held periodically and cover topics of interest, including project updates, newly proposed initiatives, wildlife management concerns, and employee benefits information.

BNL's Media & Communications Office issues press releases to news and media outlets and the Internal Communications Office publishes electronic and prints weekly employee newsletters–*Brookhaven This Week* and *The Brookhaven Digest*–that are geared toward employees with email access and those who do not have direct access to a computer. Also, a Director's Office web-based publication, *Monday Memo*, is issued bi-weekly to employees and focuses on administrative topics important to the Laboratory population.

The Laboratory maintains an informative website at *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 news service at *https://lists.bnl.gov/mailman/listinfo/bnl-announce-1*. Community members who have questions or comments can "Let us know" by clicking on the link found under "Listening to you" on the Stakeholder Relations Office website at *www.bnl.gov/stakeholder/.* Community members can also subscribe to the monthly e-newsletter, *LabLink*, found on the Stakeholder Relations webpage at *www.bnl.gov/lablink. LabLink*, which keeps the community informed about happenings at BNL, explains the science behind Laboratory research, and invites subscribers to educational and cultural events.

2.4.2.2 Community Involvement in Cleanup Projects

In 2013, BNL shared information with stakeholders on several environmental projects:

- *Environmental Assessment (EA) for the Management of the White-tailed Deer Population at BNL*: Deer management has been identified as a need at BNL for more than a decade. In working toward management of the deer population on site, BNL has held information sessions, polled its employees, and discussed the issue with regulatory and resource agencies. Several strategies for deer management were evaluated and a preferred alternative, *Integrated Wildlife Damage Management*, was selected. The CAC and BER received updates at their February meetings and a Notice of a Completed EA with a "Finding of No Significant Impact" was published in Long Island's *Newsday* on March 21, 2013.
- *New York State Department of Environmental Conservation Title V Facility Permit Renewal*: BNL manages a number of facilities which are subject to federally enforceable regulatory requirements. Among the more significant is the Central Steam Facility which operates four boilers. Two of the boilers are subject to new source performance standards (NSPS) Subpart DB requirements and are equipped with continuous emissions monitoring systems. Other regulated sources include a paint spray booth and two on-site gasoline refueling facilities. A Notice of Completed Application was published in *Newsday* on October 16, 2013 that provided the public with an opportunity to review and comment on the permit renewal application.
- *Modification of BNL's State Pollutant Discharge Elimination System (SPDES) Permit*: As part of the Wastewater Treatment Modification Project that began in 2009, BNL proposed to eliminate the discharge of its Sewage Treatment Plant effluent to the Peconic River and instead redirect the treated effluent to nearby groundwater recharge basins. A Notice of Complete Application was published in *Newsday* on November 21, 2013. Effluent limits and monitoring requirements were added to the draft permit, and the public was given 30 days to review and comment.

In addition to the projects outlined above, stakeholders were updated on the progress of other environmental cleanup projects, additional initiatives, and health and safety issues via mailings and briefings and presentations given at CAC and BER meetings. These topics included:

- *2011 Annual Groundwater Update*: The CAC received a presentation on the highlights of the annual report in January 2013. Details on the status and effectiveness of the groundwater treatment systems was provided, including an update on the new treatment system installed for the Building 452 Freon-11 plume.
- *Natural Resource Management Update*: The status of the Deer Management Plan and the schedule for implementing it, the 4-poster tick control devices, impacts from the spring 2012 wildfire, and Super Storm Sandy impacts were discussed during a February presentation to the CAC. Information from monitoring the populations of other wildlife found on site was also provided. There was also a brief discussion on the progress of the restoration of the Peconic River following the 2011 completion of the supplemental cleanup.
- *Wastewater Treatment Modification Project*: The CAC received an update on the design and construction status of this ongoing project, which will remove the Sewage Treatment Plant outfall from the Peconic River and re-direct the treated effluent to new groundwater recharge basins.
- *Ticks and Tick Borne Disease Awareness*: Because Suffolk County has a very high Lyme disease case rate, the Laboratory provided the CAC with a presentation on the risks of Lyme and other tick borne diseases, in June. Information was provided on reducing the risk of being bitten, how to remove a tick, and how to recognize the symptoms of tick borne illnesses.
- *Groundwater Treatment System Modification*: In September, an update was given to

Table 2-4. Summary of BNL 2013 Environmental Restoration Activities.

Project	Description	Environmental Restoration Actions
Soil Projects	Operable Unit (OU) I/II/III/VII	▪ Performed monitoring and maintenance of institutional controls for cleanup areas.
Groundwater Projects	OU III/V/VI	▪ Continued operation of 11 groundwater treatment systems that remove volatile organic compounds (VOCs),two systems that remove strontium-90 (Sr-90), and a pump and recharge system for tritium. ▪ Following approval from the regulatory agencies, four treatment systems were shut down and placed in an operationally-ready stand-by mode. One system was partially decommissioned in 2013 following approval from the regulators. ▪ Began operation of a new extraction well to address deeper VOC contamination in the vicinity of Middle Road. ▪ 183 pounds of VOCs and 1.3 mCi of Sr-90 were removed during the treatment of 1.4 billion gallons of groundwater. Since the first groundwater treatment system started operating in December 1996, approximately 7,133 pounds of VOCs and 28.7 mCi of Sr-90 have been removed, while treating over 22 billion gallons of groundwater. ▪ Collected and analyzed approximately 1,702 sets of groundwater samples from 653 monitoring wells. ▪ Installed several temporary wells and collected multiple samples from each location, including in the Industrial Park, to determine the extent of deeper VOC contamination and the need for an additional extraction well(s). ▪ Monitoring of the OU V VOC plume concluded. ▪ Continued monitoring the g-2 tritium plume using temporary and permanent monitoring wells.
Peconic River	OU V	▪ Performed year 8 of long-term post-cleanup monitoring of Peconic River surface water and sediment. ▪ Fish collection was performed in 2013; next collection will be in 2015. ▪ Continued monitoring and maintenance of invasive species at three excavated sediment locations within the Peconic River.
Reactors	Brookhaven Graphite Research Reactor (BGRR)	▪ Continued long-term surveillance and maintenance.
	High Flux Beam Reactor (HFBR)	▪ Continued long-term surveillance and maintenance.
	Stack (Building 705)	▪ Continued long-term surveillance and maintenance.
	Brookhaven Medical Research Reactor (BMRR) (Project managed by EPD)	▪ Continued surveillance and maintenance activities.
Buildings 810/811	Radiological Liquid Processing Facility (Project managed by EPD)	▪ Performed routine surveillance and maintenance of the facility. ▪ EPD removed and shipped the last of the 20,000 gallon tanks from the facility for disposal. ▪ EPD emptied and decontaminated Building 810 for use as a propylene glycol recycling facility.
Building 801	Inactive Radiological Liquid Holdup Facility (Project managed by EPD)	▪ Performed routine surveillance and maintenance of the facility.
Building 650	Inactive Radiological Decon Facility (Project managed by EPD)	▪ Performed routine surveillance and maintenance of the facility.

Note:
EPD = Environmental Protection Division

the CAC on deeper contamination found on site in the vicinity of the OU III Middle Road VOC plume. The deeper contamination would not be captured with the existing extraction wells so a new, deeper well was drilled and will be tied into the existing treatment system.

- *Peconic River Monitoring*: The CAC and BER were provided with the results from sampling the water column and fish in the river. The sampling results for mercury and methyl mercury found in the water column was similar to past data. However, the results for the average mercury levels found in the fish sampled on site were higher than expected. The higher levels were attributed to the sampling a small number of larger and older fish.
- *The 2012 Site Environmental Report*: In November, the CAC received a presentation on the Laboratory's environmental impact for the previous year.
- *2012 Annual Groundwater Update*: A complete review of the Laboratory's groundwater treatment systems was provided to the CAC in December. The systems that have reached their capture goals were discussed and the status of the Building 96 VOC plume source area and the Building 452 Freon-11 plume was given. Detailed cross-section maps of several of the plumes were shown and the reduction in size of the plumes that has occurred over time was highlighted.

Working closely with the community, employees, elected officials, and regulatory agency representatives, DOE and BNL continue to openly share information on issues, projects, and programs and welcome all input and feedback offered.

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 436.1, *Departmental Sustainability*, BNL prepares an Environmental Monitoring Plan (BNL 2012), 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 2013 there were 7,880 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 quality comply with regulatory and permit limits issued under the federal Clean Air Act, Clean Water Act, Oil Pollution Act, SDWA, and the New York State equivalents. Included in compliance monitoring are the following:

- *Air emissions monitoring* is conducted at reactors (no longer in operation), accelerators, and other radiological emission sources, as well as the Central Steam Facility (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.

- *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: 12 under BNL's SPDES Permit, and 12 under equivalency permits issued to the Environmental Restoration Program for groundwater treatment systems. As required by permit conditions, samples are collected daily, weekly, monthly, or quarterly and monitored for organic, inorganic, and radiological parameters. Monthly discharge monitoring reports (DMRs) that provide analytical results and an assessment of compliance for that reporting period are filed with the NYSDEC. 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 Waste Management Facility. 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 SDWA, which is administered by SCDHS.

2.4.3.2 Restoration Monitoring

The Environmental Restoration Program operates and maintains groundwater treatment systems to remediate contaminant plumes both

Table 2-5. Summary of BNL 2013 Sampling Program Sorted by Media.

Environmental Media	No. of Sampling Events(a)	Purpose
Groundwater	2,815 (b)	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	41	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	40 ES 184 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 Environmental 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)	116	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	16	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	250	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	341 ES/C 50 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.
Fauna	84	Fish and deer are monitored to assess impacts on wildlife associated with past or current BNL operations. See Chapter 6 for further detail.

(continued on next page)

Table 2-5. Summary of BNL 2013 Sampling Program Sorted by Media *(concluded).*

Environmental Media	No. of Sampling Events(a)	Purpose
Flora	28	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	51	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	715	Samples are collected periodically from potable water fixtures and dispensers, manholes, spills, to assess process waters, and to assess sanitary discharges.
Groundwater Treatment Systems and Remediation Monitoring	1,030	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 SER Volume II, Groundwater Status Report, for further details.
Vehicle Monitor Checks	102	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.
State Pollutant Discharge Elimination System (SPDES)	437	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	618	Flowcharts are exchanged weekly as part of BNL's SPDES permit requirements to report discharge flow at the recharge basin outfalls.
Floating Petroleum Checks	109	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	744	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 before they are discharged to the Peconic River.
Quality Assurance/ Quality Control Samples (QA/ QC)	109	To ensure that the concentrations of contaminants reported in the Site Environmental Report are accurate, additional quality assurance 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	**7,880**	The total number of sampling events includes all samples identified in the Environmental Monitoring Plan (BNL 2013), 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 65 temporary wells; many of which are used to collect multiple samples at different depth intervals.
C = Compliance
ER = Environmental Restoration (CERCLA)
ES = Environmental Surveillance

on and off site. BNL maintains an extensive network of groundwater monitoring wells to verify the effectiveness of the remediation effort. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. Additionally, surface water, sediment and fish sampling is conducted to verify the effectiveness of the Peconic River cleanup efforts. Peconic River monitoring is coordinated with the Surveillance Monitoring Program to ensure completeness and to avoid any duplication of effort.

Details on the Peconic River monitoring program are provided in Chapter 6, and details on groundwater monitoring and restoration program are provided in Chapter 7 and SER Volume II, *Groundwater Status Report*.

2.4.3.3 Surveillance Monitoring

Pursuant to DOE Order 436.1, *Departmental Sustainability*, 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 extensive 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 and 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 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.*

Due to external recognition of the Laboratory's knowledge and unique experience implementing the EMS program, BNL is often asked to share its experiences, lessons learned, and successes. The Laboratory's environmental programs and projects have been recognized with international, national, and regional awards and audits have consistently observed a high level of management involvement, commitment, and support for environmental protection and the EMS. For more than 60 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.

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Compliance Status 3

Brookhaven National Laboratory is subject to more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; 12 equivalency permits for operation of groundwater remediation systems; and several other binding agreements. In 2013, 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.

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility were all within permit limits. There was one unexpected opacity excursion that occurred in August 2013 for Boiler 6 as a result of a localized short-term power outage that occurred during scheduled electrical system maintenance; other opacity excursions reported for Boiler 6 and 7 were only noted during testing periods. In 2013, there were no discharges of Halon 1211 from portable fire extinguishers or Halon 1301 from accidental or fire induced activation of fixed fire suppression systems. Halon portable fire extinguishers continue to be removed and replaced by dry-chemical or clean agent units as they are encountered.

Monitoring of BNL's potable water system indicated that all drinking water requirements were met during 2013. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System permit requirements. Six excursions above permit limits were reported for the year; five occurred at the Sewage Treatment Plant (total nitrogen, ammonia nitrogen, and total nitrogen load), and one at recharge basin 002 (Tolytriazole). The permit excursions were reported to the New York State Department of Environmental Conservation (NYSDEC) and the Suffolk County Department of Health Services and corrective measures were taken. Groundwater monitoring at the Laboratory's Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

Efforts to minimize impacts of spills of materials continued in 2013. There were nine reportable spills of petroleum products, antifreeze, or chemicals, which was less than what was reported in 2012. The severity of releases were minor, and all releases were cleaned up to the satisfaction of NYSDEC.

BNL participated in 11 environmental inspections or reviews by external regulatory agencies in 2013. These inspections included Sewage Treatment Plant operations, waste water discharges to other regulated outfalls and recharge basins, hazardous waste management facilities, regulated petroleum and chemical bulk storage facilities, and the potable water system. Immediate corrective actions were taken to address all issues raised during these inspections.

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 on the following page.

- State Pollutant Discharge Elimination System (SPDES) permits, issued by NYSDEC
- Major Petroleum Facility (MPF) license, issued by NYSDEC
- Resource Conservation and Recovery Act (RCRA) permit, issued by NYSDEC for BNL's Waste Management Facility
- Registration certificate from NYSDEC for tanks storing bulk quantities of hazardous substances
- Eight 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 (CAA) Amendments authorizing the operation of 37 emission sources

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 1992, BNL entered into a tri-party agreement with EPA, NYSDEC, and DOE. BNL site remediation is conducted by the Environmental Protection Division in accordance with milestones established under this agreement. The cleanup is currently in the long-term surveillance and maintenance mode for the groundwater treatment systems, former soil/sediment cleanup areas, and the reactors; this includes monitoring of institutional controls. The High Flux Beam Reactor (HFBR) stack and reactor vessel are scheduled for D&D by 2020 and 2065, respectively.	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.	BNL is in full compliance with NEPA requirements. The Laboratory has established sitewide procedures for implementing 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 HFBR, the Brookhaven Graphite Research Reactor (BGRR) complex, World War I training trenches near the Relativistic Heavy Ion Collider (RHIC) 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/NHPA processes and evaluated to determine if the action would affect the features that make the facility eligible. Actions required for D&D of the BGRR were determined to affect its eligibility, and mitigative actions have been completed based on 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 six excursions, these discharges met the SPDES permit limits in 2013.	3.6

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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 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.	3.7
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 complied with all reporting and emergency planning requirements in 2013.	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 Sanitary Codes (SCSC) 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, and is 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 contracts and/or 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 2013, there were three projects permitted under the New York State 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 New York State 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 birds.	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: Order 231.1B 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: 1) senior management provides planning, organization, direction, control, and support to achieve DOE objectives; 2) line organizations achieve and maintain quality while minimizing safety and health risks and environmental impacts, and maximizing reliability and performance; and 3) 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 the Laboratory has the management systems, administrative controls, and physical controls to comply with DOE Order 435.1.	2.3.4.3
DOE: Order 436.1	The DOE *Departmental Sustainability* Order replaces former DOE Orders 450.1A, *Environmental Protection Programs*, and 430.2B, *Departmental Energy, Renewable Energy and Transportation Management*. The intent of the new order is to incorporate and implement the requirements of Executive Order (EO) 13514 and to continue compliance with EO 13423. The new order is supported by DOE requirements for sound sustainability programs implemented under the DOE 2010 Strategic Sustainability Performance Plan (SSPP). Contractor requirements under the order require preparation of a Site Sustainability Plan and implementation of a sound Environmental Management System (EMS).	In accordance with the requirements of the DOE Strategic Sustainability Performance Plan, BNL has developed and implemented a Site Sustainability Plan. The Goals and Strategic Objectives of the DOE SSPP are tracked and reported on annually. BNL's EMS was officially registered to the ISO 14001:1996 standard in 2001 and recertified to the revised standard in 2004, 2007 and 2010. In May 2013, an external surveillance audit was conducted that found BNL's EMS to be fully integrated and effective, with one minor nonconformity and many system strengths.	Chapter 2

(continued on next page)

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 458.1, Change 2	In February 2011, DOE released DOE Order 458.1 Radiation Protection of the Public and Environment, which replaced former Order 5400.5. The order establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The Order requires the preparation of an Environmental Radiation Protection Plan which outlines the means by which facilities monitor their impacts on the public and environment. Full compliance with the Order was required by August 2012.	In accordance with the requirements of DOE Order 458.1, BNL maintains and implements several plans and programs for ensuring that the management of facilities, wastes, effluents, and emissions do not present a risk to the public, workers, or environment. These plans and programs have existed for decades and were previously implemented under prior DOE Order 5400.5 and in accordance with the current DOE O 435.1, Radioactive Waste Management, and 10 CFR 835. Environmental monitoring plans are well documented and the results are published annually in BNL's Site Environmental Report, which is prepared in accordance with DOE O 231.1B. The Environmental Radiation Protection Program (ERPP), which was published in September 2012, provides a record of the requirements of DOE O 458.1 and documents how the Laboratory meets these requirements.	Chapters 3, 4, 5, 6 & 8

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

- Three permits issued by NYSDEC for construction activities within the Peconic River corridor or near wetlands
- EPA Underground Injection Control (UIC) Area permit for the operation of 138 UIC wells
- Permit for the operation of six domestic water supply wells, issued by NYSDEC
- Twelve equivalency permits for the operation of groundwater remediation systems installed via 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 SPDES Permits

In November 2013, BNL received a Notice of Complete Application prepared by NYSDEC along with a draft copy of the Laboratory's updated SPDES Permit. As required, the Notice was published in a local newspaper on November 21, 2013 initiating a 30-day public comment period on the proposed SPDES Permit modification, which included relocation of the Sewage Treatment Plant discharge from the Peconic River to groundwater via recharge beds. BNL submitted its comments on the draft permit on December 20, 2013 and received a final permit in March 2014.

3.2.2.2 New York State Wetlands and Wild Scenic, Recreational Rivers Act

Three actions continued in 2013 that required permits under the New York State Wetland and/or Wild, Scenic and Recreational Rivers Act legislation. Continuation projects included post-construction activities associated with the on-site Long Island Solar Farm (LISF), installation of fencing and air conditioning platforms at the Relativistic Heavy Ion Collider (RHIC), and a project for the construction of recharge basins associated with upgrades to the Laboratory's Sewage Treatment Plant (STP), which will allow for the eventual discharge of tertiary-treated wastewater directly to groundwater.

3.2.2.3 Title V Permit

In December 2012, an application to renew BNL's Title V Permit was submitted to NYSDEC 6 months prior to its expiration. Supplementary information identifying some necessary administrative changes to the permit that were not included in the renewal application was submitted to NYSDEC in January 2013. The renewal application included necessary minor

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 - NESHAPs	931	Brookhaven Linear Isotope Producer	BNL-2009-1	None	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
EPA - SDWA	BNL	Underground Injection Control	NYU500001	(a)	NA	NA
NYSDEC - Air Equivalency	517/518	South Boundary/Middle Road 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 - Air Equivalency	644	Freon-11 Treatment System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	517/518	South Boundary/Middle Road 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	NA	NA	NA
NYSDEC - SPDES Equivalency	598	Tritium Remediation System	1-52-009	04-May-16	NA	NA
NYSDEC - SPDES Equivalency	670	Sr-90 Treatment System	None	25-Feb-18	NA	NA
NYSDEC - SPDES Equivalency	TR 829	Carbon Tetrachloride System	None	Closed out 2010	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	16-Dec-14	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System - BGRR/WCF	None	16-Dec-14	NA	NA
NYSDEC - SPDES Equivalency	TR 867	T-96 Remediation System	1-52-009	20-Mar-17	NA	NA
NYSDEC - SPDES Equivalency	644	Freon-11 Treatment System	1-52-009	20-Mar-17	NA	NA
NYSDEC - Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-15	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

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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	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
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 - Water Quality	CSF	Major Petroleum Facility	1-1700	31-Mar-17	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	NY-0005835	28-Feb-15	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	1-4722-00032/00148	26-Aug-15	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	1-4722-00032/00149	27-Aug-15	NA	NA
NYSDEC - Water Quality	Site	Solar farm construction	1-4722-05846/00001	06-May-15	NA	NA
NYSDEC - Water Quality	Site	Construction of Fences and Platforms at RHIC	1-4722-00032/00144	11-Jul-16	NA	NA

Notes:
(a) Permit renewal under review by EPA
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

revisions to existing emission units, as well as a summary of new regulatory requirements now applicable to existing emission sources which had been promulgated and added to the permit since it was last renewed in June 2008, and the addition of emission units identified as U-GENER and U-SMBLR covering 12 existing stationary diesel emergency generators subject to the

New Source Performance Standard 40 CFR Subpart IIII, and 4 existing small boilers with heat input capacities between 1 and 25 MMBtu/hr subject to new boiler tune-up requirements of 40 CFR 63 Subpart JJJJJJ and 6 NYCRR 227-2.4. Table 3-2 reflects both the revisions to existing emission units and the addition of new emission units to BNL's Title V Permit.

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 2013, environmental evaluations were completed for 100 proposed projects at BNL. Of those, 94 were considered minor actions requiring no additional documentation. Six projects were addressed by submitting notification forms to DOE, which determined that all six projects were covered by existing "Categorical Exclusions" (per 10 CFR 1021) or fell within the scope of a previous environmental assessment. In addition, an Environmental Assessment (EA) for Management of the White-tailed Deer (*Odocoileus virginianus*) Population at Brookhaven National Laboratory was completed in 2013 with a Finding of No Significant Impact (FONSI).

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 (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I Army training trenches associated with Camp Upton. Several other structures of historic significance are identified in BNL's Cultural Resources Management Plan (BNL 2013), including the Brookhaven Center, and Building 120. Two other buildings, Berkner Hall and the Chemistry Building, are considered Architecturally Significant. A Department of Interior questionnaire regarding historic and cultural resources is prepared annually. Additional activities associated with historic preservation compliance are described in Chapter 6.

3.5 CLEAN AIR ACT (CAA)

The objectives of the 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" (RACT) requirements. Three of the boilers can burn either residual fuel oil or natural gas; Boiler 1A burns fuel oil only. In 2013, natural gas was the predominant fuel burned at the CSF. For boilers with maximum operating heat inputs greater than or equal to 25 MMBtu/hr (7.3 MW), the RACT requirements establish emission standards for oxides of nitrogen (NO_x). Boilers with a maximum operating heat input between 25 and 250 MMBtu/hr (7.3 and 73.2 MW) can demonstrate compliance with the NO_x standard using periodic emission tests or by using continuous emission monitoring equipment. All four CSF boilers fall in this operating range. Emission tests of Boilers 1A and 5 conducted respectively in December 2012 and March 2013 confirmed that Boilers 1A and 5, both in this size category, met the 0.30 lbs/MMBtu NO_x emission standard when burning residual fuel oil with low nitrogen content, and separate emission tests on Boiler 5 confirmed that it met the 0.20 lbs/MMBtu NO_x emission standard while burning natural gas. To ensure continued compliance with the NO_x RACT standard for residual fuel oil, an outside contract analytical laboratory analyzes composite samples (collected quarterly) of fuel deliveries to confirm that the fuel nitrogen content of residual oil burned is less than 0.3 percent by weight. The analyses of residual oil used in 2013 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 2013, NO_x emissions from Boilers 6 and 7 averaged 0.083 lbs/MMBtu and 0.093 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 the 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. In August 2013, there was one 6-minute period where measured opacity for Boiler 6 exceeded 20 percent. This was the result of a localized short-term power outage that occurred during scheduled electrical system maintenance. The only other reported periods when opacity measurements for Boilers 6 or 7 exceeded the 6-minute, 20 percent average, occurred during quarterly calibration error tests of the opacity monitors. These opacity measurements were artificially induced when opacity attenuator filters were inserted across the opacity transmissometer light path during the calibration error tests and are not considered excess opacity readings.

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 is certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. As a matter of BNL's standard practice, 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 is more stringent than the leak repair provisions of 40 CFR 82.156.

In 2013, 3,390 pounds of R-11, 27 pounds of R-12, 352 pounds of R-22, 100 pounds of R-134a, and 35 pounds of R-401a were recovered and recycled from refrigeration equipment that was serviced. In 2013, 300 pounds of R-11, 166 pounds of R-12, 845 pounds of R-22, 151 pounds of R-134a, 100 pounds of R-123, 20 pounds of R-401a, and 9 pounds of R-410A leaked from refrigeration and air conditioning equipment on site. These leaks were subsequently reported as emissions in the Annual Emissions Statement transmitted to NYSDEC.

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. Halon recovered from excessed systems is stored for reuse by BNL or shipped to the Department of Defense Ozone Depleting Substances Reserve.

In 2013, there were no discharges of Halon 1211 from portable fire extinguishers or Halon 1301 from accidental or fire-induced activation of fixed fire suppression systems. There were also no Laboratory transfers of excess ozone depleting substances to the Ozone Depleting Substances Reserve. Plans for 2014 include the transfer of excess cylinders of Halon 1301 from two fixed fire suppression systems scheduled for removal, several cylinders of excess R-22, and nine 1-pint bottles of unused CFC-113 to the Ozone Depleting Substances Reserve. The transfer will be made in accordance with the Class I Ozone Depleting Substances Disposition Guidelines prepared by the DOE Office of Environmental Policy and Guidance.

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 in 2013, it has been determined that none of the 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 2013, the Laboratory notified the EPA Region II office regarding the removal of materials containing asbestos. During the year, 5,050 linear feet of pipe insulation, 164,194 square feet of non-friable (e.g., floor tiles, siding material), and 121 cubic yards of asbestos-containing debris were removed and disposed of according to EPA requirements.

3.5.2.3 Radioactive Airborne Emissions

Minor and major sources of radiological emissions are evaluated from BNL's facilities and activities to ensure that they do not impact the environment, on-site workers, or people residing at or near the Laboratory. A full description of radiological emissions monitoring conducted in 2013 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 maximally exposed off-site individual resulting from BNL's airborne emissions in 2013 was 3.65E-01 mrem (3.6 µSv).

In March 2013, a peer review assessment of BNL's NESHAPs for Radionuclide Emissions program was conducted. The peer review team included environmental professionals from Oak Ridge National Laboratory, with observers from the Department of Energy Chicago Operations and Brookhaven Site Offices. The assessment yielded no non-conformances, five programmatic strengths, and 19 Opportunities for Improvement (OFIs). In May 2013, a team of BNL Subject Matter Experts (SMEs) were assembled to analyze the OFIs and identified actions needed to improve Rad-NESHAP program implementation. A final report was completed in June, which identified corrective actions for the OFIs, most of which were completed by September 30, 2013 (BNL 2013).

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 458.1, *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 BNL that regulates wastewater effluents. The permit specifies monitoring requirements and effluent limits for 9 of 12 outfalls, as described below. See Figure 5-2 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 is 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 these disposal systems.

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 NYSDEC central and regional offices and the SCDHS. Details of the monitoring program conducted for the groundwater treatment systems where SPDES equivalency permits are in effect are provided in SER Volume II, *Groundwater Status Report*. Evaluation of the current effluent quality shows it to consistently meet all groundwater effluent standards, and in most cases, ambient water quality standards for groundwater.

As stated in Section 3.2.2.1, BNL is in the process of modifying its SPDES permit to reflect an approved modified treatment process that will replace the existing sand filters with free standing self-enclosed filtration units and divert the discharge to on-site recharge basins. Final design and specifications for the modified treatment process were approved by NYSDEC and SCDHS in November 2012. Construction activities were initiated in July 2013, and are expected to be completed by September 2014.

Details on monitoring results, evaluation of compliance with permit limits, and description of any corrective actions taken to address permit excursions are provided in the following sections.

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 wastewater and includes the following processes: settling/sedimentation, biological reduction of organic matter and nitrogen, sand filtration, and UV disinfection. Chapter 5 provides a detailed description of the treatment process.

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 2013.

There were five excursions of the SPDES permit limits at Outfall 001 in 2013: (2) total nitrogen, (2) ammonia nitrogen, and (1) for total nitrogen loading. In May, the maximum total nitrogen load was calculated at 21.1 pounds per day, which exceeded the permit limit of 20 pounds per day. Composite samples collected from Outfall 001 for routine compliance nitrogen series analysis during the week of December 9 exhibited total nitrogen concentrations of 11.6 mg/L and 13.4 mg/L and ammonia concentrations of 1.85 mg/L and 6.7 mg/L. Permit limits for total nitrogen and ammonia are 10 mg/L and 1.5 mg/L, respectively. All other parameters at Outfall 001 were within permit limits.

The total nitrogen loading excursion was due to a higher than normal total nitrogen level observed on the same day (9.0 mg/L), which was most likely the result of issues with the operating modular aeration tank's dissolved oxygen (DO) time delay equipment. Arrangements were made to have a contractor evaluate and fix the DO blower dwell timer. In-house process control sampling and analysis of effluent for nitrates following this repair confirmed that the issue was resolved.

Several immediate and long term corrective actions were implemented to address the total nitrogen and ammonia excursions observed in December 2013, including sending a sample of the mixed liquor suspended solids (MLSS) from the aeration tank to a wastewater microbiological laboratory to evaluate the condition of the biota present within the activated sludge that is part of BNL's treatment system. A recommendation was made to raise the aeration basin pH above 7.5 with lime and caustic or magnesium hydroxide. After implementation, in-house process control samples and subsequent contract laboratory analysis indicated that ammonia and total nitrogen concentrations returned to normal concentrations and well below the permit limits. Figures 3-1 through 3-7 plot the 5-year trends for 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. In 2013, BNL continued to perform quarterly chronic toxicity testing using water fleas (*Ceriodaphnia dubia*). In each test, sets of 10 organisms are exposed to varying concentrations of the STP effluent (100, 75, 50, 25, and 12.5 percent) for 7 days. During testing, the rate of reproduction for the water flea is measured and compared to untreated organisms (i.e., controls). The test results are submitted to NYSDEC for review.

Testing in 2013 showed that there was no toxicity demonstrated in the four tests performed. Reproduction and survival rates were comparable to the control population, indicating that the STP effluent is not toxic to invertebrate organisms. Under the terms of BNL's SPDES permit, testing is required throughout the term of the permit; consequently, testing will continue in 2014.

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

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)	46	70	Daily	90	0	100
pH (SU)	6.3	7.9	Continuous Recorder	Min 5.8, Max. 9.0	0	100
Max. 5-Day BOD (mg/L)	<2	<2	Twice Monthly	5	0	100
% BOD Removal	> 91	> 98	Monthly	85	0	100
Max. TSS (mg/L)	<0.5	<0.6	Twice Monthly	20	0	100
% TSS Removal	> 98	>99	Monthly	85	0	100
Settleable solids (ml/L)	0	0	Daily	0.1	0	100
Ammonia nitrogen (mg/L)	< 0.1	6.7 (a)	Twice Monthly	1.5	2	93
Total nitrogen (mg/L)	1.96	13.4 (b)	Twice Monthly	10	2	93
Total nitrogen (lbs./day)	12	21.1 (c)	(May – October)	20	1	93
Total phosphorus (mg/L)	0.7	1.9	Twice Monthly	NA	0	100
Cyanide (mcg/L)	< 1.7	3.0	Twice Monthly	100	0	100
Copper (mg/L)	0.007	0.076	Twice Monthly	0.15	0	100
Iron (mg/L)	0.062	0.257	Twice Monthly	0.37	0	100
Lead (mg/L)	<0.001	0.005	Twice Monthly	0.019	0	100
Mercury (ng/L)	30	69	Twice Monthly	200	0	100

(continued on next page)

Table 3-3. Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001 *(concluded).*

Analyte	Low Report	High Report	Min. Monitoring. Freq.	SPDES Limit	Exceedances	% Compliance*
Methylene chloride (ug/L)	1.6	< 2	Twice Monthly	5	0	100
Nickel (mg/L)	<0.002	0.006	Twice Monthly	0.11	0	100
Silver (mg/L)	< 0.001	0.003	Twice Monthly	0.015	0	100
Toluene (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Zinc (mg/L)	0.012	0.096	Twice Monthly	0.1	0	100
1,1,1-trichloroethane (ug/L)	< 1	< 1	Twice Monthly	5	0	100
2-butanone (ug/L)	< 5	< 5	Twice Monthly	50	0	100
PCBs (ug/L)	< 0.05	< 0.2	Quarterly	NA	0	100
Max. Flow (MGD)	0.42	0.82	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.23	0.53	Continuous Recorder	NA	0	100
Avg. Fecal Coliform (MPN/100 ml)	<1	1.5	Twice Monthly	200	0	100
Max. Fecal Coliform (MPN/100 ml)	<2	<2	Twice Monthly	400	0	100
HEDP (mg/L)	<0.05	1.7	Monthly	NA	0	100
Tolytriazole (mg/L)	< 0.005	< 0.005	Monthly	NA	0	100

Notes:
See Chapter 5, Figure 5-2, for location of Outfall 001.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
BOD = Biological Oxygen Demand
HEDP = 1-Hydroxyethylidene Diphosphonic acid
MGD = Million Gallons per Day
MPN = Most Probable Number
NA = Not Applicable
SPDES = State Pollutant Discharge Elimination System
SU = Standard Unit
TSS = Total Suspended Solids
(a) Two permit exceedances for ammonia were reported in December. See Section 3.6.1 for an explanation of this permit exceedance.
(b) Two permit exceedances for total nitrogen were reported in December.
(c) A single exceedance for total nitrogen load was reported in May.

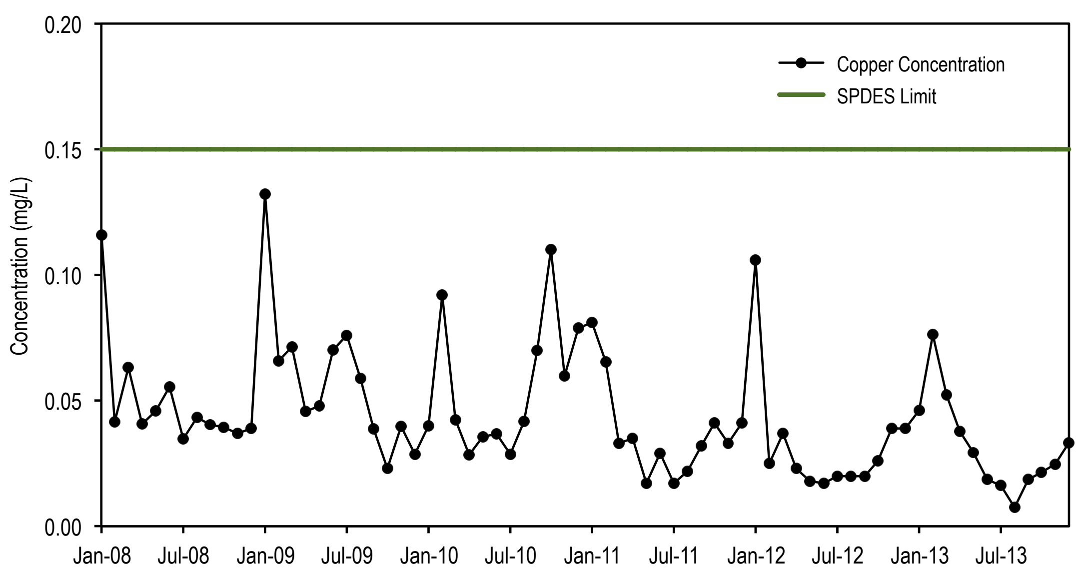


Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2008–2013.

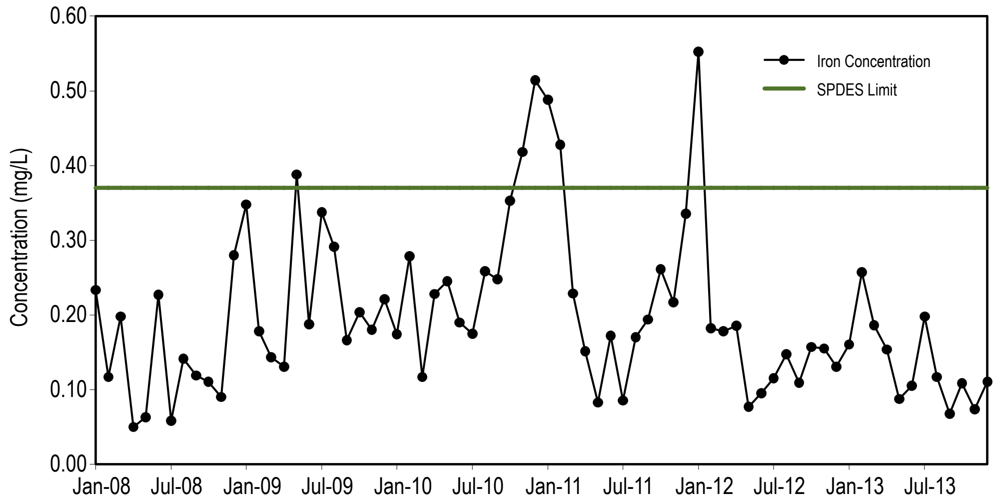


Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2008–2013.

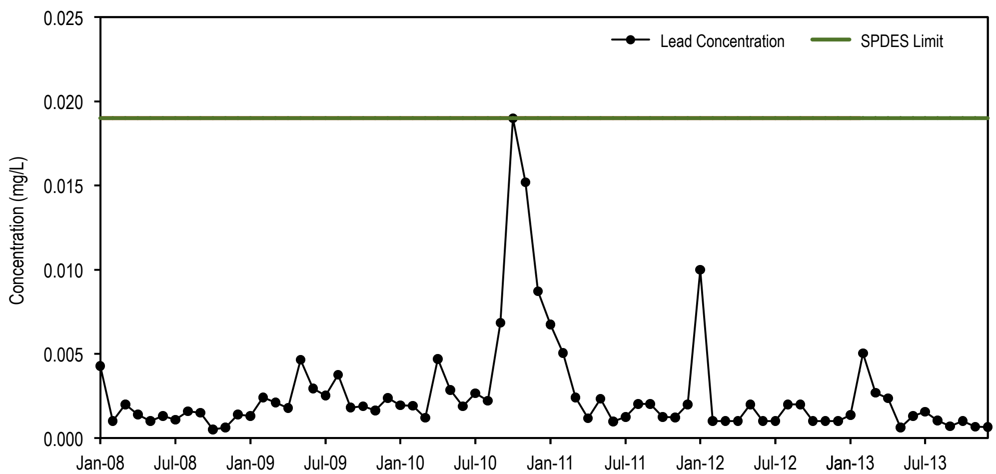


Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2008–2013.

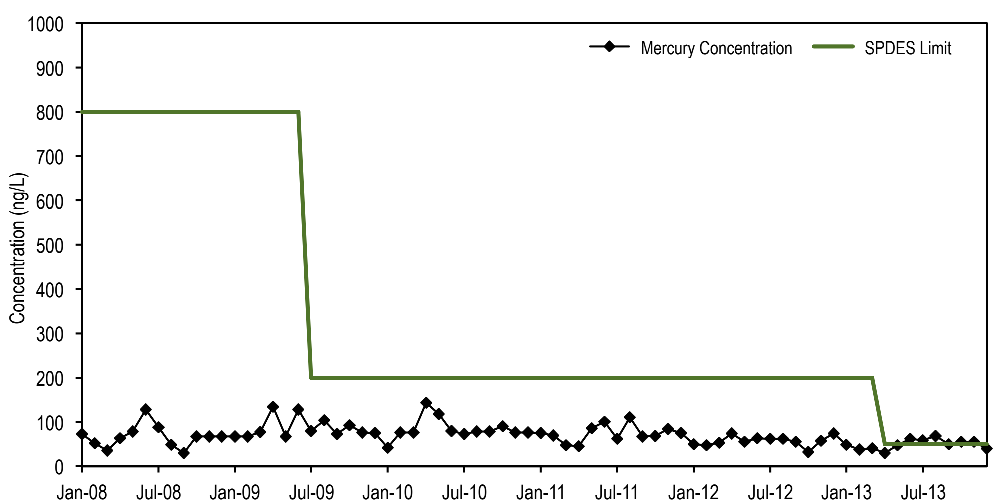


Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2008–2013.

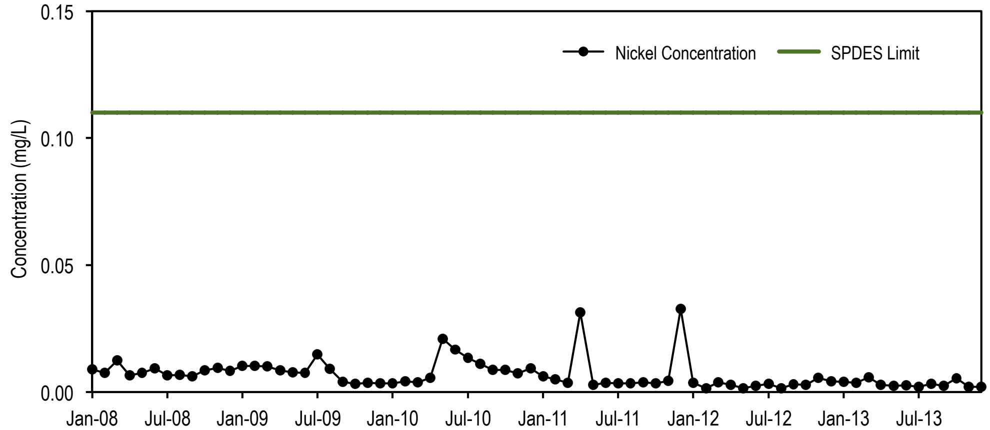


Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2008–2013.

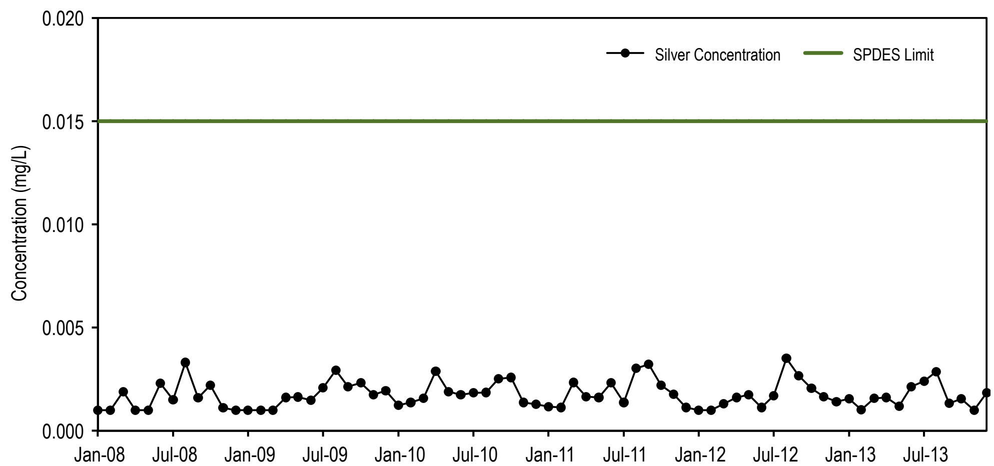
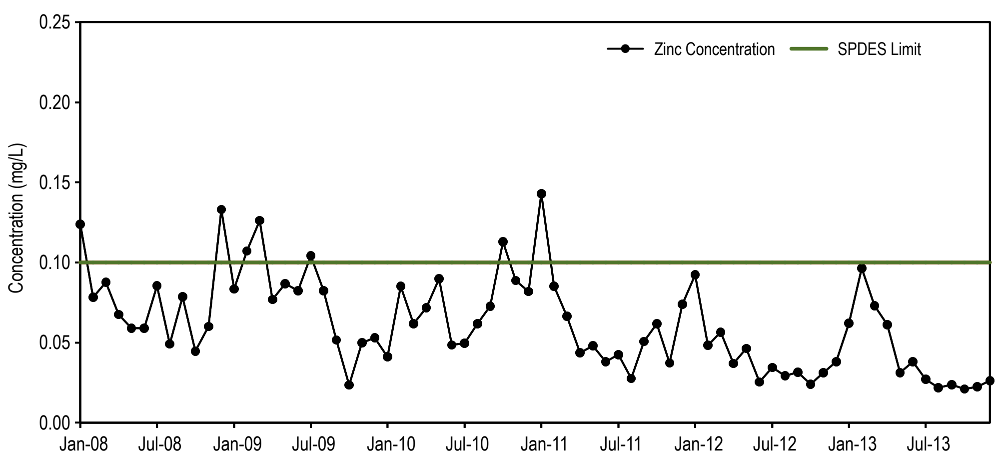


Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2008–2013.



Note: Per New York State Department of Environmental Conservation guidance, the concentrations of zinc exhibited in the effluent during January and December 2008, February, March, July 2009, October 2010, and January 2011 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, 2008–2013.

water treatment reagents used. Table 3-4 summarizes the monitoring requirements and performance results.

There was only one Tolytriazole (TTA) excursion reported for these outfalls during 2013. The TTA concentration at Outfall 002 measured on January 7, 2013 was 0.73 mg/L, which exceeded the permit level of 0.2 mg/L. An investigation revealed that the restart of Cooling Tower #7 (Bldg 1005A) after maintenance with higher doses of water treatment chemicals (WTCs) to condition the system, coupled with higher than normal water loss/overflow, was the most probable cause of the excursion. The system was tested weekly after start-up, and treatment dose was adjusted to maintain the desired chemistry in tower. Testing by the WTC supplier indicated that all treatment residuals were normal and there have not been any further excursions since then.

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 2013) is prepared by BNL to comply with these requirements.

3.7.1 Potable Water

The Laboratory maintains five 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 potable water supply monitoring data. In 2013, BNL's drinking water and the supply and distribution system was in full compliance with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting. In addition to the compliance sampling program, all wells are also sampled and analyzed quarterly under the BNL environmental surveillance program. Data collected under this program are consistent with the data

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	11	11			
	Min.	1.1	0.0006	0.14	0.04	0.01	0.16	0.0006	0.00009	NA		
	Max.	3.4	0.06	0.79	0.19	0.32	0.68	0.35	0.82	NA	NA	NA
pH (SU)	Min.	6.7	7.5	6.2	7.1	7.1	6.7	7.5	7.5	NA		
	Max.	8.2	8.7	8.4	8.4	8.6	8.4	8.3	8.3	8.5, 9.0 (a)	0	100
Oil and grease (mg/L)	N	12	11	12	12	12	NR	10	10			
	Min.	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	NR	1.1	< 1.1	NA		
	Max.	3.1	2.8	2.7	2.5	2.7	NR	2.2	3.9	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	< 0.004 (D)	NA		
	Max.	NR	NR	0.004	NR	NR	NR	NR	0.033 (D)	1.0	0	100
Aluminum (mg/L)	N	4	NR	NR	NR	NR	NR	2	3			
	Min.	< 0.07 (T)	NR	NR	NR	NR	NR	< 0.07 (D)	< 0.07 (D)	NA		
	Max	< 0.07	NR	NR	NR	NR	NR	0.2 (D)	0.1 (D)	2.0	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*
Lead, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	3			
	Min.	NR	NR	NR	NR	NR	NR	NR	< 0.0005	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	< 0.0005	0.05	0	100
Vanadium, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	3			
	Min.	NR	NR	NR	NR	NR	NR	NR	0.005	NA		
	Max	NR	NR	NR	NR	NR	NR	NR	0.005	NPL	NA	NA
Chloroform (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	< 1	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	<1	NR	NR	NR	NR	NR	NR	NR	7	0	100
Bromodichloromethane (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	0.92	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	1.0	NR	NR	NR	NR	NR	NR	NR	50	0	100
1,1,1-trichloroethane (µg/L)	N	4	NR	NR	NR	NR	NR	11	NR			
	Min.	< 1	NR	NR	NR	NR	NR	< 1	NR	NA		
	Max.	< 1	NR	NR	NR	NR	NR	< 1	NR	5	0	100
1,1-dicloroethylene (µg/L)	N	NR	NR	NR	NR	NR	NR	11	NR			
	Min.	NR	NR	NR	NR	NR	NR	< 1	NR	NA		
	Max.	NR	NR	NR	NR	NR	NR	< 1	NR	5	0	100
Hydroxyethylidene-diphosphonic acid (mg/L)	N	4	4	4	4	4	NR	NR	NR			
	Min.	<0.02	<0.05	<0.05	<0.05	<0.05	NR	NR	NR	NA		
	Max.	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	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.	0.7	<0.005	<0.005	<0.005	<0.005	NR	NR	NR	0.2	1	75

Notes:
See Figure 5-2, 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.

reported in Tables 3-5 and 3-6. This additional testing goes beyond the minimum SDWA testing requirements.

To ensure that consumers of on-site drinking water are informed about the quality of Laboratory-produced potable water, BNL annually publishes a Consumer Confidence Report (CCR) in May, a deadline stipulated by the SDWA. This report provides information regarding BNL's source water, supply system, the analytical tests conducted, and detected contaminants are 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 to all BNL employees and on-site residents, either in paper form or electronically at *http://www.bnl.gov/bnlweb/pubaf/water/reports.htm.*

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, including primary devices installed at interfaces to the potable water main, and secondary control devices at the point of use. In 2013, 209 cross-connection control units were tested, 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 throughout the year.

3.7.3 Underground Injection Control (UIC)

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 2013, six UIC devices were installed at the Northeast Solar Energy Research Center site, bringing BNL's total UIC inventory up to 138. Applications for these new devices were submitted to EPA in 2012, and all six will be used solely for the disposal of storm water runoff. In June 2010, an application was filed with EPA to renew the Class V UIC permit for the site. In August 2012, BNL received a letter from EPA indicating that addition or removal of UICs from the existing inventory would be "authorized by rule," pursuant to 40 CFR §144.24; however, it is still unclear if EPA intends on renewing BNL's Class V UIC permit. In addition to the UICs maintained for routine Laboratory discharges of sanitary waste and storm water, 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.

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	Potable Distribution Sample	NYS DWS
Water Quality Indicators							
Ammonia (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	SNS
Chlorides (mg/L)	41.6	39.8	47.9	60.8	49.5	49.9	250
Color (units)	45*	75*	5	< 5	< 5	10	15
Conductivity (µmhos/cm)	206	201	203	331	312	246	SNS
Cyanide (µg/L)	< 10	< 10	< 10	< 10	< 10	< 10	SNS
MBAS (mg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	SNS
Nitrates (mg/L)	0.2	0.19	0.39	0.66	0.81	0.24	10
Nitrites (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1
Odor (units)	0	0	0	0	0	0	3
pH (Standard Units)	5.9	5.9	5.9	6	6	7.1	SNS
Sulfates (mg/L)	8.7	9.2	11.6	10.8	11.5	9.2	250
Total coliform	ND	ND	ND	ND	ND	1***	Negative
Metals							
Antimony (µg/L)	< 0.4	<0.4	<0.4	<0.4	<0.4	0.52	6
Arsenic (µg/L)	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	50
Barium (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0	0.044	2
Beryllium (µg/L)	0.5	<0.2	<0.2	<0.2	<0.2	0.7	4
Cadmium (µg/L)	<0.4	<0.4	<0.4	<0.4	<0.4	<1.0	5
Chromium (mg/L)	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.1
Fluoride (mg/L)	0.12	0.1	0.13	< 0.1	< 0.1	< 0.1	2.2
Iron (mg/L)	2.4*	4.4*	1.4*	<0.006	<0.006	0.089	0.3
Lead (µg/L)	<1.0	<1.0	<1.0	1.21	<1.0	<1.0	15
Manganese (mg/L)	0.26	0.1	0.065	< 0.01	< 0.01	0.028	0.3
Mercury (µg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.2	2
Nickel (mg/L)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	SNS
Selenium (µg/L)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	50
Sodium (mg/L)	26.2	20.1	25	28.5	24.8	26.2	SNS

(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	Potable Distribution Sample	NYS DWS
Silver (µg/L)	<10	<10	<10	<10	<10	<10	100
Thallium (µg/L)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2
Zinc (mg/L)	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	5
Radioactivity							
Gross alpha activity (pCi/L)	< 1.96	< 1.97	< 1.99	<1.93	1.32 ± 0.95	NR	15
Gross beta activity (pCi/L)	< 1.14	1.61 ± 0.78	1.51 ± 0.67	1.35 ± 0.77	1.58 ± 0.85	NR	(a)
Radium-228 (pCi/L)	NS	NS	NS	NS	NS	NR	5
Strontium-90 (pCi/L)	< 0.7	< 0.7	< 0.75	< 0.78	< 0.68	NR	8
Tritium (pCi/L)	< 440	< 460	< 500	< 450	< 470	NR	20,000
Other							
Alkalinity (mg/L)	13.3	12.9	17.7	25.7	22.6	48.2	SNS
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	< 0.20	7
Calcium (mg/L)	6.2	5.5	6.3	12.5	9	12.7	SNS
HAA5 (mg/L)	NR	NR	NR	NR	NR	0.016	0.06**
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	1.4	4
TTHM (mg/L)	NR	NR	NR	NR	NR	0.028	0.08**

Notes:
See Figure 7-3 for well locations.
Well 12 was not operational for 2013. No testing was completed during this time.
HAA5 = Five Haloacetic Acids
MBAS = Methylene Blue Active Substances
MRDL = Maximum Residual Disinfectant Level
ND = Not Detected
NR = Analysis Not Required
NS = Not Sampled
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.

3.8 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 releases that do occur. BNL's compliance with these regulations is further described in the following sections.

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 purpose of this plan is to provide information regarding release prevention measures, the design of storage facilities, and maps detailing storage facility locations. The plan also outlines mitigating and remedial actions that would be taken in the event of a major spill. BNL's SPCC Plan

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
	µg/L						
Dichlorodifluoromethane	< 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	5
Vinyl Chloride	< 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	5
Chloroethane	< 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	5
1,1-dichloroethene	< 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	5
trans-1,2-dichloroethene	< 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	5
cis-1,2-dichloroethene	< 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	5
Bromochloromethane	< 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	5
Carbon Tetrachloride	< 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	5
1,2-dichloroethane	< 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	5
1,2-dichloropropane	< 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	5
trans-1,3-dichloropropene	< 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	5
1,1,2-trichloroethane	< 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	5
Chlorobenzene	< 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	5
Bromobenzene	< 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	5
2-chlorotoluene	< 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	5
1,3-dichlorobenzene	< 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	5
1,2-dichlorobenzene	< 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	5
Hexachlorobutadiene	< 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	5
1,1,2,2-Tetrachloroethane	< 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	5
Benzene	< 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	5
Ethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
m,p-xylene	< 1	< 1	< 1	< 1	< 1	< 1	5
o-xylene	< 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	5
Isopropylbenzene	< 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	5

(continued on next page)

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
	µg/L						
1,3,5-trimethylbenzene	< 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	5
1,2,4-trimethylbenzene	< 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	5
4-Isopropyltoluene	< 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	5
Chloroform	3	9	88*	2	0.8	0.9	50
Bromodichloromethane	2	2	5	< 0.5	< 0.5	< 0.5	50
Dibromochloromethane	2	0.7	0.8	< 0.5	< 0.5	< 0.5	50
Bromoform	2	< 0.5	< 0.5	< 0.5	< 0.5	0.9	50
Methyl tert-butyl ether	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Toxaphene	NR	< 1	< 1	< 1	< 1	< 1	3
Total PCB's	NR	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.5
2,4,5,-TP (Silvex)	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	10
Dinoseb	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	50
Dalapon	NR	< 1	< 1	< 1	< 1	< 1	50
Pichloram	NR	0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Dicamba	NR	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	50
Pentachlorophenol	NR	0.069	< 0.04	< 0.04	< 0.04	< 0.04	1
Hexachlorocyclopentadiene	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5
Bis(2-ethylhexyl)Phthalate	NR	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Bis(2-ethylhexyl)Adipate	NR	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Hexachlorobenzene	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5
Benzo(A)Pyrene	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	50
Lindane	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Heptachlor	NR	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.4
Aldrin	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5
Heptachlor Epoxide	NR	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Dieldrin	NR	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5
Endrin	NR	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.2
Methoxychlor	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	40
Chlordane	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
2,4,-D	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Alachlor	NR	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Simazine	NR	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	50
Atrazine	NR	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
Metolachlor	NR	< 0.75	< 0.75	< 0.75	< 0.75	< 0.75	50
Metribuzin	NR	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	50
Butachlor	NR	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	50
Propachlor	NR	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	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 µg/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.

* Water is treated at the Water Treatment Plant prior to site distribution.

Well 12 was offline and remained unused during 2013.

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

(Chaloupka 2011) is filed with NYSDEC, EPA, and DOE. BNL remained in full compliance with SPCC requirements in 2013.

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. Community Right-to-Know requirements are codified under 40 CFR Parts 355, 370, and 372. Table 3-7 summarizes the applicability of the regulations to BNL. The Laboratory complied with these requirements through the submittal of reports under EPCRA Sections 302, 303, 311, 312, and 313. In fulfillment of the Tier II requirements, BNL submitted an inventory of 42 on site chemicals (with thresholds greater than 10,000 pounds; or 500 pounds for acutely toxic materials) via the New York State approved E-Plan computer based submittal program. These chemicals ranged from road salt (1,200 tons) to nitric acid (604 pounds). To satisfy the requirements of the Tier III submittal, BNL submitted its data via the EPA approved TRI-ME computer based submittal program. BNL reported releases of lead (~19,580 pounds), mercury (~55 pounds), polychlorinated biphenyls (PCBs) (~308 pounds), benzo(g,h,i)perylene (<1 pound), and polycyclic aromatic compounds (<1 pound) for calendar year 2013. 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 2013, 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 BNL 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 (e.g., 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.

Similar to 2012, there were 42 spills in 2013, however, only nine of the spills met regulatory agency reporting criteria. The remaining 33 spills were small-volume releases either to containment areas or to other impermeable surfaces that did not exceed a reportable quantity. Table 3-8 summarizes each of the nine

Table 3-7. Applicability of EPCRA to BNL.

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 [ ]

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

Spill No. and Date	Material and Quantity	ORPS Report	Source/Cause and Corrective Actions
13-14 04/06/13	Hydraulic Fluid/ 4 gallons	No	The auxiliary hydraulic line to a sander attachment on a Freightline Dump Truck failed, resulting in vegetable oil leaking onto the pavement and adjacent soil along East Street. Absorbent pigs and speedy dry were used to clean up the spill, and the recovered contaminated soil was placed in a 55-gallon drum for off-site disposal.
13-15 04/18/13	HCFC-22/ 275 pounds	Yes	During a scheduled preventative maintenance inspection of a rotary screw chiller in Building 911, a pinhole leak in a solenoid valve was discovered after causing the entire refrigerant charge to be released. A work order was prepared to replace the failed solenoid valve.
13-18 05/22/13	HCFC-22/ 28 pounds	Yes	As an A/C engineer was recharging a rotary screw chiller in Building 911 after replacing the liquid solenoid valve, the hot gas pressure relief valve opened. The engineer stopped recharging the unit and recovered the balance of refrigerant that had been added. The pressure relief valve was rebuilt and reinstalled.
13-19 05/29/13	Hydraulic Fluid/ 15-20 gallons	No	While cleaning accumulated tree debris with a street sweeper, a worker noticed a path of hydraulic fluid following the sweeper. Clean sand was used to absorb the spill. Subsequent inspection of the sweeper after being towed to the Heavy Equipment Shop for repairs revealed that the leak started when a hose blew off a highly corroded accumulator valve. The valve and all hydraulic hoses were replaced.
13-21 06/18/13	Power Steering Fluid/< 5 gallons	No	After inspecting an out-of-service clamshell crane and backhoe that were scheduled to be auctioned, Heavy Equipment Shop personnel observed stained soil beneath both vehicles. After the vehicles were transferred to BNL's scrap metal yard, the contaminated soil was excavated and placed in three 55-gallon drums for off-site disposal.
13-28 08/09/13	Hydraulic Fluid/ 25 gallons	No	Hydraulic oil leaked onto the freight elevator service room floor in Building 734 when a brass fitting on a feed line from the hydraulic oil storage tank failed. A vacuum pump was used to recover and transfer 25 gallons of oil into 5-gallon pails. Custodial staff cleaned up the residual oil with detergent, which generated approximately 8 gallons of rinsate.
13-33 10/14/13	Fuel Oil/ Unknown	No	During a berm liner replacement project involving the excavation of soil at Tank #3 at the Central Steam Plant, historical/legacy petroleum contamination was found in the soil adjacent to the tank's concrete base. There was no evidence to suggest that the current #6 fuel oil storage tank was the source of the spill. After a work plan was developed, the contaminated soil was stockpiled within the tank berm area and subsequently transferred to bulk storage containers for off site disposal.
13-34 10/17/13	Diesel Fuel and Sulfuric Acid/ 4 gallons	No	A spontaneous fire caused by either an engine malfunction or battery failure melted a plastic saddle fuel tank and the casing on the battery of a Toro lawnmower as it was being utilized near Building 703. The flames were extinguished and containment trays were placed under the leaking tank and battery to capture the dripping fuel and battery acid. The stained grass and soil beneath the lawnmower from the leaks were excavated and placed into a 5-cubic yard waste container. The stained grass and soil from runoff after Fire Rescue personnel hosed down the area during the fire was also recovered and placed into the waste container.
13-39 11/22/13	Hydraulic Fluid/ 0.5 gallons	No	Using a backhoe to excavate a pipe in front of Apartment 42, a hydraulic line ruptured and caused hydraulic fluid to leak onto soil. Absorbent pads were placed beneath the backhoe to capture the leaking fluid. The contaminated soil and absorbent pads were placed in a 55-gallon drum for disposal.

Note:
ORPS = Occurrence Reporting and Processing System

reportable events, including a description of the cause and corrective actions taken. There were no long-term effects from these releases and no significant impact on the environment. All but two of the reported events were 5 gallons or less in volume or associated with a loss of refrigerant. Five of the releases occurred during Laboratory construction/operational activities, either by leaks from construction equipment (e.g. backhoe, lawn mower, and street sweeper), vehicles, or from operational equipment. The two larger-volume petroleum-based releases included a 15 to 20 gallon spill of hydraulic oil from a failed accumulator valve on a street sweeper and an approximate 25 gallon release of hydraulic oil that leaked onto the freight elevator service room floor in Building 734 when a brass fitting on a feed line from the hydraulic oil storage tank failed. In all cases, the releases were cleaned up to the satisfaction of NYSDEC.

Two of the releases were reported to DOE through BNL's Occurrence Report Processing System (ORPS), a system for identifying, categorizing, notifying, investigating, analyzing, and reporting to DOE events or conditions discovered on site. Both releases were associated with loss of refrigerant (Freon-22) from air conditioning systems. New York State has very stringent release reporting requirements for certain chemicals. The reporting threshold for Freon-22 is one pound to the air. Any release reported to an outside regulatory agency as non-routine is reportable to DOE through ORPS unless specifically exempted (e.g., small volume releases of oil and ethylene glycol are exempt from ORPS reporting). In August 2012, BNL submitted a letter to NYSDEC requesting that refrigerant leaks of Freon 22 and Freon 113 to atmosphere from air conditioning and refrigeration units would not have to be reported in accordance with 6NYCRR Part 595 as long as the release was due to routine refrigeration equipment leaks discovered during preventative maintenance inspections or service calls. A summary of these types of releases would be included in the annual update to BNL's Spill Prevention Report submitted pursuant to 6 NYCRR 598.1(k) and annual Emission Statements submitted pursuant to BNL's Title V Facility Permit. NYSDEC approval of this request would exempt reporting of these types of release to DOE through BNL's ORPS. NYSDEC approval was received in May 2013 just after the second ORPS was reported for the Freon-22 release on May 22 (See Table 3-8).

In all instances described above, any recoverable material was removed, spill absorbents were used to remove the residual product, and all materials were collected and containerized for off-site disposal. For releases to soil, contaminated soil was removed to the satisfaction of the State or local inspector and containerized for off-site disposal.

3.8.4 Major Petroleum Facility (MPF) 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 bulk of 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. The remaining storage facilities on the license range from 100 to 10,000 gallons and are located throughout the site where there is a need for building heat, emergency power, or other miscellaneous petroleum needs (motor oil, waste oil, lube oil).

In October 2013, BNL worked with NYSDEC to update the tank listing associated with the MPF license, which expires on March 3, 2017. The update recognized the removal of a tank from Building 526 and the addition of three tanks adjacent to Building 814 bringing the total amount of licensed petroleum storage facilities to 66. During 2013, BNL remained in full compliance with MPF license requirements, which include monitoring groundwater in the vicinity of the six above-ground storage tanks. The license also requires the Laboratory 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 2013, no VOCs, SVOCs, or floating products attributable to MPF activities were detected. See SER Volume II, *Groundwater Status Report*, for additional information on groundwater monitoring results.

On March 12 and 13, 2013, NYSDEC conducted its annual inspection of all storage facilities included on the MPF license. Five conditions that required corrective action were identified: faded/illegible color coding and tank identification labels and four instances where electronic leak detectors or high level alarm systems were not fully functional. All conditions were corrected in 2013 in accordance with NYSDEC directives.

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. In June 2013, BNL renewed its Chemical Bulk Storage Registration in accordance with NYSDEC directives and received a Hazardous Substance Bulk Storage Registration Certificate in June 2013, which will not expire until July 27, 2015.

NYSDEC conducted an inspection of the Chemical Bulk Storage facilities in March 2013; there were no findings.

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. In April 2010, due to a directive from NYSDEC asserting their sole jurisdiction over petroleum storage at Major Oil Storage Facilities (MOSF), SCDHS notified BNL that they will cease permitting activities (review/approval for new construction and modifications, issuance of operating permits, and registration requirement) for all petroleum bulk storage facilities. In 2011, the Laboratory received further information that indicated SCDHS had ceased applying Article 12 requirements to both petroleum and chemical storage at BNL regardless of whether the storage is regulated by NYSDEC. Currently, there are approximately 121 active storage facilities that are not regulated by NYSDEC that would normally fall under SCSC Article 12 jurisdiction. This includes storage of wastewater and chemicals, as well as storage facilities used to support BNL research.

To ensure that storage of chemicals and petroleum continue to meet Article 12 requirements, BNL will continue to abide by the original 1987 agreement with Suffolk County and will maintain conformance with applicable requirements of Article 12. These requirements include design, operational, and closure requirements for current and future storage facilities. The Laboratory will no longer submit new design plans for SCDHS review/approval or continue to perform other administrative activities such as registration of exempt facilities and updates of shared databases. BNL will continue to inspect all storage facilities to ensure operational requirements of SCSC Article 12 are maintained.

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 1 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. Included with the hazardous wastes regulated under RCRA are mixed wastes which are generated in small quantities at BNL. Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. Since the completion of RCRA closure of the former Mixed Waste Building 870 in 2012, all mixed wastes have been compliantly stored in segregated areas within the Hazardous Waste Storage Building 855. In 2013, NYSDEC performed an unannounced inspection of Hazardous Waste activities at BNL; there were no findings.

3.10 POLYCHLORINATED BIPHENYLS

The storage, handling, and use of 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 all applicable PCB regulatory requirements during 2013. The Laboratory has aggressively approached reductions in its PCB inventory, reducing it by more than 99 percent since 1993. The only known regulated PCB-contaminated piece of electrical equipment remaining on site is a one-of-a-kind klystron located in BNL's Chemistry Department.

3.11 PESTICIDES

The storage and application of pesticides (insecticides, rodenticides, herbicides, and algicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act. BNL uses an Integrated Pest Management (IPM) plan that was developed over a decade ago, and subsequently audited by a third party during 2012. Pesticides are used at the Laboratory to control undesirable insects, mice, and rats; microbial growth 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 in research 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, algaecide, and herbicide use for the previous year. On May 16, 2013, a BNL employee holding a Commercial Pesticides Technician Certification was issued a NYSDEC Notice of Violation for failure to file a 2012 Applicator/Technician Pesticide Annual Report by the February 1, 2013 deadline. Once identified, the required paperwork was immediately submitted to NYSDEC to fulfill the requirement and corrective actions were taken to prevent this administrative violation from occurring again (see Table 3-9 for details).

3.12 WETLANDS AND RIVER PERMITS

As noted in Chapter 1, portions of the site are situated in 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 (BNL 2011 and BNL 2013) 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 2012, BNL submitted a permit package to NYSDEC for the construction of recharge basins associated with upgrades to the STP as required by wetlands regulations and the Wild, Scenic, and Recreational River Systems Act. The upgrades for the STP will allow for the eventual discharge of the tertiary treated wastewater directly to groundwater. A 2011 permit for the installation of fencing and air conditioning

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

Number	Title	Parties	Effective Date	Status
Agreements				
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.
II-CERCLA-FFA-00201	Federal Facility Agreement under the CERCLA Section 120 (also known as the Interagency Agreement or "IAG" of the Environmental Restoration Program)	EPA, DOE, and NYSDEC	05/26/92	This agreement provides the framework, including schedules, for assessing the extent of contamination and conducting cleanup at BNL. 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). Cleanup is currently in long-term surveillance and maintenance mode for the groundwater treatment systems, former soil/sediment cleanup areas, and the reactors; this includes monitoring of institutional controls. The High Flux Beam Reactor stack and reactor vessel are scheduled for decontamination and decommissioning by 2020 and 2065, respectively. All groundwater treatment systems operated as required in 2013.
Notices of Violation/Enforcement Actions				
None				

Notes:
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
EPA = Environmental Protection Agency
NYSDEC = New York State Department of Environmental Conservation
SCDHS = Suffolk County Department of Health Services

platforms at the RHIC facility continues to remain open, pending completion of work. In addition, a permit prepared by BNL for the LISF continues to be open, and will be closed once vegetation is established throughout the solar farm and invasive plants in a modified tiger salamander habitat are under control.

3.13 PROTECTION OF WILDLIFE

3.13.1 Endangered Species Act

In 2013, the Laboratory updated its list of endangered, threatened, and species of special concern (see Table 6-1 in Chapter 6). There are no federally recognized endangered species on the BNL site. However, in October 2013 the U.S. Fish & Wildlife Service published a notice in the Federal Register proposing the listing of the Northern Long-eared Bat (*Myotis septentrionalis*) as a federally endangered species. This species is known to utilize the BNL site at least during the summer months. Therefore, BNL began consideration of management options to protect this species on site in preparation for its eventual listing. The northern long-eared bat will be the first federally listed species known to be present at the Laboratory. State recognized endangered (E) or threatened (T) species include: eastern tiger salamander (E), persius duskywing (E), crested fringed orchid (E), Engelman spikerush (E), dwarf huckleberry (E), whorled loosestrife (E), Swamp darter (T), Banded Sunfish (T), frosted elfin (T), little bluet (T), scarlet bluet (T), pine barrens bluet (T), northern harrier (T), stargrass (T), and stiff-leaved goldenrod (T). Although the tiger salamander is no longer the only state endangered species found at the Laboratory, 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 updated its BNL Natural Resource Management Plan (NRMP) in October 2011 (BNL 2011). 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. As part of environmental benefits associated with the LISF, a small tiger salamander habitat was modified to ensure improved water retention for longer periods of time.

The banded sunfish and swamp darter are found in the Peconic River drainage areas on site. 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; 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 the mottled duskywing is likely to exist on site; therefore, management of habitat and surveys for the three butterflies has been added to the NRMP. BNL is currently working with NYSDEC in developing a recovery plan for the frosted elfin.

Surveys for damselflies and dragonflies conducted periodically during the summer months confirmed the presence of one of the three threatened species of damselflies expected to be found on site. The pine-barrens bluet, a threatened species, has been documented at one of the many coastal plain ponds 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, red-headed woodpecker, osprey, sharp-shinned hawk, and Cooper's hawk. The management efforts for the tiger salamander also benefit the marbled salamander. At present, no protective measures are planned for the eastern box turtle or spotted turtle, as little activity occurs within their known habitat at the Laboratory. However, BNL is working with Hofstra University to study reproductive strategies and habitat use of the eastern box turtle and it is a focal species for study within the LISF. Results of these studies may show the need for conservation and management needs. BNL continues to evaluate bird populations as part of the management strategy outlined in the NRMP.

The Laboratory has 28 plant species that are protected under state law: four are endangered plants, the Engelman spikerush, dwarf huckleberry, whorled loosestrife, and crested fringed orchid; two are threatened plants, the stiff-leaved goldenrod and stargrass; and four are rare plants, the small-flowered false foxglove, narrow-leafed bush clover, wild lupine, and long-beaked bald-rush. The other 18 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 due to the large areas of undeveloped pine-barren habitat on site. As outlined in the NRMP, 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 more than 185 species of migratory birds since 1948; of those, approximately 85 species nest on site. Under the Migratory Bird Treaty Act, migratory birds are protected from capture, 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 preventive measures are taken to ensure that they do not cause problems in the future (e.g., access to nesting is closed or repaired, and/or deterrents to nesting are installed). Canada geese (*Branta canadensis*) are managed under an annual permit from the U.S. Fish and Wildlife Services goose nest management program. Occasionally, nesting migratory birds come in conflict with construction and the conflict must be resolved. When this occurs, the USDA-APHIS-Wildlife Services Division is called for consultation and resolution, if possible. Each incident is handled on a case-by-case basis to ensure the protection of migratory birds, while maintaining fiscal responsibility. 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 and the first documentation of nesting on the island occurred in 2013. Currently, the Laboratory has no concerns with eagles and no specific management needs are necessary.

3.14 PUBLIC NOTIFICATION OF CLEARANCE OF PROPERTY

In accordance with DOE Order 458.1, authorized releases of property suspected of containing residual radioactive material must meet DOE and other federal, state, and local radiation protection policies and requirements. Released property must be appropriately surveyed, and the Laboratory must adequately demonstrate that authorized limits are met. In addition, documentation supporting the release of property should be publicly available. The release of property off the BNL site from radiological areas is controlled. No vehicles, equipment, structures, or other materials can be released from the Laboratory unless the amount of residual radioactivity on such items is less than the authorized limits. The default authorized limits are specified in the Brookhaven National Laboratory Site Radiological Control Manual (RCM) (BNL 2013) and are consistent with the pre-approved authorized release limits set by DOE Order 458.1.

In 2013, excess materials such as scrap metal (174 tons) and electronics equipment (23 tons) were released to interested parties or to an off-site location. All materials were surveyed, as required, using appropriate calibrated instruments and released based on DOE pre-approved authorized limits. There were no releases of real property in 2013.

3.15 EXTERNAL AUDITS AND OVERSIGHT

3.15.1 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 2013, BNL was inspected by federal, state, or local regulators on 10 occasions. These inspections included:

- *Air Compliance*. BNL representatives accompanied NYSDEC on a site inspection in September 2013; there were no issues identified.
- *Potable Water*. In August 2013, SCDHS collected samples and conducted its annual inspection of the BNL potable water system. Corrective actions for all identified deficiencies were established and communicated with SCDHS and are being addressed by the Laboratory's Energy and Utilities Division.
- *Sewage Treatment Plant*. SCDHS conducts quarterly inspections of the Laboratory's STP to evaluate operations and sample the effluent. In 2013, no performance or operational issues were identified. NYSDEC performed an annual surveillance inspection in March; there were no issues identified.
- *Recharge Basins*. SCDHS inspected several on-site SPDES-regulated outfalls in 2013; there were no issues identified.

- *Major Petroleum Facility*. The annual NYSDEC inspection of the MPF was performed in March 2013. See Section 3.8.4 for a discussion of the issues identified.
- *Chemical Bulk Storage (CBS) Facilities*. The CBS facilities are inspected periodically by NYSDEC. An inspection was conducted in March 2013; there were no issues identified.
- *RCRA Inspections*. NYSDEC and EPA performed RCRA inspections in 2013; there were no issues identified.

3.15.2 DOE Assessments/Inspections

The DOE Brookhaven Site Office (BHSO) conducts environmentally-related assessments each year, some of which are supported by the DOE Chicago Office. In 2013, BHSO conducted a follow-up surveillance on Brookhaven Science Associates' (BSA) response to the Building 705 Stack Drain Tank High-Level Alarm, which occurred in July 2012, to verify the effectiveness of the corrective actions and participated in a peer assessment of BSA's NESHAP's Program along with a team of environmental professionals from Oak Ridge National Laboratory.

The Stack Drain Tank follow-up surveillance verified that BSA has successfully implemented numerous corrective actions to prevent recurrence of the overflow of the HFBR stack drain tank and lack of timely alarm response. The NESHAP's assessment yielded no non-conformances, five programmatic strengths, and 19 OFIs. In May 2013, a team of BNL Subject Matter Experts (SMEs) were assembled to analyze the OFIs and identify actions needed to improve Rad-NESHAP program implementation. A final report was completed in June, and most of the corrections were completed by September 30, 2013.

3.15.2.1 Environmental Multi-Topic Assessment

In 2013, BNL conducted a programmatic self-assessment on several aspects of the Laboratory's environmental management program. Topics for this assessment were determined based on institutional risk, DOE and regulatory agency expectations, and to ensure that key environmental requirements are being implemented as designed. The scope of the 2013 self-assessment focused on requirements related to BNL's Environmental Monitoring and Long Term Stewardship Programs. The specific elements that were focused on during this assessment included compliance and conformance with activated soil cap inspections, environmental monitoring and data quality, and historical contamination. During the course of the assessment, a representative sampling of managers, supervisors, and workers were interviewed. In addition, numerous documents and activities were reviewed to enable a comprehensive, independent, and objective assessment of the conformance to requirements and the effectiveness of implementation.

The assessment of these programs identified seven Noteworthy Practices and eleven OFIs for Improvement. Several of the OFI's were addressed in 2013.

3.15.2.2 Nevada National Security Site

The Laboratory continues to be a certified Nevada National Security Site (NNSS) waste generator. As part of the NNSS waste certification process, the NNSS Maintenance and Operations Contractor conducts random unannounced inspections. NNSS did not perform any inspections at BNL in 2013.

3.16 AGREEMENTS, ENFORCEMENT ACTIONS, AND OTHER ENVIRONMENTAL OCCURRENCE REPORTS

In addition to the rules and regulations discussed throughout this chapter, there were two existing agreements between BNL, DOE, and regulatory agencies that remained in effect in 2013 (Table 3-9). There were no Notices of Violation/Non-Compliance accessed in 2013; however, there were three environmental incidents that occurred that required reporting through ORPS. The incidents are summarized in Table 3-10. Causal analyses were performed for all incidents and corrective actions were taken to prevent recurrence of the issues.

Table 3-10. Summary of Other Environmental Occurrence Reports.

ORPS* ID: SC-BHSO-BNL-AGS-2013-0002	**Date: 04/18/13**
On April 17, 2013, during routine preventative maintenance of the Dunham Busch chiller in Building 911, which was shut down for the winter months, it was discovered that the refrigerant pressure was lower than normal. Follow-up investigations by Facilities and Operations maintenance personnel the following morning determined that approximately 275 pounds (full charge) of R-22 refrigerant gas had dissipated from the refrigerant system over a period of several months due to a slow leak from a solenoid valve. BNL's Environmental Protection Division (EPD) was notified of the event and immediately reported the incident to NYSDEC as a non-routine release of regulated compounds, as is required by the State. The leaking valve was replaced by A/C Mechanics.	**Status:** Closed. Repairs completed and spill report submitted.
ORPS* ID: SC-BHSO-BNL-BNL-2013-0012	**Date: 11/20/13**
On May 16, 2013, a BNL employee holding a Commercial Pesticides Technician Certification was issued a New York State Department of Environmental Conservation (NYSDEC) Notice of Violation (NOV) for failure to file a 2012 Applicator/Technician Pesticide Annual Report by a February 1, 2013 deadline. Once identified, the required paperwork was immediately submitted to NYSDEC to fulfill the requirement and corrective actions were taken to prevent this administrative violation from reoccurring.	**Status:** Closed. Corrective actions identified and completed.
ORPS* ID: SC-BHSO-BNL-BNL-2013-0006	**Date: 05/22/13**
On May 22, 2013, during maintenance repair involving recharging of refrigerant to the Dunham-Busch chiller in Building 911, a relief valve prematurely opened, resulting in a release (28 pounds) of R-22 refrigerant/oil vapor to the mechanical equipment room located on the rooftop of Building 911. As a Refrigeration and Air Conditioning Engineer left the area, he immediately secured the unit and contacted his supervisor. EPD was notified of the event and reported the incident to NYSDEC as a non-routine release of regulated compounds, as required.	**Status:** Closed. Repairs completed and spill report closed out.

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

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4 Air Quality

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

During 2013, BNL facilities released a total of 4,919 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.9 percent of the site's radiological air emissions.

Because natural gas prices were comparatively lower than residual fuel prices throughout the year, BNL's Central Steam Facility used natural gas to meet 97.4 percent of the heating and cooling needs of the Laboratory's major facilities in 2013. As a result, annual facility emissions of criteria pollutant emission were slightly higher than 2012 levels, when natural gas use accounted for 99 percent of Laboratory major facilities 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 458.1 Chg 3, *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. BNL has one facility that is continuously monitored with an in-line detection system, the Brookhaven Linac Isotope Producer (BLIP). During 2013, periodic monitoring was conducted at one active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Figure 4-1 provides the locations of these monitored facilities, and Table 4-1 presents the airborne release data for each of these facilities. Annual emissions from monitored facilities are discussed in the following sections of this chapter. The associated radiation dose estimates are presented in Chapter 8, Table 8-4.

4.1.1 High Flux Beam Reactor

In 1997, a plume of tritiated groundwater was traced back to a leak in the HFBR spent fuel storage pool. Consequently, the HFBR was put 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 continued to diffuse into the building's air through valve seals and other system penetrations, though emission rates were much lower than during the years of operation.

In 2010, the HFBR was disconnected from the 100-meter stack, and a new HFBR exhaust system was installed in 2011. Consistent with the HFBR Long-Term Surveillance and Maintenance Manual, prior to scheduled surveillance and maintenance activities, air samples are now collected from outside the HFBR confinement using a permanently installed sample port. The samples are collected by bubbling air through

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

a container of water using a fritted sampling device to ensure better collection efficiency. Samples are analyzed in-house for tritium, to ensure that air quality within the building is acceptable to permit staff entry. Additionally, samples are collected one week per month from the HFBR exhaust system using a standard desiccant sampling system for tritium analysis. Desiccant samples are analyzed by an off-site contract laboratory.

4.1.2 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 2013, BLIP operated over a period of 29 weeks, during which 1,620 Ci of C-11 and 3,300 Ci of O-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 2.68 E-4 Ci. Combined emissions of C-11 and O-15 were 4,919 Ci, only slightly higher than the combined emission of 4,910 Ci in 2012.

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

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	5.22E-01
BLIP	Carbon-11	20.4 minutes	1.62E+03
	Oxygen-15	122 seconds	3.30E+03
	Tritium	12.3 years	2.68E-04
Total			**4.92E+03**

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

4.1.3 Target Processing Laboratory

As mentioned in Section 4.1.2, 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 atmosphere. 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. Gamma analysis of monthly composite samples was discontinued in 2013. This decision was made during the preparation of BNL's 2013 Environmental Monitoring Plan, and was based on the fact that historical analytical results of TPL particulate filters showed gross alpha/beta levels to be very low and consistent with background concentrations. As a result, there are no reported radionuclide emissions from the TPL in Table 4-1. Should future gross beta analyses of TPL emissions show the potential for other radionuclide emissions, gamma analyses will be conducted.

4.1.4 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 197, 197B, 463, 480 , 490, 490A, 725, 801, 865, and 901, and 815, where research is conducted in the fields of nuclear safety, biology, high energy physics, medicine, medical therapy, photon science, advanced technology, environmental chemistry, and synthetic biology. See Table 8-4 in Chapter 8 for the calculated dose from these facility emissions.

4.1.5 Nonpoint Radiological Emission Sources

Nonpoint radiological emissions from a variety of diffuse sources were evaluated in 2013 for compliance with NESHAPs Subpart H. Diffuse sources evaluated included planned research, planned waste management activities, and planned D&D 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 environmental restoration activities that occurred in 2013.

4.2 FACILITY MONITORING

Radioactive emissions are monitored at the TPL and BLIP. 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 4-2 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 2013 are reported in Table 4-2. The average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were 0.0005 and 0.0111 pCi/m^3, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0010 and 0.0110 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 4-2 for locations). There are six blockhouse stations and three pole-mounted, battery-powered silica-gel samplers equipped for collecting samples.

At each blockhouse, vacuum pumps draw air through columns where particulate matter is captured on a glass-fiber filter. Particulate filters 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 2013, silica-gel samples were collected every 2 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. Since there are no active nuclear reactors on site and there were no planned radiological remediation projects in 2013, a decision was made to only collect ambient air samples from Stations P2, P4, P7, and P9 around the site perimeter. 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 four monitoring stations were 0.0017 and 0.0140 pCi/m^3, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-3. The results for this location are typical for the site, and show 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 collected weekly and analyzed by the NYSDOH laboratory for gross beta activity. The analytical results 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 0.0011 and 0.0210 pCi/m^3, with an average concentration of 0.0091 pCi/m^3. BNL results ranged from 0.0050 to 0.0222 pCi/m^3, with an average concentration of 0.0128 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 2013, NYSDOH reported that airborne gross beta activity at that location varied between 0.0057 and 0.0290 pCi/m^3, and the average concentration was 0.0115 pCi/m^3. All of the sample results measured at BNL 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 (tritiated water) is monitored throughout the BNL site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors that may be used for tritium sampling are located at or near the Laboratory's property boundary (see Figure 4-2 for sample locations). Tritium sampling in 2013 was limited to Stations P2, P4, P7, and P9 on the basis that they are adequately located around the site's perimeter to monitor potential impacts from BNL's three tritium sources. Observed concentrations

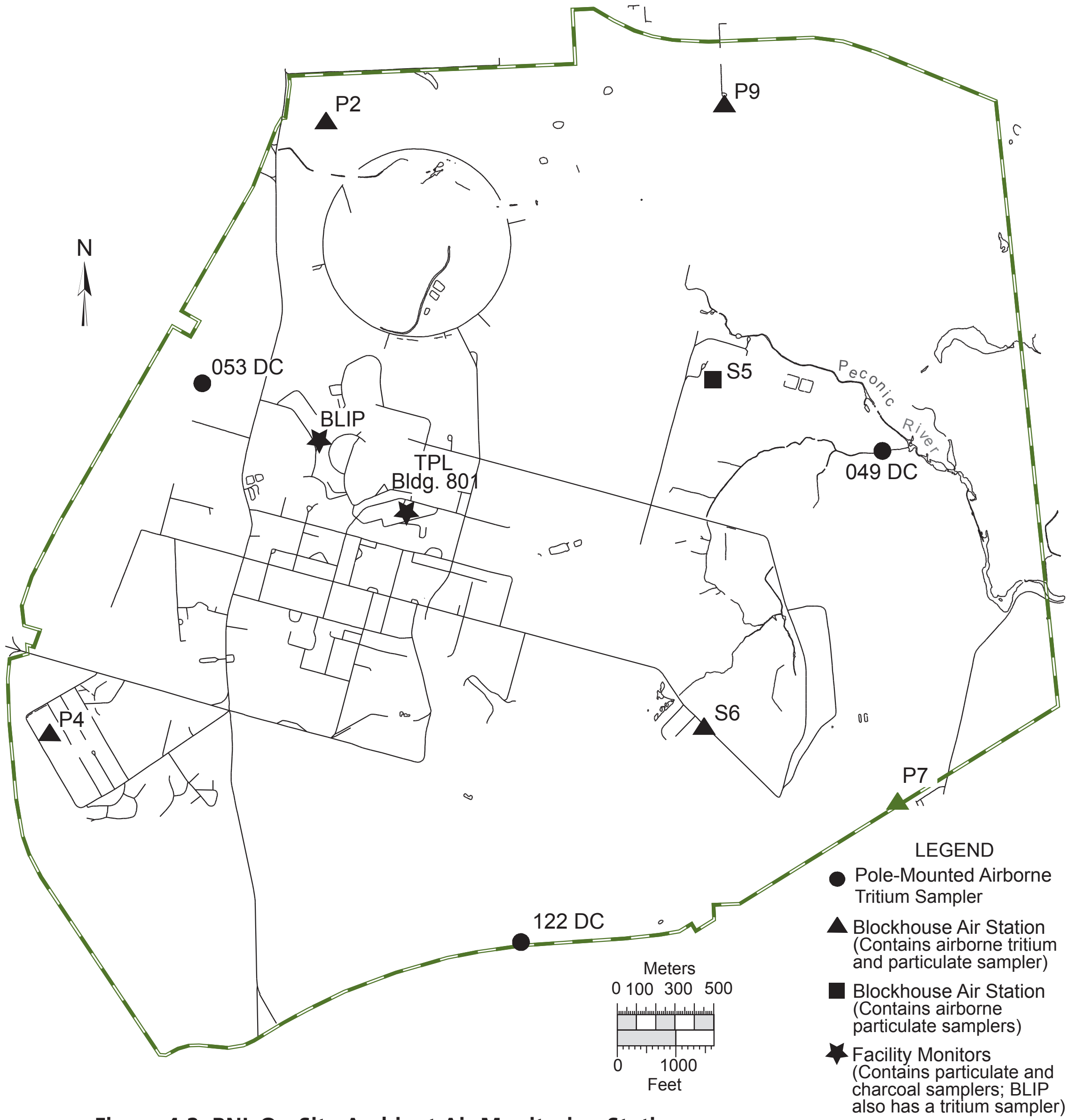


Figure 4-2. BNL On-Site Ambient Air Monitoring Stations.

of tritium at the sampling stations in 2013 were similar to concentrations observed in 2012. Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concentration. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., a battery failure in the sampler, frozen or 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 2013; however, the contract analytical laboratory rejected 20 samples because moisture captured on silica gel was insufficient for analysis. The average tritium concentrations at all of the sampling locations were less than the typical minimum detection limits (MDLs), which ranged from 3.5 to 10.0 pCi/m^3.

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

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

Facility Monitor		Gross Alpha (pCi/m³)	Gross Beta
BLIP	N	49	49
	Max.	0.0022 ± 0.0009	0.0696 ± 0.0034
	Avg.	0.0005 ± 0.0005	0.0111 ± 0.0013
	MDL	0.0007*	0.0010*
TPL-Bldg. 801	N	53	53
	Max.	0.0052 ± 0.0013	0.0458 ± 0.0019
	Avg.	0.0010 ± 0.0004	0.0110 ± 0.0010
	MDL	0.0004*	0.0006*

Notes:
See Figure 4-2 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 validated samples taken at this location

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

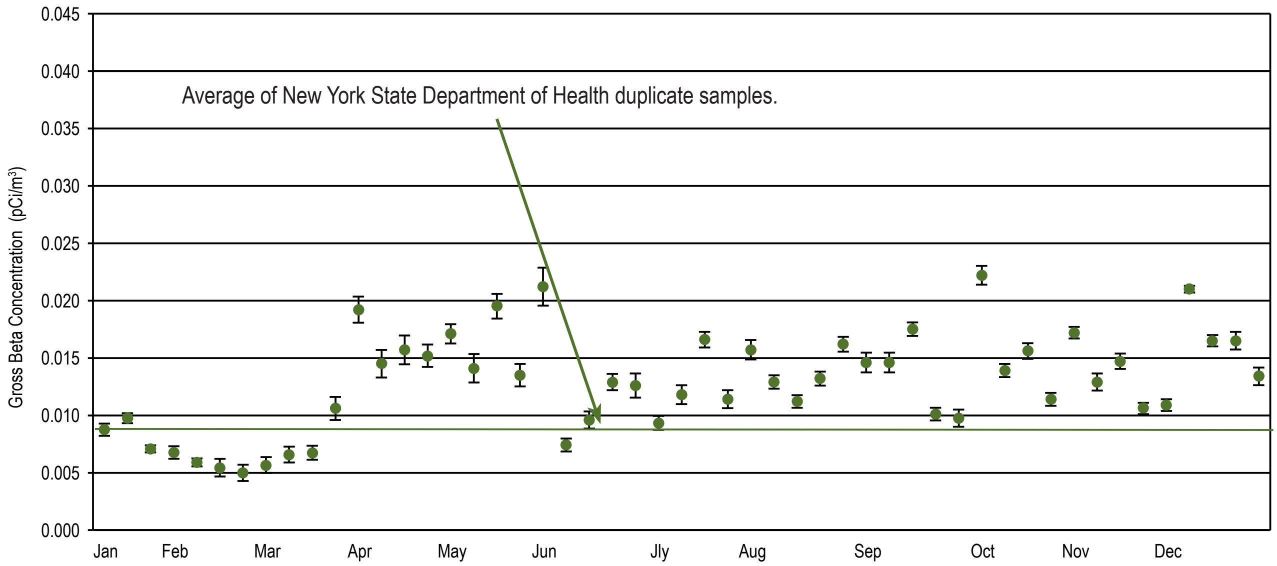
Sample Station		Gross Alpha (pCi/m³)	Gross Beta
P2	N	47	47
	Max	0.0038 ± 0.0011	0.0250 ± 0.0016
	Avg.	0.0017 ± 0.0006	0.0150 ± 0.0013
	MDL	0.0006*	0.0008*
P4	N	49	49
	Max	0.0036 ± 0.0003	0.0268 ± 0.0017
	Avg.	0.0017 ± 0.0006	0.0148 ± 0.0012
	MDL	0.0005*	0.0007*
P7	N	50	50
	Max	0.0030 ± 0.0003	0.0222 ± 0.0016
	Avg.	0.0016 ± 0.0006	0.0128 ± 0.0012
	MDL	0.0006*	0.0007*
P9	N	47	47
	Max	0.0040 ± 0.0003	0.0275 ± 0.0017
	Avg.	0.0017 ± 0.0006	0.0135 ± 0.0011
	MDL	0.0005*	0.0007*
Grand Average		**0.0017 ± 0.0006**	**0.0140 ± 0.0012**

Notes:
See Figure 4-2 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 validated samples taken at this location

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, 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 with continuous opacity monitors to demonstrate compliance with Subpart Db opacity monitoring requirements. 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



Note: All values are presented with a 95 percent confidence interval.

Figure 4-3. Airborne Gross Beta Concentration Trend Recorded at Station P7.

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 than 27 percent opacity. In 2013, there were no measured exceedances of the NO_x emission standards for either boiler.

In 2013, the one excess opacity measurement recorded by Boiler 6 during routine operations on August 5 was due to a localized short-term power outage caused by electrical maintenance work at the CSF. During quarterly quality assurance tests of the opacity monitors for Boilers 6 and 7 multiple 6-minute periods greater than 20 percent opacity were recorded. These excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to NYSDEC. 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 demonstrate periodic compliance with applicable total suspended particulate and NO_x emission standards, emission tests of all four boilers must be conducted once during the term of BNL's Title V operating permit. All of the tests were scheduled to be completed in December 2012, however unseasonably warm weather made it impractical to run Boilers 5, 6, and 7 near peak loads for the required particulate tests and subsequent operational issues caused their testing to be rescheduled to March, July, and June, respectively.

Test results showed that Boilers 1A, 5, 6, and 7 met the total suspended particulate emissions standard of 0.1 lbs/MMBtu while burning No. 6 oil near peak steam load conditions, with average emission rates of 0.035, 0.032, 0.023 and 0.032 lbs/MMBtu, respectively. NO_x emission testing of Boilers 1A and 5 demonstrated that both boilers meet current Part 227-3 NO_x emission limits of 0.3 lbs/MMBtu while burning No. 6 oil or natural gas (Boiler 5). The results also provide valuable insight that will help CSF personnel to operate the facility effectively and to comply with the new lower Part 227-3 NO_x emission standards that go into effect on July 1, 2014. Under the new standards, average NO_x emissions from midsize boilers with maximum heat input capacities between 25 and 100 MMBtu/hr

Table 4-4. Ambient Airborne Tritium Measurements in 2013.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m³)	Average (pCi/m³)
P2	NNW	24	24.8 ± 6.1	3.3 ± 4.2
P4	WSW	25	36.2 ± 4.5	2.7 ± 3.4
P7	ESE	7	4.0 ± 2.8	1.3 ± 2.3
P9	NE	23	20.5 ± 3.6	2.7 ± 3.5
Grand Average				2.8 ± 3.6

Notes:
See Figure 4-2 for station locations.
Wind sector is the downwind direction of the sample station from the High Flux Beam Reactor (HFBR) stack.
All values reported with a 95% confidence interval.
Typical minimum detection limit for tritium is between 2.0 and 10.0 pCi/m³.
DOE Order 5400.5 Air Derived Concentration Guide is 100,000 pCi/m³.

(i.e. Boiler 1A) must be no greater than 0.20 lbs/MMBtu when combusting oil or natural gas, while average NO_x emissions from large boilers with maximum heat inputs greater than 100 and less than 250 MMBtu/hr (Boilers 5, 6, and 7) must be less than or equal to 0.15 lbs/MMBtu when combusting oil or natural gas.

To satisfy quality assurance requirements for the continuous emissions monitoring system 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 December 2013. The results of the RATA demonstrated that the 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 2013, residual fuel prices exceeded those of natural gas for most of the year. As a result, natural gas was used to supply more than 97.4 percent of the heating and cooling needs of BNL's major facilities. By comparison, in 2005, residual fuel satisfied 99.9 percent of the major facility heating and cooling needs. Consequently, 2013 emissions of particulates, NO_x, and sulfur dioxide (SO_2) were 12.3, 49.7, and 90.2 tons less than the respective totals for 2005, when No. 6 oil was the predominant fuel. 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 2004.

4.5 GREENHOUSE GAS EMISSIONS

One of the overarching goals of Executive Order (EO) 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, is for federal agencies to establish agency-wide greenhouse gas (GHG) reduction targets for their combined Scope 1 and 2 greenhouse gas emissions and for their Scope 3 greenhouse gas emissions (see Appendix A for definitions).
DOE has set the following GHG emission reduction goals for fiscal year 2020: reduce Scope 1 and 2 GHG emissions by 28 percent relative to their fiscal year (FY) 2008 baseline and reduce Scope 3 GHG emissions by 13 percent relative to their FY 2008 baseline.

BNL includes these same goals in its annual Site Sustainability Plan (SSP), which is submitted to DOE in December of each year. Due to planned programmatic growth with the addition of the Laboratory's National Synchrotron Light Source II (NSLS-II) and other programs, Scope 1 and 2 emissions are projected to increase to 289,000 metric tons carbon dioxide equivalent ($MtCO_2e$) by 2020, a 95 percent increase from the FY 2008 baseline of 205,542 $MtCO_2e$. Due to the projected increase, meeting the Scope 1 and 2 reduction goal will be difficult, and BNL's SSP identifies a number of actions that have or will be taken to help the Laboratory move towards this goal.

In November 2011, the Long Island Solar Farm (LISF), a large array of more than 164,000 solar photovoltaic panels constructed at the BNL site began producing solar power. Annually, the LISF is expected to deliver 44 million kilowatt-hours of solar energy into the local utility grid. This equates to 28,000 $MtCO_2e$ that BNL can count on as GHG offsets or reductions. In March 2011, BNL began receiving 15 megawatts per hour of hydropower from the New York Power Authority. In 2013, BNL consumed 118, 856 megawatts of hy-dropower, providinga net GHG reduction of 72,502 $MtCO_2e$.

In October 2013, BHSO on behalf of BNL was awarded a Utility Energy Service Contract. This project allows for the implementation of energy savings measures and is scheduled for completion by late 2015. In addition to energy savings, it will reduce Scope 1/2 GHG levels by

Table 4-5. Central Steam Facility Fuel Use and Emissions (2004 – 2013).

	Annual Fuel Use and Fuel Heating Values						Emissions			
Year	**No. 6 Oil** (10^3 gals)	**Heating Value** (MMBtu)	**No. 2 Oil** (10^3 gals)	**Heating Value** (MMBtu)	**Natural Gas** (10^6 ft^3)	**Heating Value** (MMBtu)	**TSP** (tons)	**NO_x** (tons)	**SO_2** (tons)	**VOCs** (tons)
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	14	496.48	506,406	5.7	46.7	23.0	1.9
2009	1,904.32	283,734	0.00	0	375.03	382,529	9.0	53.4	44.9	2.1
2010	447.47	66,591	0.00	0	561.42	568,939	3.4	41.5	10.0	1.8
2011	31.49	4,726	0.01	2	657.06	668,564	2.6	30.4	0.9	1.8
2012	43.44	6,519	0.00	0	613.44	630,616	2.5	29.1	1.2	1.7
2013	117.21	17,590	0.00	0	631.95	649,645	2.9	30.7	2.9	1.8
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

approximately 7,000 $MtCO_2e$. Some of the Phase I energy conservation measures that will be employed in 2014 include:

- Improvements that will increase that efficiency in supplying chilled water
- Upgraded lighting throughout the site
- Building control additions to provide for heating, ventilation, and air conditioning setbacks

Other planned energy savings initiatives include improvements at the Central Steam Facility and in the steam distribution system, and the construction of a combined heat and power plant.

To meet the 2020 Scope 3 GHG emissions reduction goal, Scope 3 emissions must be lowered by nearly 2,600 $MtCO_2e$ from the FY 2008 baseline of 20,000 $MtCO_2e$. A secondary Scope 3 goal set by DOE is to reduce GHG emissions from employee business travel by 12 percent from the FY 2008 baseline or 1,065 $MtCO_2e$. Overall, Scope 3 GHG emissions have dropped by 2,706 $MtCO_2e$ or 13 percent from FY 2008 to FY 2012, despite a 113 $MtCO_2e$ or 1.0 percent increase in employee business travel GHG emissions over the same period. This reduction was a direct result of the purchase and use of 118, 856 megawatt-hours of hydropower from the New York Power Authority in 2013. Hydropower purchased in 2013 accounted for 43.9 percent of all BNL power purchases. As a result, GHG emissions from transmission and distribution losses dropped 3,399 $MtCO_2e$, or 30.5 percent.

To achieve the employee travel reduction goal, BNL must reduce its employee travel GHGs by 1,040 $MtCO_2e$. Reaching this goal is complicated by a growing employee population that rose 12.6 percent from 2,669 full-time employees at the end of FY 2008 to 3,004 as of end of March in 2013. Further increases are projected due to programmatic growth. Actions taken in 2013 that will help BNL move forward in meeting the employee business travel GHG reduction goals included:

- BNL staff continued to work with administrators of MetroPool, the New York State Department of Transportation regional commuting services contractor, on developing a rideshare portal customized to meet the needs of employees interested in ridesharing. Some issues with securing personally identifiable information used in ridematch search applications must be addressed before the portal development can continue. The proposed portal would include ride-match maps, displaying the location of other employee homes within a defined radius of the person seeking partners, or home locations of other employees near the route traveled by the employee. The portal will include other features, such as the location of park & ride lots, a commute cost calculator, Guaranteed Ride Service Information, and a live link to traffic conditions on major arteries.

- A working group led by BNL Human Resources developed two new procedures that will be added to the BNL Standards-Based Management System (SBMS) Flexible Work Arrangements Subject Area. These new procedures expand flexible workweek and compressed workweek schedules for non-bargaining non-exempt employees and non-bargaining employees, respectively.
- BNL's Badging Office amended forms used to register employee vehicles and provide stickers for site entrance purposes. The form now includes the vehicle model, in addition to the model year and make that was previously recorded. These records will serve as an improved metric for estimating the average mileage of vehicles used in vehicle commuting and for measuring reductions in commuter GHGs over time as employees replace older less fuel efficient models with vehicles meeting the progressively higher corporate average fuel economy standards that became effective with 2011 model year light duty vehicles.

Future actions that should help to reduce business travel GHS include plans to deploy greatly enhanced Unified Communications technologies in FY 2014 and FY 2015 as part of BNL's site-wide telephone replacement project. In addition to providing users with the ability to rapidly schedule and conduct ad-hoc audio teleconferences, the new technologies will enable users to integrate desktop video teleconferencing capabilities with larger room-based sessions and mobile devices. This allows teleconferencing sessions to be scheduled by any individual user, and spans the use of previously disparate technologies. As such, the need to travel for traditional face-to-face meetings is expected to decrease.

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5 Water Quality

Wastewater generated from operations at Brookhaven National Laboratory 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 regulatory requirements and that the public, employees, and the environment are protected.

Analytical data for 2013 show that the average gross alpha and beta activity levels in the discharge of the STP (EA, Outfall 001) were within the typical range of historical levels and were well below New York State Drinking Water Standards (NYS DWS). Tritium was not detected above method detection limits in the STP discharge during the entire year and no cesium-137, strontium-90, or other gamma-emitting nuclides attributable to Laboratory operations were detected.

Nonradiological monitoring of the STP effluent showed that organic and inorganic parameters were within State Pollutant Discharge Elimination System (SPDES) effluent limitations or other applicable standards. The average concentrations of gross alpha and beta activity in water discharged to recharge basins were within typical ranges and no gamma-emitting radionuclides were detected. Tritium was not detected above method detection limits in any of the discharges to recharge basins. Disinfection byproducts continue to be detected at very low concentrations, just above the method detection limit, 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) were detected; however, their presence is due primarily to sediment run-off in stormwater discharges.

Radiological data from Peconic River surface water sampling in 2013 show that the average concentrations of gross alpha and gross beta activity from BNL on-site locations were indistinguishable from off-site locations and control locations, and all detected levels were below the applicable NYS DWS. Tritium was detected in a single water sample collected upstream of the STP discharge at Station HY (530 ± 370 pCi/L). However, due to the low level of detection and high uncertainty with the measurement, the data may be a false positive. Inorganic data from Peconic River samples collected upstream, downstream and at control locations demonstrated that elevated amounts of aluminum and iron detected in the river are associated with natural sources. Concentrations of silver, copper, lead, and zinc detected were consistent with concentrations found in the STP discharge, and were within BNL SPDES permit limits.

5.1 SURFACE WATER MONITORING PROGRAM

Treated wastewater from the Laboratory's STP is discharged into the headwaters of the Peconic River. This discharge is permitted under the New York State Department of Environmental Conservation (NYSDEC) SPDES Program. Effluent limits are based on water quality standards established by

NYSDEC, as well as historic operational data. To assess the impact of wastewater discharge on Peconic River water quality, surface water is monitored at several locations upstream and downstream of the discharge point. Monitoring Station HY on site, but upstream of all Laboratory operations, provides information on the background water quality of the Peconic River (see Figure 5-4). The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by operations at BNL and is not within the Peconic River watershed.

On the Laboratory site, the Peconic River is an intermittent, ground water fed stream. Off-site flow occurs only following periods of sustained precipitation and a concurrent rise in the water table, typically in the spring. Off-site flow in 2013 was only persistent between March and April due to a wet spring and then again for a short period of time in June and July. When flow ceased, standing water was present throughout the year in several of the deeper sections of the river.

Five years of analytical data associated with BNL's surface water monitoring program were evaluated in 2012, and a determination was made by DOE and BNL personnel to reduce the sampling frequencies for both on- and off-site Peconic River monitoring stations starting in 2013. This decision was based on the fact that historical monitoring data indicates no significant variations in water quality throughout the Peconic River system, Peconic River Remediation efforts have been completed, and pollution prevention efforts at the Laboratory has significantly reduced the risk of accidental releases to the sanitary system. 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 BNL's SPDES permit. Figure 5-1 shows a schematic of the STP and its sampling locations. The Laboratory's STP treatment process includes four principal steps:

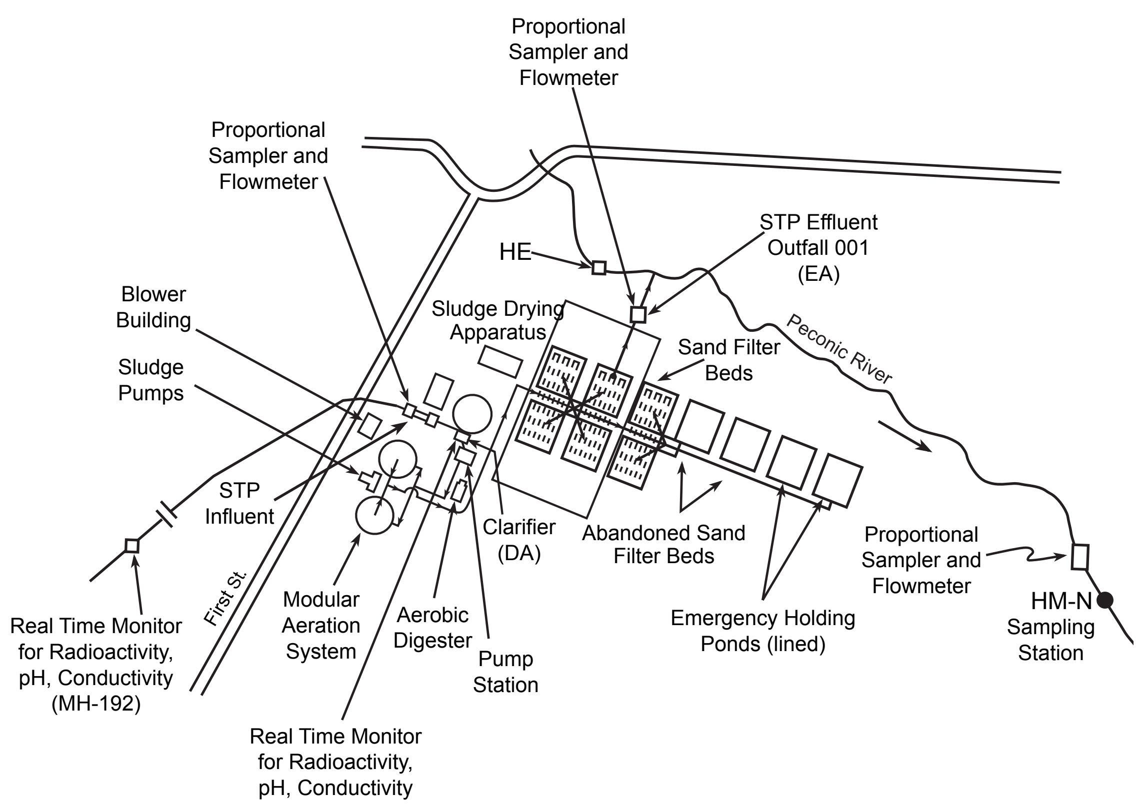

Figure 5-1. Schematic of BNL's Sewage Treatment Plant (STP).

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, 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. Limiting the concentration of nitrogen in the STP discharge is important in maintaining a balance of plant growth in the Peconic River with the nutrients provided by natural sources.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity occurs at two locations. The first site, MH-192 (see Figure 5-1), is approximately 1.1 miles upstream of the STP, providing a minimum of 30 minutes' warning to the STP operators that wastewater is en route that may exceed SPDES limits or BNL administrative effluent release criteria. The second monitoring site is at the point where the STP influent enters the treatment process.

Based on the data collected by the real-time monitoring systems, any influent to the STP that may not meet SPDES limits and BNL effluent release criteria 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 would continue until the effluent's water quality meets the permit limits and 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 nonradiological parameters or BNL effluent release criteria for radiological parameters.

In 2013, there was one instance that resulted in diversion of wastewater to the hold-up ponds. On November 14, BNL wastewater was diverted to a holdup pond due to elevated concentrations of ammonia that was initially identified during routine in-house process control sampling. Immediate corrective actions taken by the STP operators to address the issue (e.g., increase aeration time in clarifier to improve nitrification of ammonia) reduced the concentrations and the plant was placed back to normal operations the next day. However, STP effluent SPDES results from samples collected in December 2013 revealed that permit limits exceeded total nitrogen and ammonia. Section 3.6.1 in Chapter 3 provides more information on the immediate and long-term corrective actions that were implemented to address these excursions.

Solids separated in the clarifier are pumped to aerobic digesters for continued biological solids reduction and sludge thickening. Once the sludge in the aerobic digester reaches a solids content of 6 percent, the sludge is sampled to ensure it meets the waste acceptance criteria for disposal at the Suffolk County Department of Public Works Sewage Treatment Facility at Bergen Point, in West Babylon, New York.

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. In 2013, samples were collected weekly. In previous years, samples were collected three times per week. The reduction in sampling frequency was justified after a review of radiological data collected over the previous 5 years showed only an occasional low-level detection of tritium and no detection of any other BNL-generated radionuclides in both the STP influent and effluent. In addition, the sewage collection system is monitored in real-time using beta and gamma detection systems to detect any unplanned releases that could jeopardize the quality of the STP effluent. 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 may receive an annual dose greater than 4 mrem from radionuclides that are beta or photon emitters, which includes up to 168 individual radioisotopes. BNL 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 alpha and beta activity 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 2013. Annual average gross alpha and beta activity levels in the STP effluent were 0.4 ± 0.1 pCi/L and 4.3 ± 0.2 pCi/L, respectively. These concentrations have remained essentially unchanged from year to year. Control location data from the Carmans River Station HH (see Figure 5-4) show average gross alpha and beta levels of 0.52 ± 0.24 pCi/L and 0.84 ± 0.35 pCi/L, respectively (see Table 5-5) and concentrations were less than method detection limits in the one sample collected upstream of the STP outfall. Tritium was not detected above method detection limits in the discharge of the STP (EA, Outfall 001) for the entire year. The annual average tritium concentration, as measured in the STP effluent, was 68.2 ± 38.7 pCi/L, which is only 16 percent of the average minimum detection level (MDL) of 424.9 pCi/L, and well below the NYS DWS of 20,000 pCi/L. Using the annual average concentration and the flow recorded for the year, a total of 0.0312 Ci (31.2 mCi) of tritium was released during 2013, which is consistent with total releases of tritium over the past 5 years. In 2013, there were no gamma-emitting nuclides detected in the STP effluent, which is consistent with data reported since 2003. Sr-90 was detected in one effluent sample collected in September (0.73 ± 0.46 pCi/L); however, this value is consistent with historical levels both upstream and downstream of the STP and most likely attributable to worldwide fallout and not BNL-derived.

5.2.2 Sanitary System Effluent – Nonradiological Analyses

Starting in 2013, surveillance monitoring of the STP for VOCs, inorganics, and anions was discontinued. This decision was based on historical data and that all of these parameters are already monitored as part of the Compliance Program, which is discussed in further detail in Chapter 3.

5.3 PROCESS-SPECIFIC WASTEWATER

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

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*	1.51E+07	< 470	<MDL	< 1.6	1.1 ± 0.2	5.4 ± 1.2	3.6 ± 1.3
	effluent	3.27E+07	< 310	<MDL	< 1.6	0.1 ± 0.6	5.5 ± 1.2	4.6 ± 0.9
February	*influent*	3.01E+07	< 420	<MDL	< 1.9	0.6 ± 1.3	3.4 ± 0.8	2.7 ± 0.6
	effluent	2.95E+07	< 460	<MDL	1.3 ± 1.0	0.6 ± 0.5	4.7 ± 1.0	3.9 ± 0.9
March	*influent*	3.25E+07	< 420	<MDL	1.3 ± 0.9	0.6 ± 0.9	17.7 ± 2.1	6.8 ± 7.1
	effluent	2.94E+07	< 340	<MDL	< 1.5	0.2 ± 0.4	5.6 ± 1.1	4.5 ± 0.8
April	*influent*	4.54E+07	< 440	<MDL	< 1.5	0.4 ± 0.4	5.7 ± 1.1	5.1 ± 0.4
	effluent	5.68E+07	< 460	<MDL	< 1.8	0.6 ± 0.3	5.4 ± 1.1	4.5 ± 0.6
May	*influent*	4.11E+07	< 430	<MDL	< 1.5	0.1 ± 0.2	9.6 ± 1.5	6.9 ± 2.2
	effluent	2.84E+07	< 440	<MDL	< 1.4	0.2 ± 0.3	6.0 ± 1.2	5.1 ± 0.9
June	*influent*	4.73E+07	< 490	<MDL	7.6 ± 3.4	2.2 ± 3.6	12.4 ± 2.8	7.0 ± 3.5
	effluent	3.84E+07	< 390	<MDL	< 1.7	0.3 ± 0.4	4.4 ± 1.0	3.9 ± 0.7
July	*influent*	7.04E+07	< 450	<MDL	5.9 ± 2.3	2.7 ± 1.7	6.7 ± 1.5	6.2 ± 0.7
	effluent	5.28E+07	< 430	<MDL	< 1.2	0.7 ± 0.2	6.5 ± 1.2	4.6 ± 1.0
August	*influent*	3.25E+07	< 440	<MDL	6.3 ± 2.3	2.1 ± 2.9	7.1 ± 1.5	6.4 ± 1.0
	effluent	3.26E+07	< 460	<MDL	< 1.2	0.4 ± 0.4	5.1 ± 0.9	4.8 ± 0.4
September	*influent*	5.05E+07	< 390	<MDL	12.5 ± 6.6	5.8 ± 4.8	21.2 ± 4.9	11.7 ± 5.8
	effluent	3.74E+07	< 397	<MDL	< 1.5	0.2 ± 0.4	6.5 ± 1.2	4.4 ± 1.3
October	*influent*	3.44E+07	< 355	<MDL	4.7 ± 2.1	2.4 ± 1.7	9.0 ± 1.7	6.5 ± 2.3
	effluent	2.72E+07	< 467	<MDL	< 1.9	0.2 ± 0.4	4.3 ± 0.8	3.8 ± 0.7
November	*influent*	3.06E+07	< 410	<MDL	< 7.8	4.4 ± 3.0	17.7 ± 4.5	11.2 ± 6.4
	effluent	2.18E+07	< 496	<MDL	< 1.8	0.1 ± 0.2	5.5 ± 0.9	4.5 ± 0.7
December	*influent*	3.19E+07	< 442	<MDL	6.7 ± 2.8	2.3 ± 2.3	11.4 ± 2.1	6.5 ± 2.8
	effluent	2.58E+07	< 436	<MDL	< 1.9	0.9 ± 0.6	4.5 ± 1.0	3.7 ± 0.8
Annual Avg.	*influent*			<MDL		2.1 ± 0.8		6.8 ± 1.1
	effluent			<MDL		0.4 ± 0.1		4.3 ± 0.2
Total Release		**4.13E+08**		**31.2 mCi**		**0.2 mCi**		**1.8 mCi**
Average MDL (pCi/L)				**424.9**		**1.6**		**0.9**
SDWA Limit (pCi/L)				**20000**		**15**		**(b)**

Notes:
All values are reported with a 95% confidence interval.
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.

discharges from Building 902. These operations are monitored for contaminants such as metals, cyanide, VOCs, and SVOCs. In 2013, 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 sanitary 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.

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 5-2 shows the locations of the Laboratory's discharges to recharge basins (also called "outfalls" under BNL's SPDES permit). Figure 5-3 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 High Flux Beam Reactor (HFBR).
- Several other recharge areas are used exclusively for discharging stormwater runoff. These areas include Basin HW near the National Synchrotron Light Source II (NSLS-II) site, 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. Recharge basins HP and RAV are used for discharge of treated water from the groundwater remediation systems and are monitored under BNL's CERCLA equivalency permits.

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 the monitoring program, samples are also routinely collected and analyzed under BNL's Environmental Surveillance Program for radioactivity, VOCs, metals, and anions. During 2013, water samples were collected from all basins listed above semi-annually 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.

5.4.1 Recharge Basins – Radiological Analyses

Discharges to the recharge basins were sampled semi-annually and analyzed for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. The results are presented in Table 5-2, and show that low levels of alpha and beta activity were detected in most of the samples. Activities ranged from non-detectable to 2.7 ± 1.1 pCi/L for gross alpha activity, and from 1.52 ± 0.57 pCi/L to 4.4 ± 1.0 pCi/L for gross beta activity. These 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).

No gamma-emitting nuclides attributable to BNL operations were detected in any discharges, and tritium was not detected above method detection limits.

5.4.2 Recharge Basins – Nonradiological Analyses

To determine the overall impact on the environment from 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 semi-annually for water quality parameters, metals, and VOCs. Field-measured parameters (pH, conductivity, and temperature) were routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 5-3 and 5-4.

Low concentrations of disinfection byproducts were periodically detected above method detection limits 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 5 µg/L. No other VOCs were detected above method detection limits in any of the recharge basins in 2013.

For 2013, all water quality parameters were within effluent standards (Table 5-3), and most metals, except for aluminum and iron, complied with the respective water quality or groundwater discharge standards (Table 5-4). Due to the natural prevalence of these metals in soils, their presence in the water samples is likely due to suspended soil particles introduced at the time of collection. Acidification of the samples results in the dissolution of the element and its detection during analysis. This is supported by the observation that the concentrations in all filtered samples were significantly less, and well below the discharge standard or AWQS. As these metals are in particulate form, they pose no threat to groundwater quality, because the recharge basin acts as a natural filter, trapping the particles before they reach groundwater.

Table 5-2. Radiological Analysis of Samples from BNL On-Site Recharge Basins.

Basin		Gross Alpha	Gross Beta	Tritium
			(pCi/L)	
No. of samples		2	2	2
HN	*max.*	< 1.6	1.55 ± 0.69	< 360
	avg.	0.51 ± 1.35	1.25 ± 0.6	<MDL
HO	*max.*	2.7 ± 0.97	3.24 ± 0.76	< 470
	avg.	1.55 ± 2.26	1.94 ± 2.56	<MDL
HS	*max.*	< 1	5.1 ± 1.1	< 370
	avg.	0.93 ± 0.1	3.18 ± 3.75	<MDL
HT-E	*max.*	< 1.4	2.94 ± 0.66	< 370
	avg.	0.52 ± 1.35	2.02 ± 1.79	<MDL
HT-W	*max.*	1.81 ± 0.89	2.01 ± 0.53	< 370
	avg.	1.24 ± 1.12	1.43 ± 1.14	<MDL
HW	*max.*	2.7 ± 1.1	4.4 ± 1	< 310
	avg.	2.13 ± 1.12	3.24 ± 2.26	<MDL
HZ	*max.*	2.45 ± 0.87	1.52 ± 0.57	< 490
	avg.	1.8 ± 1.28	1.11 ± 0.8	<MDL
SDWA Limit		15	(a)	20,000

Notes:
See Figure 5-2 for the locations of recharge basins/outfalls.
All values reported with a 95% confidence interval.
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 radionuclides, a dose equivalent of this value cannot be calculated.
MDL = Minimum Detection Limit
SDWA = Safe Drinking Water Act

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

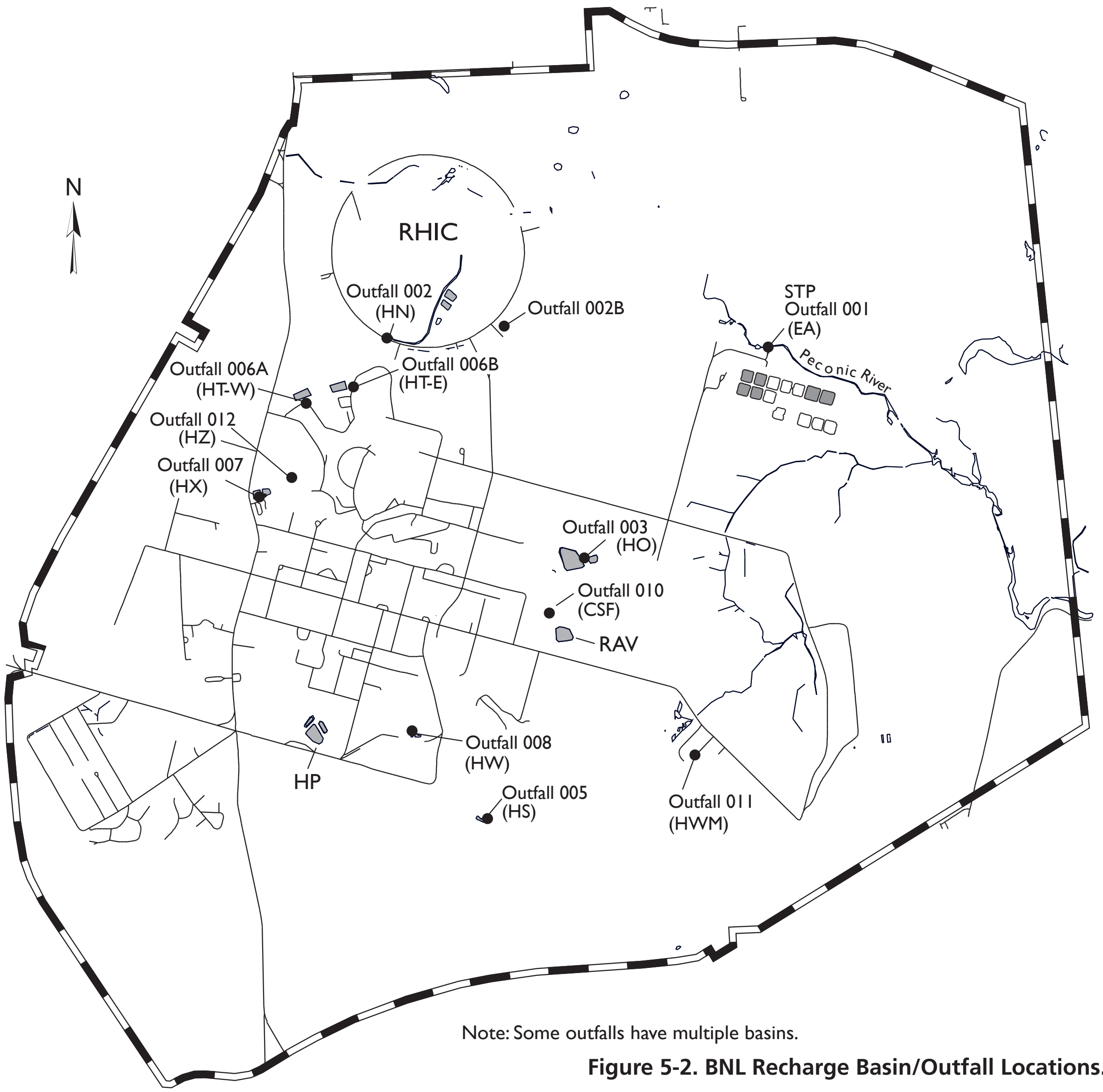

Figure 5-2. BNL Recharge Basin/Outfall Locations.

impermeable surfaces and directing it to recharge basins via underground piping and above-grade 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 HFBR areas. Basin CSF receives runoff from the CSF area and along Cornell Avenue east of Renaissance Road. Basin HW receives runoff from the NSLS-II site, 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 has 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 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.

Table 5-3. Water Quality Data for BNL On-Site Recharge Basin Samples.

ANALYTE		Recharge Basin HN (RHIC)	HO (AGS)	HS (s)	HT-W (Linac)	HT-E (AGS)	HW (s)	CSF (s)	HZ (s)	NYSDEC Effluent Standard	Typical MDL
No. of samples		2	2	2	2	2	2	2	2		
pH (SU)	*min.*	7.0	8.0	7.5	7.3	7.2	8.0	7.9	7.9	6.5 - 9.0	NA
	max.	7.2	8.7	8.2	8.1	7.7	8.3	8.3	8.7		
Conductivity (µS/cm)	*min.*	202	70	139	190	110	62	109	46	SNS	NA
	max.	238	232	224	272	128	117	208	274		
	avg.	220	151	182	231	119	90	159	160		
Temperature (ºC)	*min.*	8.4	11.1	7.4	18.1	6.4	6.2	7.2	9.7	SNS	NA
	max.	27.2	20.5	21.0	23.1	24.1	23.0	20.9	21.2		
	avg.	17.8	15.8	14.2	20.6	15.3	14.6	14.0	15.5		
Dissolved oxygen (mg/L)	*min.*	7.3	7.1	6.6	7.2	12.4	7.9	8.7	7.1	SNS	NA
	max.	10.8	12.0	11.8	9.1	732.0	12.6	12.5	11.9		
	avg.	9.1	9.5	9.2	8.1	372.2	10.2	10.6	9.5		
Chlorides (mg/L)	*min.*	31.2	11.7	34.0	42.3	28.4	9.6	7.0	8.4	500	4
	max.	45.5	45.5	61.7	51.0	49.9	13.5	17.8	45.3		
	avg.	38.4	28.6	47.9	46.7	39.2	11.6	12.4	26.9		
Sulfates (mg/L)	*min.*	8.5	1.5	5.5	11.1	3.2	1.2	1.5	1.2	500	4
	max.	8.8	9.4	8.5	13.9	14.3	7.2	4.2	9.4		
	avg.	8.7	5.5	7.0	12.5	8.8	4.2	2.9	5.3		
Nitrate as nitrogen (mg/L)	*min.*	0.6	0.1	0.5	0.7	0.7	0.1	0.1	0.1	10	1
	max.	0.9	0.3	1.5	1.4	1.4	1.3	0.8	0.2		
	avg.	0.7	0.2	1.0	1.1	1.0	0.7	0.4	0.1		

Notes:
See Figure 5-2 for the locations of recharge basins/outfalls.
(s) = stormwater
AGS = Alternating Gradient Synchrotron
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

Basin sediment sampling is conducted on a 5-year testing cycle to ensure these discharges are in compliance with regulatory requirements. The next sampling event will occur in 2017.

5.5 PECONIC RIVER SURVEILLANCE

Several locations are monitored along the Peconic River to assess the overall water quality of the river and to assess any impact from BNL discharges. Sampling points along the Peconic River are identified in Figure 5-4. In total, 10 stations (three upstream and seven downstream of the STP) were sampled in 2013. 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 monitored for radiological and nonradiological parameters.

As mentioned in Section 5.1, five years of analytical data associated with BNL's surface water monitoring program were evaluated in 2012, and a determination was made to reduce the sampling frequencies for both on- and off-site Peconic River monitoring stations starting in 2013. This decision was based on the fact that historical data has shown no significant variations in water quality throughout

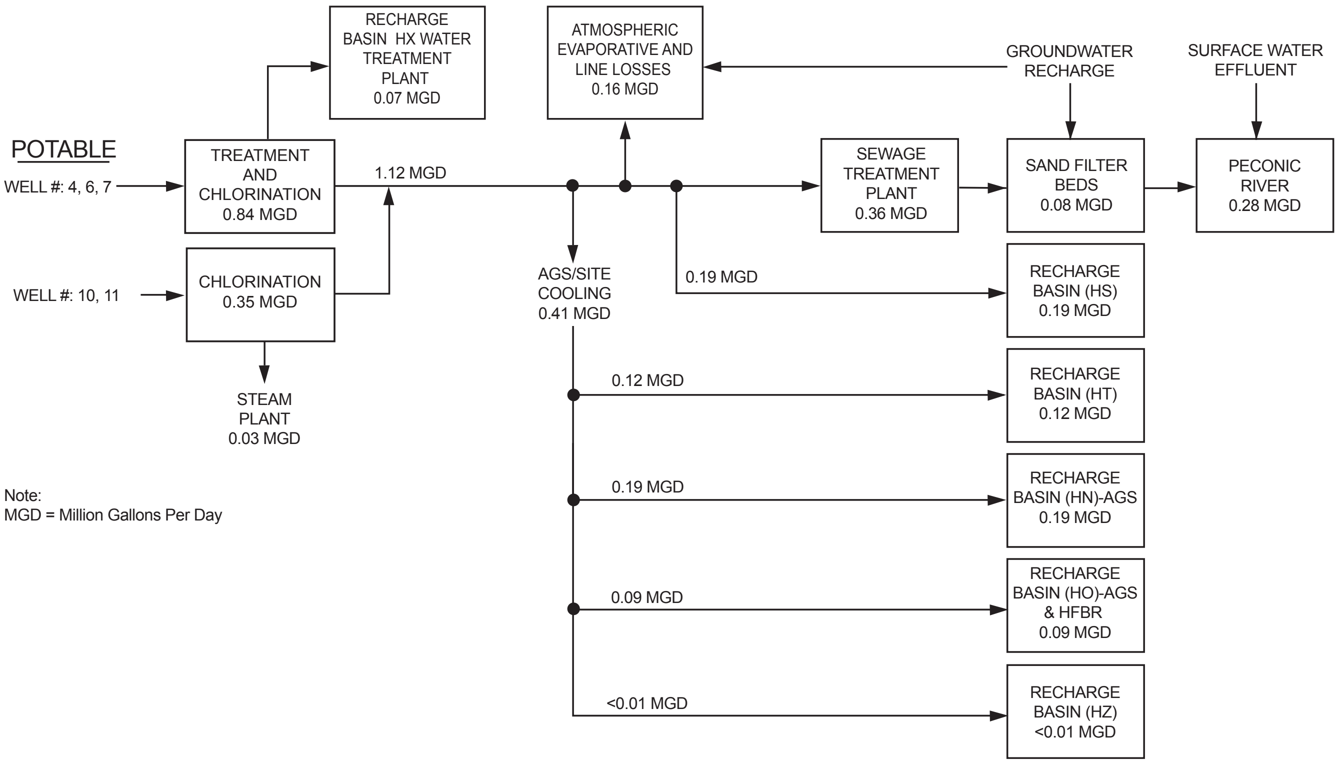

Figure 5-3. Schematic of Potable Water Use and Flow at BNL.

the Peconic River system, Peconic River remediation efforts have been completed, and pollution prevention efforts at the Laboratory has significantly reduced the risk of accidental releases to the sanitary system. 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
- 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 sampling locations, plus the control location. Routine samples at stations HM-N and HQ were collected once per quarter, as flow allowed. All other stations were sampled semiannually 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.

Table 5-4. Metals Analysis of Water Samples from BNL On-Site Recharge Basins.

METAL		HO (AGS)		HT-E (AGS)		HT-W (Linac)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
	Total (T) or Filtered (F)	T	F	T	F	T	F	T	F		
	No. of samples	2	2	2	2	2	2	2	2		
Ag Silver (µg/L)	*min.*	< 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		
	avg.	< 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	114.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	2,000	50
	max.	1880.0	< 50.0	306.0	102.0	89.6	< 50.0	2050.0	< 50.0		
	avg.	940.0	< 50.0	210.0	65.7	< 50.0	< 50.0	1032.3	< 50.0		
As Arsenic (µg/L)	*min.*	< 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		
	avg.	< 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	23.4	23.1	< 20.0	< 20.0	2,000	20
	max.	27.1	27.3	26.0	22.7	39.9	39.7	25.4	24.2		
	avg.	< 20.0	< 20.0	< 20.0	< 20.0	31.7	31.4	< 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	SNS	2.0
	max.	< 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		
Cd Cadmium (µg/L)	*min.*	< 2.0	< 2.0	0.2	< 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		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co Cobalt (µg/L)	*min.*	1.0	1.9	0.2	1.5	< 5.0	0.9	1.2	1.1	5	0.1
	max.	< 5.0	< 5.0	0.3	< 5.0	< 5.0	< 5.0	< 5.0	2.0		
	avg.	< 5.0	< 5.0	0.3	< 5.0	< 5.0	< 5.0	< 5.0	1.6		
Cr Chromium (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	100	10.0
	max.	< 10.0	< 10.0	< 10.0	< 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		
Cu Copper (µg/L)	*min.*	< 10.0	< 10.0	11.5	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	1,000	10.0
	max.	10.7	< 10.0	22.7	16.3	19.6	15.5	48.4	41.9		
	avg.	< 10.0	< 10.0	17.1	12.8	11.1	< 10.0	28.9	21.6		
Fe Iron (mg/L)	*min.*	0.06	0.05	0.29	0.08	< 0.05	< 0.05	0.07	0.04	0.6	0.05
	max.	2.34	0.05	0.41	0.15	0.14	< 0.05	2.59	0.05		
	avg.	1.20	0.05	0.35	0.12	0.07	< 0.05	1.33	0.05		
Hg Mercury (µg/L)	*min.*	< 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		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	< 5.0	< 5.0	7.4	5.5	< 5.0	< 5.0	< 5.0	5.2	600	5.0
	max.	42.1	7.3	20.1	5.6	21.5	11.7	42.1	7.0		
	avg.	23.3	< 5.0	13.8	5.6	11.2	6.1	23.5	6.1		

(continued on next page)

Table 5-4. Metals Analysis of Water Samples from BNL On-Site Recharge *(concluded).*

METAL		HO (AGS)		HT-E (AGS)		HT-W (Linac)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F		
No. of samples		2	2	2	2	2	2	2	2		
Na Sodium (mg/L)	*min.*	9.1	9.1	24.1	24.2	31.5	31.9	7.3	6.9	SNS	0.25
	max.	26.4	26.2	38.1	37.5	38.2	37.6	27.0	25.9		
	avg.	17.7	17.7	31.1	30.9	34.9	34.8	17.2	16.4		
Ni Nickel (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	200	10.0
	max.	< 10.0	< 10.0	< 10.0	< 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		
Pb Lead (µg/L)	*min.*	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	6.9	< 3.0	50	3.0
	max.	7.7	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	24.2	15.4		
	avg.	3.9	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	15.6	7.9		
Sb Antimony (µg/L)	*min.*	< 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		
	avg.	< 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	20	5.0
	max.	< 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		
Tl Thallium (µg/L)	*min.*	< 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		
	avg.	< 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	3.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5.0
	max.	7.1	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	7.2	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Zn Zinc (µg/L)	*min.*	< 10.0	< 10.0	26.5	22.8	14.0	9.6	38.8	13.5	5000	10.0
	max.	77.3	24.8	38.5	23.8	115.0	97.9	53.8	38.0		
	avg.	38.7	12.4	32.5	23.3	64.5	53.8	46.3	25.8		

Notes:
See Figure 5-2 for the locations of recharge basins/outfalls.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards

The radiological data from Peconic River surface water sampling in 2013 are summarized in Table 5-5. 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 of gross alpha activity was found at station HV, located upstream of the STP and the maximum beta activity was found at station HM-N, located downstream of the STP Outfall on site. The average concentrations from off-site and control locations were indistinguishable from BNL on-site levels. The beta activity for all locations is therefore attributed to natural sources. All detected levels were below the applicable 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 HY, an area upstream of the STP discharge, at a concentration of 530 ± 370 pCi/L. Due to the low level of detection and high level of uncertainty in the measurement, the reported result may be a false positive.

Monitoring for Sr-90 was performed at all but one Peconic River station and both control location stations in 2013. A sample from Station HV was not collected due to no water flow conditions. One low-level detection (0.38 ± 0.21 pCi/L) was found at Station HM-N, which is much less than the NYS DWS of 8 pCi/L. This concentration is consistent with historical levels, and can be attributed to worldwide fallout.

5.5.2 Peconic River – Nonradiological Analyses

River water samples collected in 2013 were analyzed for water quality parameters (pH, temperature, conductivity, and dissolved oxygen), anions (chlorides, sulfates, and nitrates), metals, and VOCs. The analytical data for the Peconic River and Carmans River samples are summarized in Table 5-6 (water quality) and Table 5-7 (metals). There were no VOCs detected above the method detection limits from any of the Peconic River sampling stations in 2013.

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 sulfates were highest at Station HM-N, which is immediately downstream of the STP outfall, and were likely a result of road salting operations at the Laboratory. There are no NYS AWQS imposed for chloride or sulfates in discharges to surface water; however, since the Peconic River recharges to groundwater, the

Table 5-5. 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 (headwaters) on site, west of the RHIC ring	*N*	2	2	2	2
	max	< 1.1	2.38 ± 0.78	530 ± 370	< 0.77
	avg	0.71 ± 0.69	2.02 ± 0.7	< MDL	0.24 ± 0.64
HV (headwaters) on site, inside the RHIC ring	*N*	2	2	2	NS
	max	0.99 ± 0.6	1.11 ± 0.59	< 490	
	avg	0.92 ± 0.15	1.08 ± 0.06	< MDL	
HE upstream of STP outfall	*N*	1	1	1	1
	max	< 0.84	< 0.87	< 350	< 0.18
	avg	NA	NA	NA	NA
HM-N downstream of STP, on site	*N*	4	4	4	4
	max	< 1.5	6.11 ± 1.14	< 450	0.38 ± 0.21
	avg	0.77 ± 0.34	4.24 ± 1.35	< MDL	0.42 ± 0.23
HM-S tributary, on site	*N*	1	1	1	1
	max	< 0.76	< 0.51	< 370	< 0.62
	avg	NA	NA	NA	NA
HQ downstream of STP, at BNL site boundary	*N*	3	3	3	3
	max	< 1.8	2.92 ± 0.86	< 360	< 0.76
	avg	0.4 ± 1.17	2.21 ± 1.04	< MDL	0.18 ± 0.07
HA off site	*N*	2	2	2	2
	max	< 0.88	1.4 ± 0.66	< 420	< 0.19
	avg	-0.05 ± 0.64	1.11 ± 0.57	< MDL	0.08 ± 0
Donahue's Pond off site	*N*	2	2	2	2
	max	< 1.6	< 0.98	< 470	< 0.18
	avg	0.42 ± 0.04	0.22 ± 0.36	< MDL	0.09 ± 0.14
Forge Pond off site	*N*	2	2	2	2
	max	< 0.9	1.56 ± 0.67	< 410	< 0.21
	avg	0.52 ± 0.32	1.21 ± 0.69	< MDL	0.05 ± 0.1
Carmans River HH control location, off site	*N*	2	2	2	2
	max	< 1.1	1.02 ± 0.66	< 420	< 0.19
	avg	0.52 ± 0.24	0.84 ± 0.35	< MDL	-0.09 ± 0.02
Swan Pond control location, off site	*N*	2	2	2	2
	max	< 0.68	2.13 ± 0.68	< 460	< 0.22
	avg	-0.01 ± 0.14	1.34 ± 1.54	< MDL	0.13 ± 0.12
SDWA Limit (pCi/L)		**15**	**(a)**	**20,000**	**8**

Notes:
See Figure 5-4 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.
MDL = Method Detection Limit
N = Number of samples analyzed
NA = Not Applicable
NS = Not Sampled for this analyte
RHIC = Relativistic Heavy Ion Collider
SDWA = Safe Drinking Water Act
STP = Sewage Treatment Plant

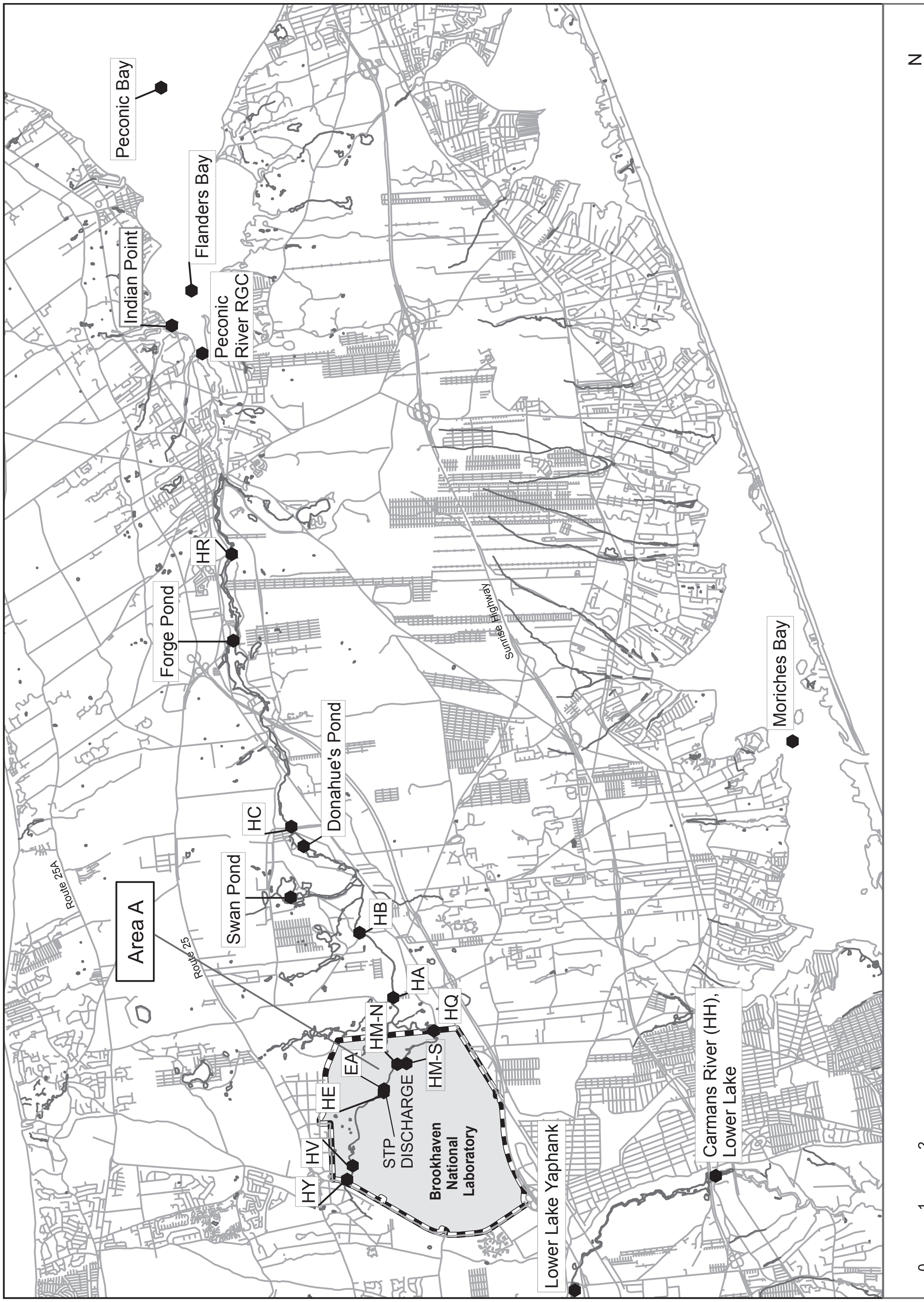

Figure 5-4. Sampling Stations for Surface Water, Fish, and Shellfish.

Table 5-6. Water Quality Data for Surface Water Samples Collected along the Peconic and Carmans Rivers.

Analyte		Peconic River Station Locations										NYSDEC Effluent Standard	Typical MDL
		HY	HE	HM-N	HM-S	HQ	HA	Donahue's Pond	Forge Pond	Swan Pond	(Control) HH		
	No. of samples	2	1	4	1	3	2	2	2	2	2		
pH (SU)	*min.*	6.5	NA	7.0	NA	6.8	6.3	5.3	6.1	6.1	7.5	6.5-8.5	NA
	max.	7.7	6.5	8.3	3.4	8.1	7.2	6.1	7.5	6.8	7.8		
Conductivity (µS/cm)	*min.*	34	NA	315	NA	9	69	48	70	57	109	SNS	NA
	max.	241	60	431	40	367	71	77	158	75	181		
	avg.	138	NA	379	NA	237	70	63	114	66	145		
Temperature (ºC)	*min.*	12.2	NA	3.9	NA	5	8.9	8.3	8.3	8.6	10.7	SNS	NA
	max.	21.4	4.1	28.2	5.0	28.0	13.0	18.0	20.8	15.6	14.8		
	avg.	16.8	NA	13.4	NA	16	10.9	13.2	14.6	12.1	12.8		
Dissolved oxygen (mg/L)	*min.*	8.2	NA	6.6	NA	5	7.4	8.0	10.2	9.3	10.1	>4.0	NA
	max.	10.4	10.8	15.4	9.8	12.7	10.2	11.4	12.1	10.9	11.2		
	avg.	9.3	NA	12.0	NA	10	8.8	9.7	11.1	10.1	10.7		
Chlorides (mg/L)	*min.*	1.2	NA	56.7	NA	16	8.2	10.2	15.7	9.6	32.7	250(a)	4.0
	max.	66.4	11.5	74.8	4.6	65.8	9.9	11.4	23.2	10.9	33.4		
	avg.	33.8	NA	67.2	NA	46	9.1	10.8	19.5	10.3	33.1		
Sulfates (mg/L)	*min.*	1.2	NA	14.8	NA	5	2.4	4.2	8.5	4.6	12.2	250(a)	4.0
	max.	2.1	6.1	20.0	2.1	14.1	5.5	6.1	13.0	6.4	12.3		
	avg.	1.7	NA	17.3	NA	11	4.0	5.2	10.8	5.5	12.3		
Nitrate as nitrogen (mg/L)	*min.*	0.1	NA	2.5	NA	0	< 0.02	0.0	0.0	< 0.02	1.7	10(a)	1.0
	max.	0.3	0.02	7.0	0.1	1.6	0.1	0.0	0.1	< 0.02	1.7		
	avg.	0.2	NA	4.7	NA	1	0.0	0.0	0.1	< 0.02	1.7		

Notes:
See Figure 5-4 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

AWQS for groundwater (250 mg/L) for these substances is used for comparison purposes.

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 2013, 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 total (i.e., particulate form) metals data showed that silver, aluminum, copper, iron, mercury, lead, and zinc were present in concentrations at some locations that exceeded NYS AWQS. Aluminum and iron 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. The highest levels for silver, copper, mercury, lead, and zinc were found in samples collected immediately downstream

Table 5-7. 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	2	2	1	1	5	3	1	1	4	2	2	2	2	2	2	2	2	2	2	2		
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.	< 2.0	< 2.0	< 2.0	< 2.0	9.5	< 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	3.5	< 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.*	217.0	< 50.0	239.0	205.0	< 50.0	< 50.0	449.0	379.0	< 50.0	217.0	58.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	100	50
	max.	628.0	304.0	239.0	205.0	1200.0	87.0	449.0	379.0	547.0	264.0	115.0	104.0	83.0	65.7	88.1	< 50.0	66.0	< 50.0	< 50.0	< 50.0		
	avg.	422.5	172.5	239.0	205.0	372.4	< 50.0	449.0	379.0	279.7	240.5	86.5	69.4	66.1	52.7	57.3	< 50.0	< 50.0	< 50.0	< 50.0	< 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.	< 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		
	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	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	7.2	5.2	18.6	18.7	16.1	11.0	7.1	5.8	7.4	6.4	7.7	6.9	9.0	8.2	4.8	3.9	9.5	8.4	33.0	31.9	SNS	1.8
	max.	24.3	13.8	18.6	18.7	44.0	26.0	7.1	5.8	10.9	6.7	12.9	12.2	12.2	11.5	5.7	5.3	12.0	11.6	38.8	37.1		
	avg.	15.8	9.5	18.6	18.7	25.7	17.6	7.1	5.8	9.3	6.6	10.3	9.6	10.6	9.9	5.3	4.6	10.8	10.0	35.9	34.5		
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.	< 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		
	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	< 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	< 2.0	< 2.0	1.1	2
	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	< 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	< 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.	< 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		
	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	< 5.0	< 5.0	< 5.0	< 5.0		
Cr (I) Chromium (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	< 10.0	< 10.0	< 10.0	< 10.0	34	10
	max.	< 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	< 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	< 10.0	< 10.0	< 10.0	< 10.0		
Cu (D) Copper (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	19.1	< 10.0	< 10.0	< 10.0	11.2	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	4	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	76.0	41.2	< 10.0	< 10.0	15.2	13.2	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	35.3	33.8	< 10.0	< 10.0	< 10.0	12.2	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		

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Table 5-7. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers. *(continued)*.

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		2	2	1	1	5	3	1	1	4	2	2	2	2	2	2	2	2	2	2	2		
Fe (AS) Iron (mg/L)	*min.*	0.2	0.1	0.3	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.3	0.2	0.0	0.0	0.3	0.2	0.2	0.1	0.3	0.075
	max.	0.7	0.2	0.3	0.2	0.9	0.1	0.2	0.2	0.2	0.1	3.8	2.2	1.2	1.0	0.1	0.0	0.3	0.2	0.3	0.2		
	avg.	0.5	0.1	0.3	0.2	0.4	0.1	0.2	0.2	0.2	0.1	2.0	1.2	0.8	0.6	0.1	0.0	0.3	0.2	0.3	0.1		
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	0.5	< 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	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	6.2	4.0	54.3	55.6	7.3	4.9	30.0	31.4	6.3	4.7	19.8	20.1	36.7	35.9	11.4	10.4	14.4	12.8	31.1	30.1	SNS	2
	max.	33.4	30.7	54.3	55.6	16.5	9.1	30.0	31.4	18.2	17.9	173.0	169.0	85.8	82.0	14.8	11.6	66.5	62.6	66.5	66.5		
	avg.	19.8	17.4	54.3	55.6	12.8	6.8	30.0	31.4	11.9	11.3	96.4	94.6	61.3	59.0	13.1	11.0	40.5	37.7	48.8	48.3		
Na Sodium (mg/L)	*min.*	2.2	2.2	7.9	8.0	43.4	48.2	3.1	3.0	15.1	15.2	5.8	5.4	7.4	7.3	6.3	6.6	11.4	10.7	20.1	20.1	SNS	1
	max.	44.7	45.7	7.9	8.0	58.0	56.0	3.1	3.0	49.7	50.1	7.6	7.7	7.4	7.4	6.4	6.6	13.7	14.1	22.5	22.4		
	avg.	23.4	24.0	7.9	8.0	49.5	51.2	3.1	3.0	37.1	32.7	6.7	6.6	7.4	7.4	6.3	6.6	12.6	12.4	21.3	21.3		
Ni (D) Nickel (µg/L)	*min.*	< 1.1	< 1.1	< 1.1	1.1	2.4	2.7	< 1.1	1.2	1.2	1.2	< 1.1	< 1.1	< 1.1	< 1.1	< 10.0	< 1.1	< 10.0	< 1.1	< 10.0	< 1.1	23	1.1
	max.	1.4	1.1	< 1.1	1.1	6.5	4.1	< 1.1	1.2	3.8	3.8	< 10.0	< 1.1	< 10.0	< 1.1	< 10.0	< 1.1	< 10.0	< 10.0	< 10.0	< 1.1		
	avg.	< 1.1	< 1.1	< 1.1	1.1	3.7	3.4	< 1.1	1.2	2.6	2.5	< 10.0	< 1.1	< 10.0	< 1.1	< 10.0	< 1.1	< 10.0	< 10.0	< 10.0	< 1.1		
Pb (D) 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	< 3.0	< 3.0	< 3.0	< 3.0	1.4	3
	max.	3.9	< 3.0	< 3.0	< 3.0	5.9	< 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		
	avg.	< 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	< 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	< 5.0	SNS	5
	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	< 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	< 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.	< 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		
	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	< 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.	< 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		
	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	< 5.0	< 5.0	< 5.0	< 5.0		

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Table 5-7. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers *(concluded).*

METAL		Peconic River Locations																		Control		NYSDEC AWQS	Typical MDL
		HY		HE		HM-N		HM-S		HQ		HA		DP		Swan Pond		Forge Pond		HH			
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		2	2	1	1	5	3	1	1	4	2	2	2	2	2	2	2	2	2	2	2		
V (AS) 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	< 5.0	< 5.0	< 5.0	< 5.0	14	5
	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	< 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	< 5.0	< 5.0	< 5.0	< 5.0		
Zn (D) Zinc (µg/L)	*min.*	19.2	15.6	18.6	16.6	18.0	28.0	10.2	20.4	< 10.0	25.8	10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	34	10
	max.	30.2	22.0	18.6	16.6	66.0	69.9	10.2	20.4	34.5	30.2	10.0	12.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	24.7	18.8	18.6	16.6	43.1	44.6	10.2	20.4	19.1	28.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		

Notes:
See Figure 5-4 for the locations of sampling stations.
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
D = Dissolved
DP = Donahue's Pond
NA = Not Applicable
SNS = Effluent Standard Not Specified for these elements in Class C Surface Waters
T = Total

of the STP discharge (Station HM-N) at concentrations greater than the NYS AWQS. The concentrations detected were consistent with those found in the STP discharge and, in most instances, were within the BNL SPDES permit limits. Mercury was detected once in an unfiltered sample collected at Station HM-N, most likely due to historical operations, but none was detectable in filtered samples. The NYS AWQS limits for copper, lead, and zinc are very restrictive; consequently, BNL's 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.

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6 Natural and Cultural Resources

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 on-site personnel 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 2013, deer and fish sampling results were consistent with previous years. Vegetables grown in nearby farms continue to support historical analyses that there are no Laboratory-related radionuclides in produce.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL 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 Natural Resource Management Program at BNL promotes stewardship of the natural resources found at the Laboratory, and integrates natural resource management and protection with BNL's scientific mission. The Natural Resource Management Plan (NRMP) for Brookhaven National Laboratory describes the program strategy, elements, and planned activities for managing the various natural resources found on site. The first iteration of the NRMP was approved by DOE in 2003 and the plan is updated every 5 years (BNL 2011).

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 2012, a forest fire was started on the northern part of BNL property, burning approximately 300 acres on site and an additional 700 acres off site. Within 2 days of the fire, Laboratory personnel began recording the extent of the fire using GPS, established photo points, and began tracking both fire damage and post-fire recovery. Maps of the fire and photo locations were entered into the GIS for future reference and are revisited periodically to track recovery. A deer exclosure area was established to track impacts of BNL's high deer population on the burn area as it continues to recover.

Work associated with tracking impacts from the construction of the Long Island Solar Farm (LISF) at BNL continue to be entered into a GIS as a tool to assist analysis of changes to wildlife populations and vegetation. In 2013, natural resource personnel and interns continued to look at use of the LISF site by wildlife; use of fence openings by wildlife; changes in bird use; and changes in vegetation.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site. Through implementation of the NRMP, endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years or are expected to be present on site (Table 6-1). The only New York State endangered species confirmed as currently inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Five other New York State endangered species have been identified at BNL in the past: the Persius duskywing butterfly (*Erynnis p. persius*), the crested fringed orchid (*Platanthera cristata*), Engelman spikerush (*Eleocharis engelmannii*), dwarf huckleberry (*Gaylussacia bigeloviana*), and whorled loosestrife (*Lysimachia quadrifoli*).

Six New York State threatened species have been positively identified on site and three other species are considered likely to be present. Threatened species include two fish, the banded sunfish (*Enneacanthus obesus*) and swamp darter (*Etheostoma fusiforme*); and plants, including the stiff goldenrod (*Solidago rigida*) and stargrass (*Aletris farinose*). The northern harrier (*Circus cyaneus*) is periodically seen in the fall. Insects listed as threatened include the Pine Barrens bluet (*Enallagma recurvatum*), a damselfly, which was confirmed at one of the many coastal plain ponds located on site. Two other damselflies, the little bluet (*Enallagma minisculum*) and the scarlet bluet (*Enallagma pictum*), are likely to be present at one or more of the ponds on site. The frosted elfin (*Callophrys irus*), a butterfly, has been historically present on site due to its preferred habitat and host plant, wild lupine (*Lupinus perennis*).

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 are listed in Table 6-1.

BNL historically has had no federally threatened or endangered species present on site. On October 2, 2013, the U.S. Fish & Wildlife Service (FWS) published a notice in the Federal Register that the northern long-eared bat (*Myotis septentrionalis*) be recommended for listing as an Endangered Species under the Federal Endangered Species Act. The comment period is to be completed by early 2014 and listing to occur in late 2014. The northern long-eared bat is known to be present at BNL having been identified as the first case of white-nosed syndrome found on Long Island in 2011. Work on identifying bats continued in 2013 and is discussed below in Section 6.5.

6.1.2 Habitat Protection and Enhancement

BNL has administrative processes in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on endangered, threatened, or sensitive species are either incorporated into Laboratory procedures or into specific program or project plans. Human access to critical habitats, when necessary, is limited, and habitats are enhanced to improve survival or increase populations. Routine activities, such as road maintenance, are not performed until the planned activities have been evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

Many safeguards are in place to protect eastern tiger salamander breeding areas. BNL staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts. A map of the breeding areas is reviewed when new projects are proposed. The map is updated as new information concerning the salamanders is generated through research and monitoring. The current map incorporates a buffer area around tiger salamander habitat of 1,000 feet based on guidance from the New York State Department of Environmental Conservation (NYSDEC).

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 post-poned or closely monitored.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with NYSDEC, habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed 26 on-site ponds that are used by eastern tiger salamanders. In 2013, egg mass surveys confirmed the presence of salamanders in 8 of the 26 ponds identified at BNL. Whenever possible, ponds with documented egg masses from the spring surveys are revisited in June and July to check for the presence of larval salamanders.

Protection of the eastern tiger salamander was a key component of the Environmental Assessment (EA) conducted for the LISF project. The unique shape of the project construction area is, in part, the result of a need to provide sufficient, viable habitat for the tiger salamander within the area to be developed. In 2010, the LISF project completed habitat enhancements to improve one pond in the area, with the enhancements intended to allow the pond to retain water for longer periods of time to support larval development. The enhanced pond is currently being managed to remove invasive plants that moved into the pond from surrounding areas. Several areas of the LISF have maintained standing water since construction, and these areas have been monitored for use by amphibians.

6.1.2.2 Banded Sunfish

Banded sunfish protection efforts include observing whether adequate water is present within areas currently identified as sunfish habitat, ensuring that existing vegetation in their habitat is not disturbed, and evaluating all activities taking place in ponds and the Peconic River on site for potential impacts on these habitats. Population estimates are periodically conducted within these waters to determine their current health.

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			
Comet darner	*Anax longipes*	SGCN	Confirmed
Frosted elfin	*Callophrys iris*	T	Likely
New England bluet	*Enallagma laterale*	SGCN	Likely
Little bluet	*Enallagma minusculum*	T	Confirmed
Scarlet bluet	*Enallagma pictum*	T	Likely
Pine Barrens bluet	*Enallagma recurvatum*	T	Confirmed
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Pine barrens zanclognatha	*Zanclognatha martha*	SGCN	Confirmed
Black-bordered lemon moth	*Marimatha nigrofimbria*	SGCN	Confirmed
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Fowler’s toad	*Bufo fowleri*	SGCN	Confirmed
Four-toed salamander	*Hemidactylium scutatum*	SGCN	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Worm snake	*Carphophis amoenus*	SC	Confirmed
Snapping turtle	*Chelydra serpentina*	SGCN	Confirmed
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Northern black racer	*Coluber constrictor*	SGCN	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Stinkpot turtle	*Sternotherus odoratus*	SGCN	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Eastern ribbon snake	*Thamnophis sauritus*	SGCN	Confirmed
Birds (nesting, transient, or potentially present)			
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Sharp-shinned hawk	*Accipiter striatus*	SC	Confirmed
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Great egret	*Ardea alba*	SGCN	Confirmed
Whip-poor-will	*Caprimulgus vociferus*	SC	Confirmed
Northern harrier	*Circus cyaneus*	T	Confirmed
Black-billed cuckoo	*Coccyzus erythropthalmus*	SGCN	Confirmed
Northern bobwhite	*Colinus virginianus*	SGCN	Confirmed
Prairie warbler	*Dendroica discolor*	SGCN	Confirmed
Horned lark	*Eremophila alpestris*	SC	Confirmed
Wood thrush	*Hylocichla mustelina*	SGCN	Confirmed
Red-headed woodpecker	*Melanerpes erythrocephalus*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Scarlet tanager	*Piranga olivacea*	SGCN	Confirmed
Glossy ibis	*Plegadis falcinellus*	SGCN	Confirmed
Brown thrasher	*Toxostoma rufum*	SGCN	Confirmed
Blue-winged warbler	*Vermivora pinus*	SGCN	Confirmed
Plants			
Small-flowered false foxglove**	*Agalinis paupercula*	R	Confirmed
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa ssp. interior*	V	Confirmed

(continued on next page)

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

Common Name	Scientific Name	State Status	BNL Status
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Flowering dogwood	*Cornus florida*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Ground pine	*Dendrolycopodium obscurum*	V	Confirmed
Round-leaved sundew**	*Drosera rotundifolia var. rotundifolia*	V	Confirmed
Marginal wood fern**	*Dryopteris marginalis*	V	Confirmed
Engelman spikerush**	*Eleocharis engelmannii*	E	Confirmed
Dwarf huckleberry**	*Gaylussacia bigeloviana*	E	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
Wild lupine**	*Lupinus perennis*	R	Confirmed
Whorled loosestrife	*Lysimachia quadrifolia*	E	Confirmed
Bayberry	*Myrica pensylvanica*	V	Confirmed
Stiff-leaved goldenrod	*Oligoneuron rigida*	T	Confirmed
Cinnamon fern	*Osmunda cinnamomea*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Green fringed orchis**	*Platanthera lacera*	V	Confirmed
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Marsh fern	*Thelypteris palustris var. pubescens*	V	Confirmed
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed

Notes:
* Table information based on 6 NYCRR Part 182, NYCRR Part 193, and BNL survey data.
** Species added in 2012
No federally listed threatened or endangered species are known to occur at BNL.

E = endangered
R = rare
T = threatened
SC = species of special concern
SGCN = species of greatest conservation need
V = exploitably vulnerable

During the last population survey in 2011, approximately 6,400 banded sunfish were counted.

6.1.2.3 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 seven permanent bird survey routes in various habitats on site. A new route was established in 2010 in the vicinity of the LISF.

In 2013, monthly surveys were conducted starting at the end of April and extending through the end of August. Two routes associated with the LISF were monitored bi-weekly from mid-May through mid-September. These surveys identified 73 songbird species, compared to the 69 species identified in 2012 and 62 species in 2011. A total of 129 bird species have been identified in surveys in the past 14 years; 59 of these species were present in each of the past 14 years. Variations in the number and species identified during each survey may reflect the time of observation, variations in weather patterns between years, and possible changes in the environment. The two most diverse transects pass near on-site wetlands near the LISF and the Peconic River. The four transects passing through the various forest types on site (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Bird survey data are stored in an electronic database for future reference and study. In 2013, BNL worked with a statistician to analyze 13 years of collected data to determine any trends. This effort found that 20 percent of the bird species detected accounted for 80 percent of the number of birds detected on bird surveys. This is known as the Pareto Principle, or the 80-20 rule: approximately 80 percent of the effects come from 20 percent of the causes (Rispoli, et al. 2014).

No known data on the effects of a large, utility-scale solar arrays such as the LISF are known within scientific literature. To assess the effects of the solar farm on local bird populations, the collection of migratory bird data in both the Biology Field transect and the solar farm transect is important. It is currently predicted that the LISF will improve habitat for some migratory birds over time, as understory vegetation grows below the arrays and deer are kept out of the area. One species, indigo bunting (*Passerina cyanea*), was absent along the Biology Field transect in 2011, but was heard along the solar farm transect in 2012 and returned to the Biology Field transect in 2013. This temporary absence is thought to be due to disturbance from construction activities while building the solar farm.

The eastern bluebird (*Sialia sialis*) has been identified as a declining species of migratory birds in North America. This is due to loss of habitat and 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. Although many of these boxes were removed from service in 2010 in preparation for the construction of the LISF, the LISF created nearly 200 acres of suitable habitat for the eastern blue bird. Forty additional boxes were installed around the northernmost portions of the LISF in 2012, and an additional 40 boxes are planned for installation or replacement in 2014.

Migratory birds occasionally cause safety and health concerns, particularly Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas on site. Over the past several years, the resident Canada goose population at BNL began increasing, with the potential to reach large enough numbers that could result in health and safety issues. In 2007, under a permit from FWS, the Laboratory began managing the resident goose population. In 2013, 20 nests were treated, but many nests were missed and approximately 45 goslings were produced, resulting in a population increase to more than 130 individuals. In order to educate BNL facility managers and other environmental and safety personnel about migratory birds, a training program on the Migratory Bird Treaty Act and other bird regulations was prepared. It is anticipated that this training will result in improved employee awareness of the Canada goose problems, and allow for a more timely response for nest management.

6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, 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*). In 2013, the on-site population appears to have stabilized at approximately 300 birds. In 2009, the wild turkey population across Suffolk County, Long Island, was determined to be of sufficient size to support hunting. Each year, the NYSDEC manages a five-day hunting period for several areas across Long Island, which typically results in over 100 birds taken each year.

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 currently 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 optimal circumstances. This was the approximate density in 1966, when BNL reported an estimate of 267 deer on site (Dwyer 1966). The Laboratory has been conducting population surveys of the white-tailed deer since 2000. Spring surveys in 2013 estimated the population at more than 600 animals.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries to both humans and animals), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (collision damage to autos and browsing damage to ornamental plantings). Deer related collisions on site are less common than in the past, presumably due to improved vehicular speed controls and employee training.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. In 2012, several governmental entities on eastern Long Island began working to manage deer populations and the

USDA-Wildlife Services, in cooperation with NYSDEC and the Suffolk County Farm Bureau, planned a limited culling operation. Culling was to start in several of Long Island's east end towns in late 2013, but was delayed to early 2014 due to public concerns about the culling program.

In 2008, BNL began developing a deer management plan which includes an option to reduce the population through culling. The planning effort has included engagement of Laboratory employees and guests in discussions concerning the need and methods for deer management. In 2012, an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA) was completed and sent to NY State for comment. The Final EA was completed in the spring of 2013. Additionally, under BNL's permit for deployment of the 4-Poster tick management system issued by the NYSDEC, the Lab is required to implement a deer management program. Planning for implementing the deer cull is ongoing.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL ensures that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory uses NEPA when identifying potential environmental impacts associated with site activities, especially projects that may result in physical alterations to the landscape and structures. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council, and the Brookhaven Executive 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. As discussed previously, in 2012, BNL started an EA for the proposed management of white-tailed deer on the BNL site. The EA was completed in the spring of 2013 with a Finding of No Significant Impact (FONSI). A summary of NEPA reviews is provided in Chapter 3.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

The Upton Ecological and Research Reserve (Upton Reserve) consists of 530 acres located on the eastern boundary of the BNL site. The Reserve has been designated as an area for the protection of sensitive habitats and a place where researchers can study local ecosystems. The Upton Reserve 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).

The Upton Reserve is managed by BNL and the Foundation for Ecological Research in the Northeast (FERN). Funding is coordinated for research projects that occur within the reserve and the larger pine barrens area of Long Island. Research supported by FERN in 2013 included continued investigation into bat populations on Long Island that were impacted by white-nosed syndrome, and the funding of a leopard frog identification guide to help differentiate a newly discovered species of leopard frog in the northeast. Information on these projects and others is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely conducts surveillance monitoring of flora and fauna to determine the effects of past and present activities on site. In addition to surveillance monitoring, CERCLA-required monitoring results associated with post-cleanup monitoring of the Peconic River are now addressed in the annual Site Environmental Report. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces of Cs-137 can be 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 also list analytical results for potassium-40 (K-40), a naturally occurring radioisotope of potassium that is commonly found in flora and fauna. Studies indicate that Cs-137 out-competes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables allow for a comparison with Cs-137 levels and is used, in part, to determine the accuracy of analytical results. 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 are typically large, with males weighing, on average, approximately 150 pounds; females typically weigh 1/3 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 2013, as in recent years, an on- and off-site deer-sampling program was conducted. While most off-site samples are the result of car/deer accidents near the Laboratory, in most years, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than 1 mile from BNL are used. Based on more than a decade of sampling, deer taken from more than 1 mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source. In 2013, six deer were obtained on site, three from off-site locations within 1 mile of the Laboratory, and two from areas greater than 1 mile from the BNL boundary. The results of deer sampling are shown in Table 6-2.

BNL sampling technicians collect the samples and send them for analysis. Samples of meat (flesh) and liver are taken from each deer, when possible, and are analyzed for Cs-137. Data are reported on a wet-weight basis, as that is the form most likely used for consumption.

6.3.1.1 Cesium-137 in White-Tailed Deer

Based on historic and current data, white-tailed deer sampled at or near the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), most likely 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 or is consumed directly while the animal is grazing.

Removal of contaminated soil areas on site has occurred under the Laboratory's cleanup program, with all major areas of contaminated soil being remediated by September 2005. The number of deer obtained for sampling steadily increased between 1996 and 2004. However, the number of deer obtained from 2005 to 2013 was significantly lower. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer, but the number obtained each year has varied due to the sampling method, which depends on accidents between vehicles and deer and people reporting dead deer. The number of deer hit by vehicles also 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 2009. 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 and traffic to and from the front gate is greatest.

In 2013, Cs-137 concentrations in deer meat (muscle) samples were obtained from six deer on site with a range of values from non-detect to 0.85 pCi/g, wet weight, and an arithmetic average of 0.51 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.

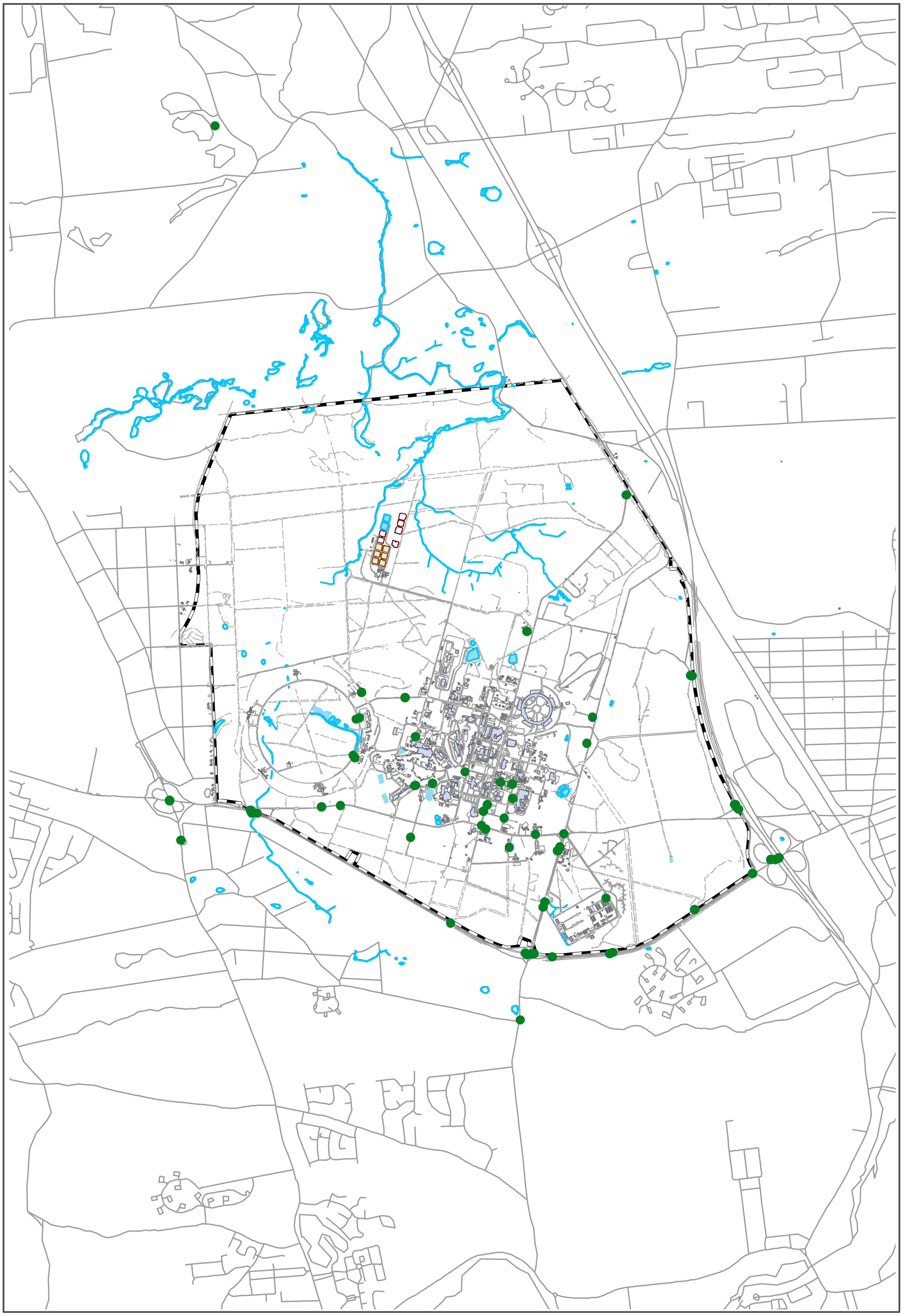


Figure 6-1. Deer Sample Locations, 2009—2013.

Dry weight concentrations are typically higher than wet weight values. The highest on-site sample in 2013 (0.85pCi/g, wet weight) was 3 times higher than the highest on-site sample reported in 2012 (0.27 pCi/g, wet weight) and 14 times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight).

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within 1 mile of BNL (three samples) and samples taken farther away (two samples), as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from 0.14 to 1.08 pCi/g, wet weight, with an arithmetic average of 0.46 pCi/g, wet weight. Because deer on site may routinely travel up to 1 mile off site, the arithmetic average for deer taken on site and within 1 mile of the Laboratory is also calculated; for 2013, this was 0.50 pCi/g, wet weight. Deer samples from greater than 1 mile from BNL ranged from 0.05 pCi/g, wet weight, to 1.39 pCi/g, wet weight, with the arithmetic average being 0.72 pCi/g, wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2013 from four different location groupings; 2013 is the first year in which the average Cs-137 content from deer taken within 1 mile of the Laboratory is lower than the on-site average. While no definitive explanation can be given to the difference from past results, it could simply be due to the low sample numbers and randomness in sample acquisition. Although not shown on the figure, 89 percent of all meat samples taken both on and off site are below 1 pCi/g, wet weight.

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 2007, samples from 2013 indicate a similar range of error. The average is approximately 10 percent lower than the 2007 average and is 30 percent higher than the 2012 average, which was the lowest average seen since trending began in 2000. These sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the trend being slightly downward from 2003 to 2013.

When possible, liver samples are taken concurrently with meat samples. The 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 2013, Cs-137 concentrations ranged from non-detect to 0.24 pCi/g, wet weight, with an average of 0.10 pCi/g, wet weight. The off-site Cs-137 concentration in liver ranged from 0.02 to 0.25 pCi/g, wet weight, with an arithmetic average for all off-site liver samples of 0.17 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 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.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137. In 2013, a single turkey was found dead from unknown trauma. A sample of the breast meat was sent

Table 6-2. Radiological Analyses of Deer Tissue.

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL, On Site				
Bldg. 490	01/29/13	Flesh	3.09±0.10	0.40±0.01
		Liver	2.14±0.08	0.07±0.00
NW Corner, Center and Cornell Streets	02/14/13	Flesh	2.43±0.13	ND
		Liver	1.74±0.17	ND
AGS Well 102	11/08/13	Flesh	3.03±0.20	0.85±0.03
North Gate	11/08/13	Flesh	3.56±0.18	0.65±0.02
		Liver	3.04±0.18	0.24±0.01
South Gate	11/15/13	Flesh	3.22±0.26	0.85±0.03
North Gate Rd.	11/20/13	Flesh	2.78±0.29	0.32±0.02
< 1 Mile from BNL				
William Floyd Parkway and North Gate	01/03/13	Flesh	3.25±0.10	1.08±0.01
		Liver	2.48±0.15	0.23±0.01
William Floyd Parkway, 1 mile S of Main Gate	03/20/13	Flesh	3.03±0.17	0.16±0.01
William Floyd Parkway and Long Island Expressway	12/19/13	Flesh	2.63±0.13	0.14±0.01
> 1 Mile from BNL				
Middle Island Rd. and Sunrise Highway	11/05/13	Flesh	3.18±0.12	1.39±0.02
		Liver	2.76±0.16	0.25±0.01
East Merideth, NY	11/16/13	Flesh	3.08±0.27	0.05±0.01
		Liver	2.52±0.26	0.02±0.01
Averages by Tissue				
Flesh Averages				
All Samples (11)			3.03±0.63	0.54±0.06
BNL Average (6)			3.02±0.50	0.51±0.06
< 1 Mile Average (3)			2.97±0.24	0.46±0.02
BNL + < 1 mile (9)			3.00±0.55	0.50±0.06
> 1 Mile Average (2)			3.13±0.30	0.72±0.02
Liver Averages				
All Samples (7)			2.34±0.44	0.12±0.03
BNL Average (3)			2.31±0.26	0.10±0.02
< 1 Mile Average (2)			2.11±0.18	0.14±0.01
BNL + < 1 mile (5)			2.23±0.32	0.12±0.02
> 1 Mile Average (2)			2.64±0.30	0.13±0.02

Notes:
All values are shown with a 95% confidence interval.
All averages are the arithmetic average with confidence limits with a 2 sigma (95%) propogated error
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
AGS = Alternate Gradient Synchrotron
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected

for radiological analysis, and Cs-137 level was determined to be 0.12 pCi/g, wet weight.

6.3.3 Fish Sampling

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Monitoring of the river is conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring occurs during even-numbered years and post-cleanup monitoring occurs in odd-numbered years. Therefore, data presented for 2013 is for compliance with post-cleanup monitoring requirements. Data for 2014 will consist of surveillance monitoring of fish from the Peconic River locations, as well as background monitoring of fish from Lower Lake on the Carmans River.

Due to the deepening of several areas of the river during restoration activities, large areas of open water on site were created that provide sufficient habitat to support larger fish. During 2013, sampling activities, numerous schools of bass and sunfish fry have been 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 2013 to take advantage of periods of high oxygen.

Samples collected on site were from Area A of the Peconic River just downstream of the Sewage Treatment Plant (STP) outfall and Area D near the east boundary of the Laboratory. Various species of fish were also collected off site from Shultz Road, Donahue's Pond, and Lower Lake on the Carmans River (see Figure 5-4 for sampling stations). Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out under a permit with NYSDEC.

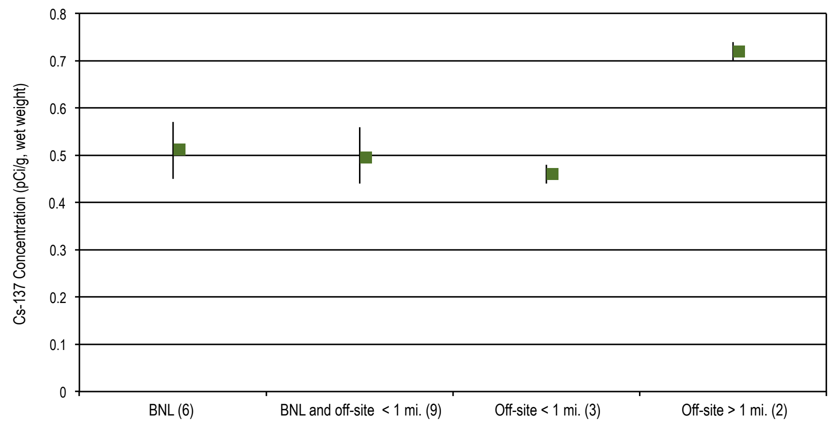
6.3.3.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2013 included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), and pumpkinseed (*Lepomis gibbossu*). The edible (fillet) content of each fish were collected for analysis. Gamma spectroscopy analysis was performed on all samples. When fish samples were not of sufficient volume to conduct all non-radiological and radiological analyses, samples of the same species were composited. Table 6-3 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations, and information on the naturally occurring radioisotope K-40 is included as a comparison.

Cs-137 was measured at levels ranging from non-detected to 0.47 pCi/g, wet weight, from the Peconic River system, and all samples from the Carmans River had non-detectable levels. Detectable Cs-137 levels in fish ranged from and estimated 0.06 pCi/g, wet weight, in a brown bullhead taken from Donahue's Pond to an estimated 0.47 pCi/g, wet weight, in a chain pickerel taken from Area D. For comparison, the highest recent value of Cs-137 was 0.78 pCi/g, wet weight, in a composite sample of bluegill (*Lepomis macrochirus*) taken from Forge Pond in 2011.

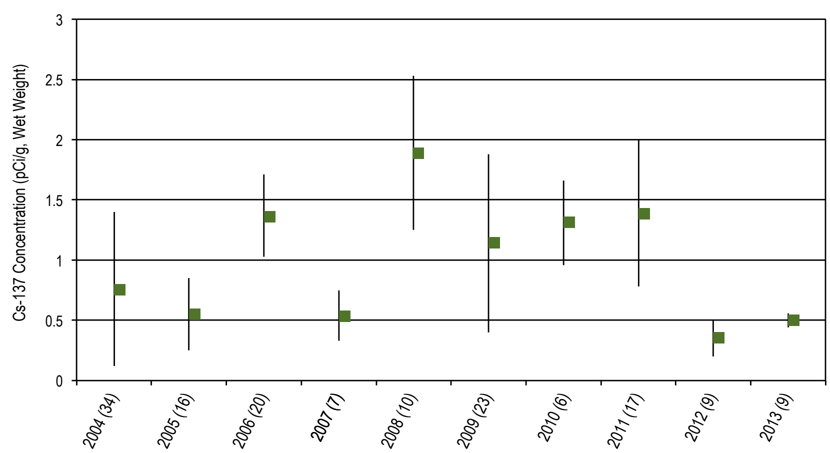
To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders). This comparison within different feeding guilds extends to other potential contaminants and is not limited to comparisons for radionuclides. Cs-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.23 pCi/g, wet weight. Largemouth bass, the top predator from the Peconic River, showed Cs-137 levels of 0.34 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



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, off site within 1 mile of BNL, and off site greater than 1 mile from BNL.
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 Meat, 2013.



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.

by natural radioactive decay. Cs-137 has a half-life of 30 years. Discharge monitoring has demonstrated that no Cs-137 was released from the BNL Sewage Treatment Plant (STP) to the Peconic River during 2003 through 2013. Additionally, the cleanup of both on- and off-site portions of the Peconic River in 2004 and 2005 is estimated to have removed approximately 88 percent of the identified Cs-137 in the sediment that was co-located with mercury. Removal of this contamination is expected to result in continued decreases in Cs-137 levels in fish.

6.3.3.2 Fish Population Assessment

The relative sizes of fish caught during annual sampling events are tracked and modifications to future sampling events are made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis from 2008 through 2013, even with low water levels in the on-site portion of the Peconic River, indicated that populations are maintaining themselves and can continue to support annual sampling efforts.

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

Location/Species	K-40	Cs-137
	pCi/g Wet Weight	
On Site		
Area A		
Largemouth Bass*	3.16±0.68	0.23±0.05
Largemouth Bass*	3.94±0.90	0.18±0.08
Largemouth Bass (composite)*	3.20±1.08	0.22±0.07
Largemouth Bass (composite)*	3.03±0.79	0.15±0.07
Chain Pickerel (composite)*	3.22±0.67	0.32±0.05
Pumpkinseed (composite)*	3.21±0.86	0.22±0.07
Brown Bullhead (composite)*	3.61±0.83	0.23±0.04
Brown Bullhead (composite)*	2.61±0.71	0.18±0.05
Area D		
Largemouth Bass*	3.65±0.67	0.34±0.06
Largemouth Bass*	3.82±0.61	0.30±0.05
Chain Pickerel*	3.31±0.64	0.35±0.05
Chain Pickerel*	3.53±0.79	0.47±0.08
Black Crappie (composite)*	2.70±0.84	0.20±0.06
Brown Bullhead (composite)	3.37±0.83	0.23±0.08
Brown Bullhead (composite)*	3.12±0.65	0.19±0.05
Brown Bullhead (composite)	1.78±0.89	ND
Largemouth Bass*	2.51±0.28	0.21±0.02
Largemouth Bass*	2.72±0.35	0.23±0.03
Chain Pickerel*	2.77±0.38	0.24±0.03
Brown Bullhead (composite)*	3.88±0.78	0.19±0.07
Off Site		
Schultz Road		
Largemouth Bass*	3.46±0.90	0.15±0.07
Largemouth Bass*	3.46±0.65	0.16±0.05
Largemouth Bass*	3.68±0.72	0.10±0.01
Largemouth Bass*	2.90±0.84	0.22±0.07
Largemouth Bass*	2.97±0.71	0.11±0.36
Largemouth Bass*	3.80±0.75	0.15±0.06
Donahue's Pond		
Largemouth Bass	2.94±1.33	ND
Largemouth Bass*	2.31±0.89	0.10±0.05
Largemouth Bass*	3.90±0.72	0.10±0.04
Largemouth Bass*	4.09±0.87	0.07±0.06

(continued)

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

Location/Species	K-40	Cs-137
	pCi/g Wet Weight	
Black Crappie*	3.77±0.77	0.09±0.04
Brown Bullhead*	3.30±1.16	0.13±0.07
Brown Bullhead*	2.31±0.80	0.11±0.06
Brown Bullhead*	3.25±0.96	0.08±0.06
Brown Bullhead*	2.86±1.11	0.06±0.05
Brown Bullhead*	2.75±0.78	0.08±0.08
Lower Lake, Carmans River		
Largemouth Bass	4.04±1.05	ND
Brown Bullhead	4.13±1.06	ND
Brown Bullhead	3.37±0.91	ND
Brown Bullhead	2.96±0.96	ND
Brown Bullhead	3.31±0.81	ND
Largemouth Bass	3.37±0.89	ND
Largemouth Bass	3.24±1.02	ND
Largemouth Bass	2.80±0.87	ND
Largemouth Bass	2.64±1.00	ND
Brown Bullhead	2.77±0.88	ND

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

6.3.3.3 Non-Radiological Analysis of Fish

Beginning in 2005, all fish of sufficient size have been analyzed as edible portions (fillets). Due to its known health effects, mercury is the metal of highest concern. Monitoring results for 2013 from post cleanup monitoring of the Peconic River and comparison to Lower Lake on the Carmans River is shown in Table 6-4. All samples are obtained between April and mid-June. During 2013, mercury ranged from 0.09 mg/kg in a composite of brown bullhead to 1.49 mg/kg in a composite sample of chain pickerel in Area A; 0.05 mg/kg in a composite of brown bullhead to 4.08 mg/kg in a chain pickerel in

Area D; 0.07 mg/kg to 0.68 mg/kg in a largemouth bass taken from the Peconic River at Shultz Rd; and 0.06mg/kg in a brown bullhead to 0.48 mg/kg in a largemouth bass at Donahue's Pond. Mercury in control fish taken from Lower Lake on the Carmans River ranged from less than the method detection level (MDL) in both brown bullhead and largemouth bass to 0.42 mg/kg in a largemouth bass.

Monitoring data for mercury analysis in fish is presented as a range of results by species and location in Table 6-5 to facilitate comparisons. The data are presented graphically in Figure 6-4. Data are typically compared to the EPA mercury water criterion of 0.3 mg/kg. Mercury values in on-site fish taken from Areas A and D during 2013 are much higher than those seen in 2011 and 2012. The increase was most likely due to water flow conditions in the river since late summer 2011. Since that time, the river was running low and open water areas were limited, with little or no flow off site. Consequently, fish were isolated to the BNL site and any methylated mercury was not diluted by flow. A total of 27 samples were taken from the three cleanup locations, with an average mercury concentration of 0.86 mg/kg. When sample results from the entire main stream of the Peconic River were combined (inclusion of Donahue's Pond samples), the average was 0.69 mg/kg. As a comparison to the main portion of the river, mercury averages for Shultz Road (six samples) was 0.37 mg/kg and Donahue's Pond (ten samples) was 0.23 mg/kg, and Lower Lake on the Carmans River (ten samples) was 0.12 mg/kg.

When comparing data from location to location along the Peconic River from year to year, a wide range of values are seen between locations and both within and between species. This lack of a clear pattern is likely attributable to fish age, size, time spent in areas of high methylation of mercury, and foods consumed. The data presented in Table 6-4 are from larger fish, which allow for the analysis of all metals of interest, as well as radiological analysis for Cs-137 and K-40. Data are also presented graphically in Figure 6-4 to facilitate year-to-year comparisons of the data.

The cleanup of the Peconic River that was conducted in 2005 and 2011 removed most of the PCBs present within the sediments. Although BNL has discontinued most pesticide and PCB monitoring, tests for PCBs in fish taken on site continue to be conducted to track the presence or absence of these long lived contaminants. Table 6-6 presents PCB data for fish taken from Area A and D. Only two PCB congeners were detected (Aroclor-1254 and Aroclor-1260). Most values were below the MDL. Aroclor-1260 was detected above the MDL in a composite sample of largemouth bass at a concentration of 32.1 µg/kg. The highest concentration of Aroclor-1254 was also detected in this composite sample at 64.1 µg/kg.

6.3.4 Aquatic Sampling

6.3.4.1 Radiological Analysis

Annual sampling of sediment and vegetation in the Peconic River and a control location on the Carmans River was conducted in 2013. (See Chapter 5 for a discussion on water quality and monitoring and Figure 5-4 for the locations of sampling stations.) During 2013, Cs-137 was detected in a single aquatic vegetation sample at an estimated concentration of 0.09 pCi/g, wet weight (Table 6-7).

6.3.5 Peconic River Post-Cleanup Monitoring

Approximately 20 acres of the Peconic River were remediated in 2004 and 2005 to remove sediments contaminated with mercury and associated contaminants. To ensure that the cleanup provided adequate protection of human health and the environment, BNL conducted five years (2006-2010) of post-cleanup monitoring of the sediment, surface water, and fish. This monitoring effort identified approximately 0.39 acres in three small areas (PR-WC-06, PR-SS-15, and sediment trap areas) with mercury concentrations greater than the cleanup goal of 2.0 mg/kg. The three areas were remediated between November 2010 and February 2011 (see Section 6.3.5.1).

During the required CERCLA Five-Year review process in 2011, all data and accomplishments related to the Peconic River cleanup and subsequent monitoring were summarized

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

Location/Species	Mercury (mg/kg)
On Site	
Area A	
Largemouth Bass	1.27
Largemouth Bass	1.07
Largemouth Bass (composite)	1.13
Largemouth Bass (composite)	0.55
Chain Pickerel (composite)	1.49
Chain Pickerel	0.82
Pumpkinseed (composite)	0.80
Brown Bullhead (composite)	0.28
Brown Bullhead (composite)	0.09
Area D	
Largemouth Bass	2.47
Largemouth Bass	0.77
Largemouth Bass	1.12
Largemouth Bass	1.16
Chain Pickerel	1.63
Chain Pickerel	4.08
Chain Pickerel	1.30
Black Crappie (composite)	0.55
Brown Bullhead (composite)	0.11
Brown Bullhead (composite)	0.17
Brown Bullhead (composite)	0.05
Brown Bullhead (composite)	0.16
Off Site	
Shultz Road	
Largemouth Bass	0.68
Largemouth Bass	0.53
Largemouth Bass	0.08
Largemouth Bass	0.56
Largemouth Bass	0.27
Largemouth Bass	0.07
Donahue's Pond	
Largemouth Bass	0.41
Largemouth Bass	0.31
Largemouth Bass	0.48
Largemouth Bass	0.26
Black Crappie	0.14
Brown Bullhead	0.06
Brown Bullhead	0.10

(continued on the right)

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

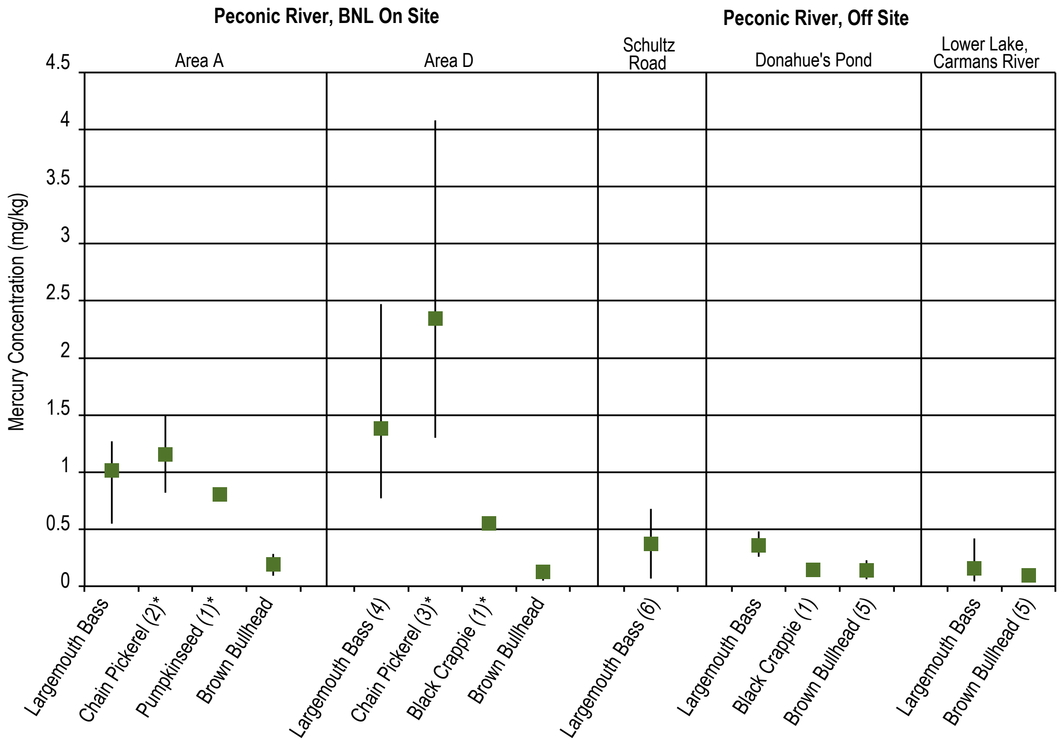
Location/Species	Mercury (mg/kg)
Brown Bullhead	0.23
Brown Bullhead	0.14
Brown Bullhead	0.17
Lower Lake, Carmans River	
Largemouth Bass	<MDL
Brown Bullhead	0.09
Brown Bullhead	<MDL
Brown Bullhead	<MDL
Brown Bullhead	<MDL
Largemouth Bass	0.42
Largemouth Bass	0.08
Largemouth Bass	0.19
Largemouth Bass	0.04
Brown Bullhead	0.12

Notes:
See Figure 5-4 for sampling locations.
All samples were analyzed as edible portions (fillets), including composite samples.
Area letter designation refers to Peconic River cleanup areas on site.
MDL = minimum detection limit

and reviewed. The Five-Year Review recommended that reduced monitoring should take place beginning in 2012, and all future reporting of post-cleanup monitoring results would be documented in the annual Site Environmental Report. The 2013 sediment and surface water results follow.

6.3.5.1 Sediment Sampling

Sediment was sampled in June 2013 at three Peconic River locations associated with the supplemental cleanup areas (Table 6-7). Radiological analysis of sediments at all three locations indicate that low levels of Cs-137 are present, ranging from 0.19 pCi/g to 0.51 pCi/g, which are consistent with previous analyses of the river sediments. Analysis of sediment for mercury identified values ranging from 0.06 mg/kg to 1.50 mg/kg, with all values being below the cleanup goal of 2.0 mg/kg. Sediment from the three locations was also analyzed for presence of PCBs in order to track presence/absence of these long lived contaminants. Aroclor-1254 was the only congener detected at estimated concentrations between 15 and 36 µg/kg.



Notes: Number in parentheses indicate the number of samples included.
* = some samples were composite

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

6.3.5.2 Water Column Sampling

Surface water was analyzed in June and July 2013 for total mercury and methyl mercury at 9 of the 14 Peconic River sampling stations (Table 6-8). Water column sampling locations are shown on Figure 6-6. A sample of the treated STP effluent was also collected during each round of sampling. Six stations could not be sampled in June and nine in July due to either being too shallow or dry. Total Suspended Solids (TSS) are reported in Table 6-8 as a point of comparison for total mercury and methyl-mercury. TSS values can provide an indication of the quality of the sample collection effort. Low TSS indicates a sample was taken without disturbing bottom sediments, whereas samples with high TSS values might explain, in part, unusually high mercury values due to increased particles that may contain mercury. The maximum total mercury concentration in the June (48 ng/L) and July (58 ng/L) STP effluent samples were typical of what has been seen since efforts at mercury minimization have been implemented. The total mercury concentrations generally trended downwards, with minor fluctuations at increasing distance downstream from the STP until reaching concentrations of 22 ng/L (June 2013) and 21 ng/L (July 2013) at sampling stations near Shultz Road, approximately 2.52 miles and 2.1 miles downstream of the STP outfall, respectively.

Methyl mercury is the form of mercury that is bio-available to aquatic organisms. Methyl mercury was detected in STP effluent samples in June at a concentration of 0.06 ng/L and was detected at an estimated 0.04 ng/L in a July sample. Between the station immediately downstream of the STP effluent outfall and the BNL east boundary, the June methyl mercury concentrations fluctuated between 0.6 ng/L and 1.9 ng/L, and the July concentrations fluctuated between 0.46 ng/L and 2.5 ng/L. The methyl mercury values from downstream of the BNL boundary to the second station west of Shultz

Table 6-5. Mercury Analysis of Fish from the Peconic River System and Lower Lake, Carmans River.

Location/Species (number of samples)	Mercury mg/kg Min.	Max.	Avg.
On Site			
Area A			
Largemouth Bass (4)*	0.55	1.27	1.00
Chain Pickerel (2)*	0.82	1.49	1.15
Pumpkinseed (1)*	0.80	0.80	0.80
Brown Bullhead (2)*	0.09	0.28	0.19
Area D			
Largemouth Bass (4)	0.77	2.47	1.38
Chain Pickerel (3)	1.30	4.08	2.34
Black Crappie (1)*	0.55	0.55	0.55
Brown Bullhead (4)*	0.05	0.17	0.12
Off Site			
Schultz Road			
Largemouth Bass (6)	0.07	0.68	0.37
Donahue's Pond			
Largemouth Bass (4)	0.26	0.48	0.36
Black Crappie (1)	0.14	0.14	0.14
Brown Bullhead (5)	0.06	0.23	0.14
Lower Lake, Carmans River			
Largemouth Bass (5)	0.04	0.42	0.16
Brown Bullhead (5)	0.07	0.12	0.09
Peconic River, BNL On Site			
Largemouth Bass (8)*	0.55	2.47	1.19
Chain Pickerel (5)*	0.82	4.08	1.86
Pumpkinseed (1)*	0.80	0.80	0.80
Black Crappie (1)*	0.55	0.55	0.55
Brown Bullhead (6)*	0.05	0.28	0.14
Peconic River, Off Site			
Largemouth Bass (10)	0.07	0.56	0.36
Black Crappie (1)	0.14	0.14	0.14
Brown Bullhead (5)	0.06	0.23	0.14

Notes:
See Figure 5-4 for sampling locations.
All samples were analyzed as edible portions (fillets), including composite samples.
Area letter designation refers to Peconic River cleanup areas on site.
* = one or more samples in the average were composite samples.

Road (PR-WC-02) fluctuated between 1.4 ng/L and 2.5 ng/L in June (which is consistent with previous measurements) and a single value of 0.8 ng/L was obtained at station PR-WC-03 in July due to low water levels. Alternating wet/dry periods often facilitate the methylation of mercury, and could explain the elevated levels in isolated pools of the river.

Table 6-6. PCB Analysis of Fish from BNL Portions of the Peconic River System.

Location/Species	Aroclor-1254 µg/kg	Aroclor-1260
On Site		
Area A		
Largemouth Bass	<MDL	<MDL
Largemouth Bass	60.8	<MDL
Largemouth Bass (composite)	50.2	<MDL
Largemouth Bass (composite)	64.1	32.1
Chain Pickerel (composite)	< MDL	< MDL
Chain Pickerel	No Data	No Data
Pumpkinseed (composite)	No Data	No Data
Brown Bullhead (composite)	<MDL	<MDL
Brown Bullhead (composite)	45.6	31.9
Area D		
Largemouth Bass	<MDL	<MDL
Largemouth Bass	<MDL	<MDL
Chain Pickerel	<MDL	<MDL
Chain Pickerel	<MDL	<MDL
Black Crappie (composite)	No Data	No Data
Brown Bullhead (composite)	<MDL	<MDL
Brown Bullhead (composite)	<MDL	<MDL
Brown Bullhead (composite)	No Data	No Data
Largemouth Bass	<MDL	<MDL
Largemouth Bass*	11.5	<MDL
Chain Pickerel	<MDL	<MDL
Brown Bullhead (composite)	<MDL	<MDL

Notes:
See Figure 5-4 for sampling locations.
All samples were analyzed as edible portions (fillets), including composite samples.
Area letter designation refers to Peconic River cleanup areas on site.
MDL = minimum detection limit
No Data = insufficient sample size to complete analysis
* = estimated value for reported analyte based on lab qualifiers

6.3.6 Vegetation Sampling

6.3.6.1 Farm Vegetables

Farm vegetables and a representative soil sample were taken from four local farms as

Table 6-7. Survellience and Post Cleanup Montioring Data for Aquatic Vegetation and Sediment from the Peconic River.

Location	Matrix	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Aroclor 1254 µg/kg	Mercury mg/kg
Surveillance Samples					
BNL	Vegetation	4.21±0.60	ND	NT	NT
BNL	Vegetation	3.75±0.61	ND	NT	NT
BNL	Vegetation	4.37±0.72	0.09±0.04 *	NT	NT
BNL	Vegetation	3.51±0.54	ND	NT	NT
Post-Cleanup Samples[t]					
PR-SS-15-U1-L65-O	Sediment	NT	0.19±0.05	ND	0.06
ST1-80-U20	Sediment	NT	0.51±0.11	15**	0.50
PR-WC-06-D1-L50	Sediment	NT	0.47±0.10	36**	1.50

Notes:
All radiological analysis values are shown with a 95% confidence interval.
K-40 Occurs naturally in the environment and is presented as a comparison to Cs-137
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
NT = not tested
* = values for Cs-137 are estimated based on analytical lab qualifiers
** = values for Aroclor 1254 are estimated based on analytical lab qualifiers
t = Sediment values reported as dry weight

part of the surveillance monitoring program. The data from farm vegetables and soil are shown in Table 6-9. None of the vegetables sampled had detectable levels of Cs-137. Soil samples had concentrations of Cs-137 ranging from 0.07 pCi/g to 0.10 pCi/g, dry weight. Because BNL no longer has operating nuclear reactors, surveillance monitoring of farm vegetables is no longer needed, and will be discontinued after 2013.

6.3.6.2 Grassy Plants and Soil

Grassy vegetation sampling around the Laboratory was conducted in 2013. Vegetation was sampled from 10 random locations around the Laboratory as shown in Figure 6-6. All samples were analyzed for Cs-137 (Table 6-10). The grassy vegetation samples had levels of Cs-137 ranging from non-detectable to 0.08 pCi/g, wet weight, which is consistent with past sampling efforts. Monitoring results for grassy vegetation is utilized for the annual dose to biota analysis reported in Chapter 8.

Soil sampling was conducted at the same 10 locations where the grassy vegetation was collected. Soil samples were analyzed for Cs-137 (Table 6-10). Cs-137 concentrations in soils ranged from non-detect to 0.26 pCi/g, dry weight. These values were consistent with past soil monitoring results.

6.4 OTHER MONITORING

6.4.1 Basin Sediments

A 5-year cycle for the collection of recharge basin sediment samples was established in 2003. There are 11 recharge basins receive water discharges that are permitted under the Laboratory's State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-2 for outfall locations). Basin sediments were last sampled in 2012 and results were summarized in the 2012 Site Environmental Report (BNL, 2013b). The next round of routine basin sampling will be conducted in 2017.

In 2012, sampling at Basin HT-W identified four semi-volatile organic compounds (SVOC) that were above SCDHS action levels. All four compounds consisted of polycyclic aromatic hydrocarbons (PAHs), which are petroleum breakdown products, and are most likely attributable to road runoff and the combustion of fossil fuels. Work planning to further characterize Basin HT-W was initiated at the end of 2012 and additional samples were collected in March 2013.

Table 6-8. Post Cleanup Peconic River Water Column Monitoring.

Location	Station Description	Dist from STP (miles)	June 2013 Mercury (ng/L)	June 2013 Methyl Mercury (ng/L)	June 2013 TSS (mg/L)	July 2013 Mercury (ng/L)	July 2013 Methyl Mercury (ng/L)	July 2013 TSS (mg/L)
PR-WC-15	Upstream of Forest Path	-0.17	SW	SW	SW	SW	SW	SW
PR-WC-14	Upstream of STP	-0.13	SW	SW	SW	SW	SW	SW
PR-WC-13	Upstream of STP	-0.07	SW	SW	SW	SW	SW	SW
PR-WC-12-D7	Downstream of Sump	-0.04	11	1.7	ND	10	0.5	4
STP-EFF-UVG	Grab Sample	0	48	0.06	ND	58	0.04*	ND
PR-WC-11DS	50" Downstream of Outfall	0.01	32	0.6	ND	SW	SW	SW
PR-WC-10	West of Station HMN	0.3	49	1.6	4	51	0.46	ND
PR-WC-09	Downstream of Station HMN	0.56	SW	SW	SW	SW	SW	SW
PR-WC-08	South of Area B	0.78	30	1.9	ND	17	1.2	2
PR-WC-07	South of Area C	0.96	SW	SW	SW	SW	SW	SW
PR-WC-06	South of Area D	1.1	32	1.9	ND	17	2.5	6
PR-WC-05	Downstream of Station HQ	1.46	28	1.7	ND	SW	SW	SW
PR-WC-04	2nd Downstream of Station HQ	1.7	SW	SW	SW	SW	SW	SW
PR-WC-03	3rd West of Schultz Road	2.1	25	2.5	ND	21	0.8	7
PR-WC-02	2nd West of Schultz Road	2.52	22	1.4	ND	SW	SW	SW

Notes:
See Figure 6-5 for Peconic River sampling locations.
ND = not detected based on lab qualifiers
STP = Sewage Treatment Plant
SW = water too shallow to sample
* = estimated value based on lab qualifiers

The scope of this sampling effort included the collection of five additional surface samples downstream of the outfall for SVOC analysis. In addition, a field blank and blind duplicate sample was collected for quality assurance and quality control purposes. Review of these data showed that, with the exception of one sample location, SVOC results were all below SCDHS action levels. One sample collected furthest downstream of the outfall contained three PAHs that were just above SCDHS action levels. However, a blind duplicate sample collected at the same location did not show any PAHs above action levels. Prior to making any final decisions on whether remediation is necessary at this outfall, and based on the discrepancy in the 2013 analytical results, a decision was made to coordinate further characterization efforts with SCDHS, which will include the collection and analysis of split samples. The results of this coordinated characterization effort and any final decisions made between SCDHS and BNL on whether remediation is necessary will be reported in a future Site Environmental Report.

6.4.2 Chronic Toxicity Tests

Under BNL's SPDES discharge permit, the Laboratory conducted chronic toxicity testing of the STP effluent. The results of the chronic toxicity tests are discussed in Chapter 3, Section 3.6.1.1.

6.4.3 Radiological and Mercury Monitoring of Precipitation

During 2013, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-3 for station locations). The samples were analyzed for radiological content and total mercury. A total of four samples were taken from each of these two stations

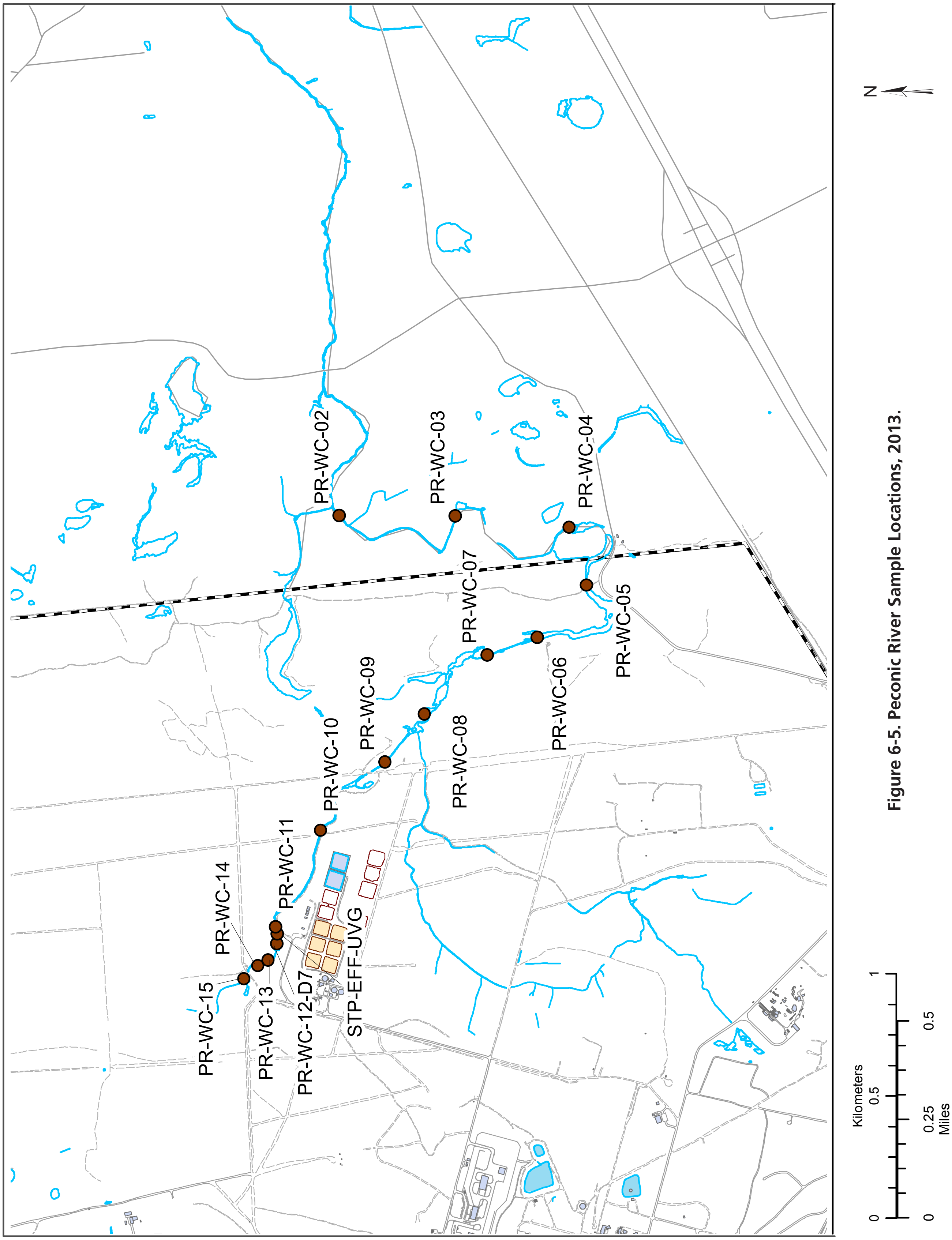


Figure 6-5. Peconic River Sample Locations, 2013.

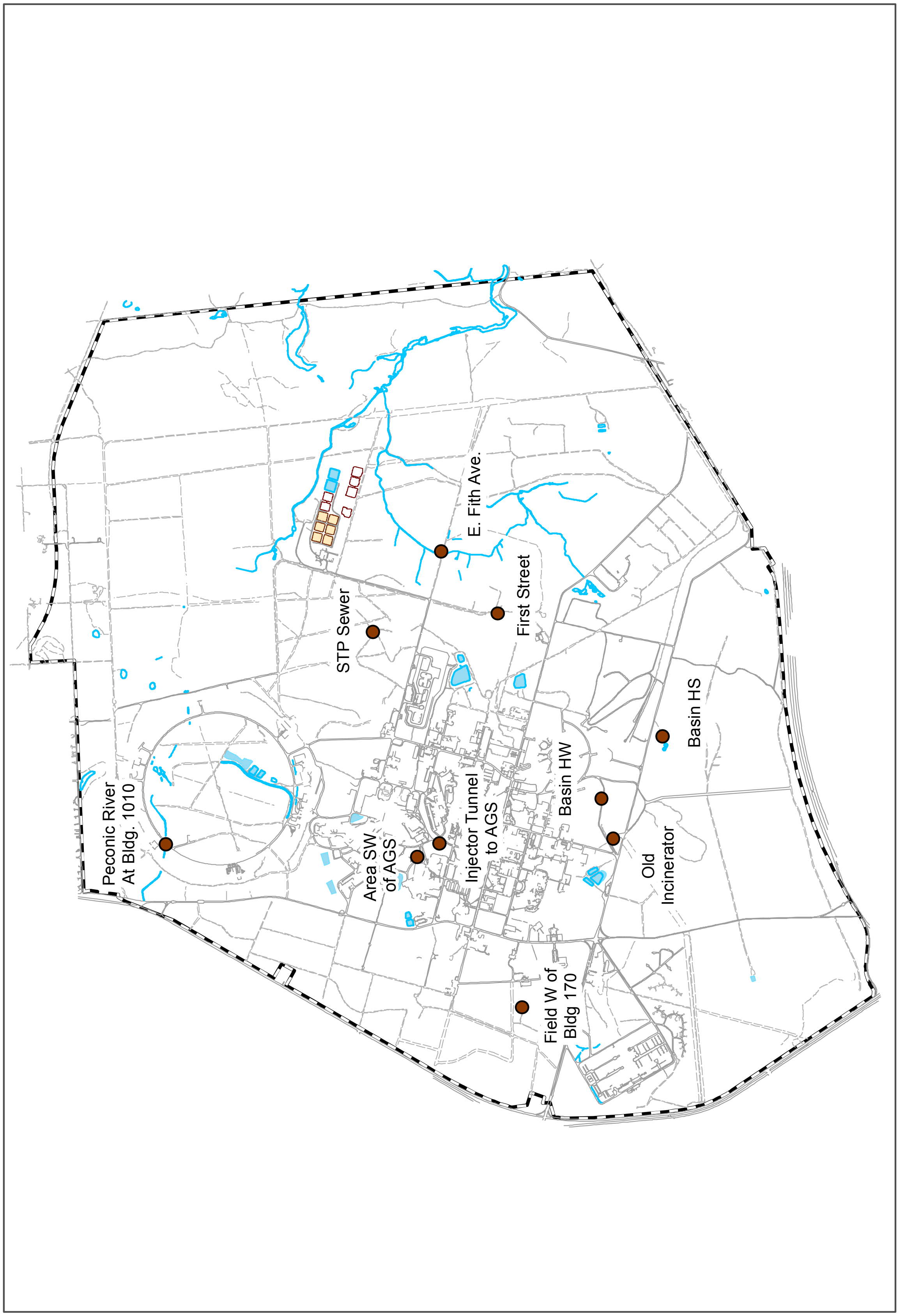


Figure 6-6. Vegetation Sample Locations, 2013.

Table 6-9. Radiological Analysis of Farm Vegetables and Associated Soils.

Location/Vegetable	K-40	Cs-137
	pCi/g (Wet Weight)	
May's Farm		
Cantalope	1.67±0.09	ND
Corn	2.62±0.21	ND
Zucchini	2.01±0.05	ND
Tomato	2.09±0.09	ND
Eggplant	1.89±0.11	ND
Soil (dry weight)	7.71±0.71	0.07±0.03
Lewin's Farm		
Potato	3.03±0.16	ND
Corn	2.32±0.19	ND
Eggplant	1.59±0.09	ND
Squash	4.55±0.18	ND
Zucchini	1.85±0.08	ND
Soil (dry weight)	6.69±0.66	0.09±0.04
Cornell Farm		
Pumpkin	2.67±0.14	ND
Corn	1.62±0.11	ND
Soil (dry weight)	7.83±0.66	0.10±0.04
Bruno Farm		
Corn	2.84±0.17	ND
String Beans	2.32±0.18	ND
Tomato	2.13±0.12	ND
Eggplant	2.02±0.18	ND
Soil (dry weight)	7.59±0.70	0.09±0.04

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.
ND = not detected

in 2013 and tested for radiological parameters. Gross alpha activity measurements were above the MDL at P4 in the second and fourth quarters and in the first two quarters at S5 (Table 6-11).

Gross beta activity was measured in samples collected during all four quarters, at both P4 and S5. Location P4 had a maximum gross beta activity level of 4.44 pCi/L in the first quarter of 2013. Location S5 had a maximum gross beta activity level of 4.35 pCi/L in the second quarter. Gross beta activity values were within the range of historically observed values at these two locations. Beryllium-7 (Be-7) derived from sun spot activity was not detected at either P4 or S5 in 2013. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation.

Precipitation was also analyzed for Sr-90. Analyses indicated non-detectable levels at both

Table 6-10. Radiological Analysis of Grassy Vegetation and Associated Soils.

Location/ Matrix	K-40	Cs-137
	pCi/g (Wet Weight)	
Basin HS		
Vegetation	4.89±0.19	ND
Soil (dry weight)	4.37±0.46	ND
Old Incinerator		
Vegetation	3.07±0.47	ND
Soil (dry weight)	6.39±0.63	0.26±0.04
Basin HW		
Vegetation	2.55±0.48	0.03±0.03 *
Soil (dry weight)	4.60±0.56	0.10±0.03
Field W of Bldg. 170		
Vegetation	2.55±0.44	ND
Soil (dry weight)	6.73±0.79	0.22±0.05
Injector Tunnel to AGS		
Vegetation	2.61±0.52	ND
Soil (dry weight)	5.41±0.60	0.07±0.04 *
Area SW of AGS		
Vegetation	4.18±0.48	ND
Soil (dry weight)	4.86±0.60	0.25±0.05
First St. near Ecology Field		
Vegetation	3.87±0.74	ND
Soil (dry weight)	5.20±0.52	0.16±0.04
E. Fifth Ave., East of First St.		
Vegetation	4.68±0.59	0.06±0.04 *
Soil (dry weight)	4.61±0.63	0.12±0.05
STP Sewer, Main Firebreak		
Vegetation	2.75±0.40	0.08±0.02
Soil (dry weight)	6.42±0.68	0.10±0.03
Peconic River at Bldg. 1010		
Vegetation	3.04±0.45	ND
Soil (dry weight)	5.10±0.52	ND

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.
AGS = Alternate Gradient Synchrotron
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected
* = value for Cs-137 is estimated

Table 6-11. Precipitation Monitoring (Radiological and Mercury).

Location/Period	Gross Alpha	Gross Beta	Sr-90	Mercury
		pCi/L		ng/L
P4				
01/16/13	—	—	—	6.01
01/31/13	ND	4.44±0.98	ND	—
04/05/13	—	—	—	6.69
04/30/13	0.69±0.47	1.64±0.75	ND	—
07/15/13	—	—	—	9.35
07/31/13	ND	1.55±0.63	ND	—
10/08/13	—	—	—	24.6
11/27/13	2.12±1.12	2.54±0.84	ND	—
S5				
01/16/13	—	—	—	5.24
01/31/13	1.18±0.64	3.48±0.89	ND	—
04/05/13	—	—	—	8.98
04/30/13	1.30±0.59	4.35±0.94	ND	—
07/15/13	—	—	—	7.21
07/31/13	ND	1.17±0.62	0.21±0.11	—
10/08/13	—	—	—	10.4
11/27/13	ND	1.75±0.70	ND	—

Notes:
See Figure 4-2 for P4 and P5 locations.
Method detection limit for mercury is 0.2 ng/L.
— = parameter not tested on date
ND = not dected
P4 = precipitation sampler near BNL Apartment area
S5 = precipitation sampler near BNL Sewage Treatment Plant
Sr-90 - strontium-90

locations in all but a single positive detection of 0.21 pCi/L at station S5 in the third quarter of 2013. However, the associated analytical error (or measurement uncertainty) was more than 50 percent of the value, making the result questionable.

Analysis of mercury in precipitation is conducted to document mercury deposition that is attributable to off-site sources. This information is compared to Peconic River monitoring data and aids in understanding the sources of mercury within the Peconic River watershed. Mercury was detected in all of the precipitation samples collected at both sampling stations. Mercury ranged from 5.24 ng/L at station S5 in January to 24.6 ng/L at station P4 in October. The 24.6 ng/L concentration is the highest value measured in precipitation since mercury monitoring began in 2007.

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 an interest in science. Wildlife programs are conducted at the Laboratory 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 2013, BNL hosted 15 student interns and two faculty members. Three of the interns worked with a faculty member from Dowling College as part of the BNL Visiting Faculty Program (VFP). An additional 3 interns worked on various research projects associated with the LISF.

The VFP teams continued ongoing work on soil microbial studies of Pine Barrens soils, statistical analysis of migratory bird data, and data associated with Cs-137 in deer. Analysis of bird data resulted in a published paper (Rispoli, et al., 2014), and a second paper is being prepared for the Cs-137 in deer studies.

Work associated with the LISF involved tracking 26 eastern box turtles outfitted with transmitters to determine home range sizes. Many of the turtles were captured in or near the LISF in order to determine if they utilize habitats found in the facility. Since 2011, student interns have followed a total of 38 different turtles, and as a result BNL is building a very good understanding of their habits.

Interns also conducted surveys in and around the LISF to study the relationship and impacts of this facility on the local ecosystems. Vegetation data were gathered on paired transects during the spring and fall, and paired small mammal trapping grids and moveable cameras were used to look at how animals used the fence openings. Paired transects for vegetation allow comparison of vegetation growth and establishment inside and outside of the LISF. In addition, interior transects were established based on the vegetative assemblage that existed prior to construction. Paired trapping grids were established to compare small mammal population in the core of the facility to core habitats outside of the facility, and to compare recruitment of small mammals from the forest to the immediate interior of the solar farm (one grid on either side of the LISF fence). Wildlife cameras were placed for 2-week periods on individual openings along the fence line to document wildlife use of the fence openings. The camera surveillance data verified that all species that were expected to use the openings are doing so (e.g., raccoons, skunks, foxes, etc.).

To facilitate the analysis of the wildlife surveillance data, and to develop plans for the placement of transects, trapping grids, and placement of cameras, all surveillance data are entered into databases, and a GIS is used to visualize the data.

In March 2011, a northern long-eared bat was found on the ground outside a building on site. The bat appeared to have discoloration on the fur around its muzzle and was reported to NYSDEC as a possible incidence of white-nose syndrome. White-nose syndrome is a recently identified fungal infection impacting bats throughout the Northeast and Midwest. The bat was the first recorded incidence of white-nose syndrome on Long Island. As a result, BNL and the NYSDEC established permanent acoustical survey routes on Long Island for monitoring. In 2013, a bat specialist captured bats on site using mist-netting. These results were compared to 2012 efforts, and confirmed that white-nosed syndrome has had a major impact on certain bat species, particularly the northern long-eared bat which showed a dramatic reduction in population at BNL based upon 15 captures in 2012 to only one capture in 2013.

In 2013, BNL participated in several events in support of ecological education programs including: providing on site ecology tours; hosting the Eighteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results; participated in the Fourth Annual Pine Barrens Discovery Day held in association with the Tri-Hamlet Celebration at the Wertheim National Wildlife Refuge; assisting the Central Pine Barrens Commission on ‘A Day in the Life of the Carmans River’ which allowed students from multiple school districts to acquire environmental and biological data about the river, an successful effort that will be expanded to the Peconic and Nissequogue Rivers in 2014; and BNL and the Long Island Nature Organization hosted the second annual Long Island Natural History conference.

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 firefighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. The Laboratory continues the use of prescribed fire for fuel and forest management and is working with NYSDEC to conduct growing season fires in 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 numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL 2013a) guides the management of all of the Laboratory'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 on site. BNL's cultural resources include 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 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 (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the WWI training trenches associated with Camp Upton. The trenches are examples of the few surviving WWI earthworks in the United States.

In 2013, BNL submitted a revised Cultural Resource Management Plan to the New York State Historic Preservation Office for review and received no comments. Small displays on Camp Upton are maintained in Berkner Hall for the interest of the visiting public. In 2013, the Long Island Museum again requested loan of historic materials from BNL for a planned display on 'Long Island at War' for the summer of 2014.

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7 Groundwater Protection

Brookhaven National 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. During 2013, BNL collected groundwater samples from approximately 780 permanent monitoring wells and 65 temporary wells during 2,815 individual sampling events. Eleven groundwater remediation systems removed 183 pounds of volatile organic compounds (VOCs) and returned approximately 1.4 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the treatment systems have removed 7,133 pounds of VOCs by treating nearly 22 billion gallons of groundwater. Also during 2013, two groundwater treatment systems removed approximately 1.3 millicuries of strontium-90 (Sr-90) while remediating approximately 26 million gallons of groundwater. Since 2003, BNL has removed approximately 29 millicuries of Sr-90 from the groundwater while remediating 130 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 various New York State operating permits, DOE Order 458.1, *Radiation Protection of the Public and Environment*, and DOE Order 436.1, *Departmental Sustainability*. This program also satisfies the requirements of several Comprehensive Environmental Response, Compensation and Liability (CERCLA) Records of Decision (RODs). 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, 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 remediate 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 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. 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, designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) 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, 32 separate Areas of Concern (AOC) were grouped into six Operable Units (OUs). Remedial actions have been implemented for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) have been 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 groundwater protection issues and cleanup progress 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, The Laboratory has developed a Groundwater Protection Contingency Plan (BNL 2013) that provides formal processes to promptly communicate off-normal or unusual monitoring results to BNL 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 over the past 20 years and continues to make progress in achieving its goal of preventing new groundwater impacts and to remediate previously contaminated groundwater. No new impacts to groundwater quality were discovered during 2013. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

7.3 GROUNDWATER MONITORING PROGRAMS

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 volatile organic compounds (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 780 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 725 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 BNL facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP), Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), 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 the Brookhaven Medical Research Reactor (BMRR). Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively.

7.4 GROUNDWATER MONITORING RESULTS

During 2013, the Facility Monitoring program monitored 127 wells during 225 individual sampling events. No new impacts to groundwater quality were discovered during the year. The CERCLA groundwater monitoring program monitored 653 monitoring wells during 2,590 individual groundwater sampling events. Sixty-five temporary wells were also installed as part of this program. Detailed descriptions and maps related to the groundwater monitoring programs can be found in *SER Volume II, Groundwater Status Report*.

Highlights of the groundwater monitoring programs for 2013 include:

- Significant reductions in contaminant concentrations continue to be observed in a number of on- and off-site areas. As a result, the OU I South Boundary Treatment System, OU III Industrial Park Treatment System, OU III North Street Treatment System, and the HFBR Tritium Pump and Recharge System were shut down and placed in standby mode.
- Monitoring results indicated that the OU III Industrial Park East Treatment System, which was placed in standby mode in late 2009, met its cleanup objectives. As a result, the treatment system was decommissioned in 2013.
- Monitoring results indicate that the North Street East Treatment System has met its cleanup objectives. A *Petition for Shutdown* will be submitted to the regulatory agencies in early 2014.
- Natural attenuation monitoring of the remaining portion of the OU V VOC plume was concluded in 2013 after verification that all VOC concentrations had attenuated to levels below applicable NYS AWQS. The monitoring requirements for complet-

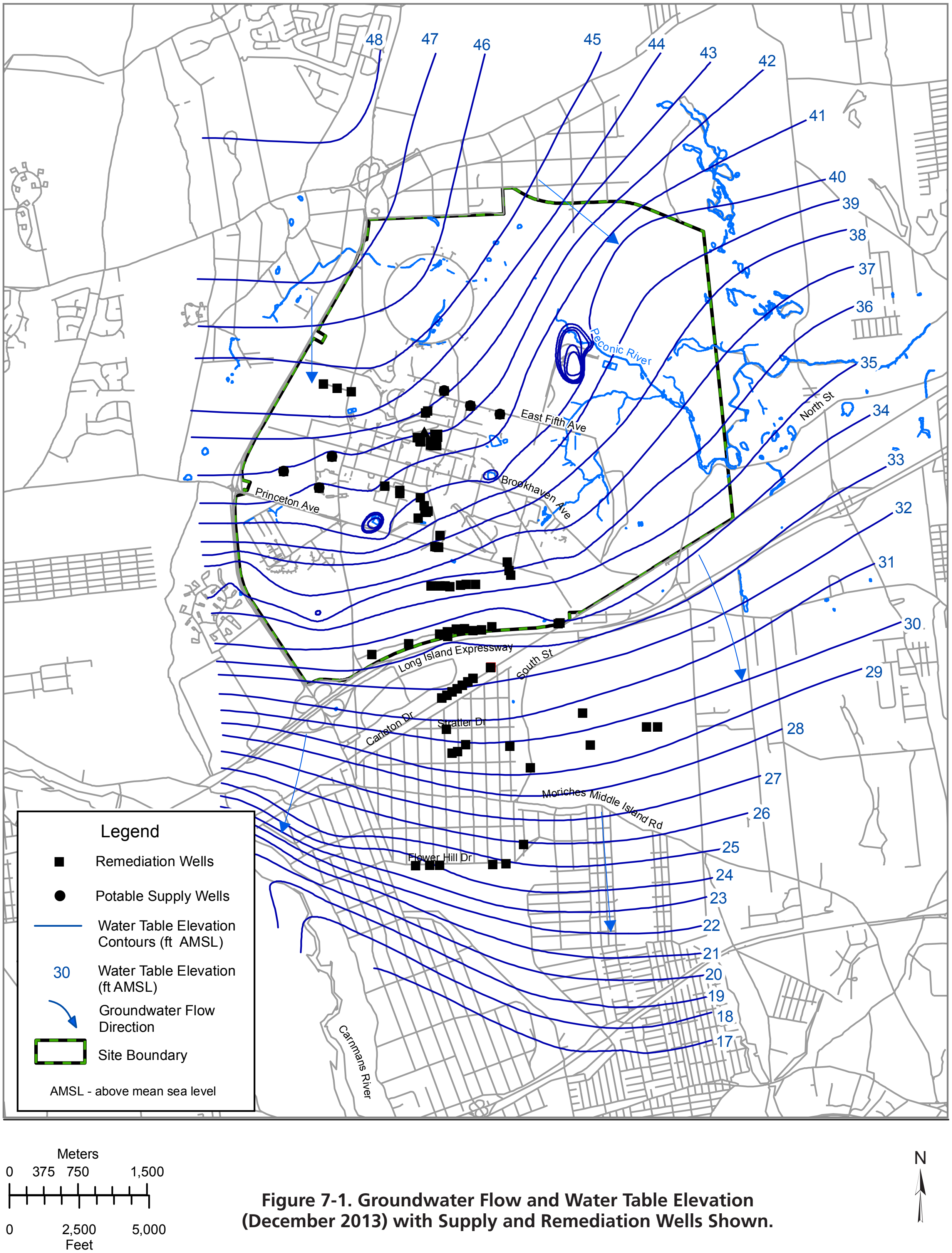

Figure 7-1. Groundwater Flow and Water Table Elevation (December 2013) with Supply and Remediation Wells Shown.

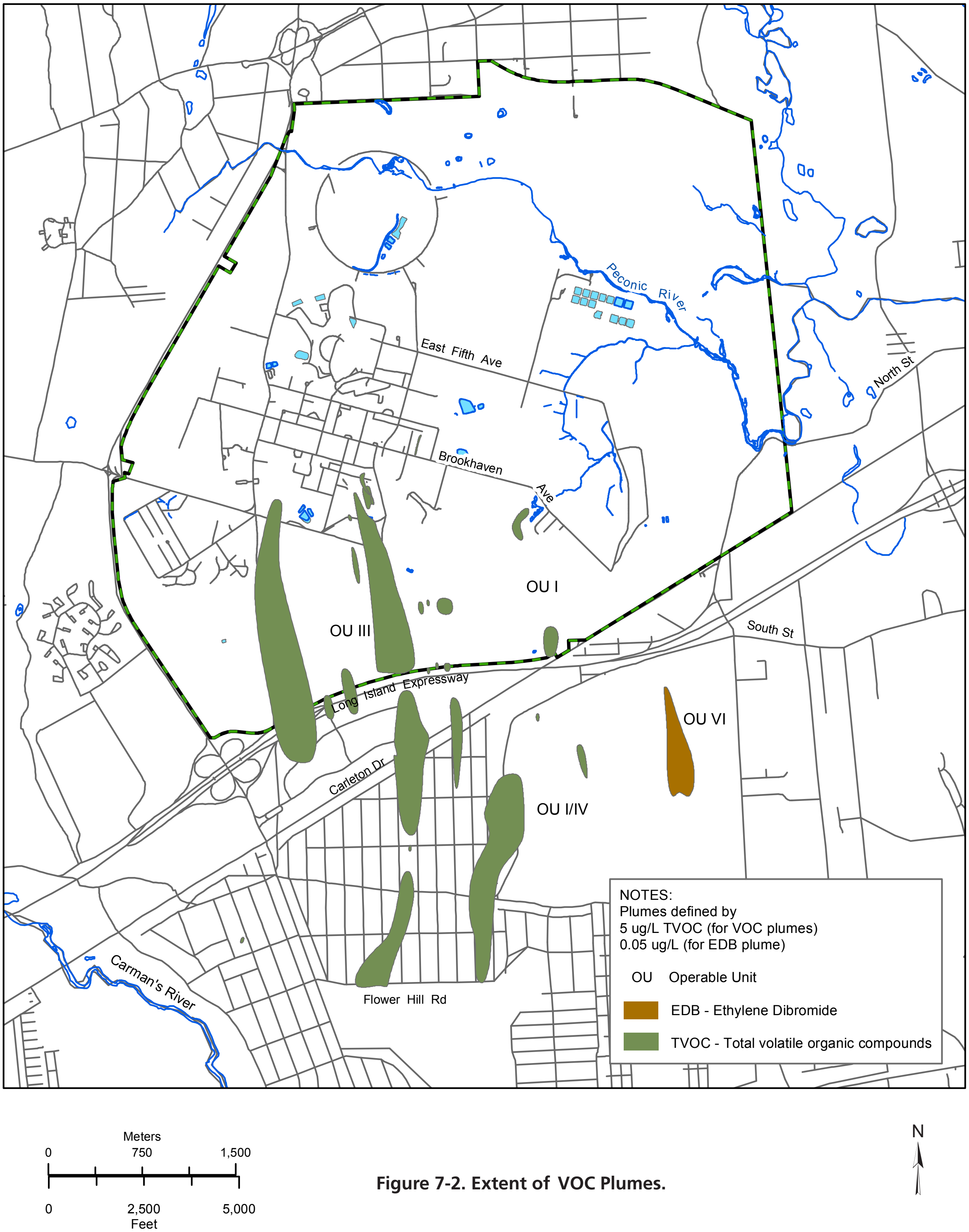

Figure 7-2. Extent of VOC Plumes.

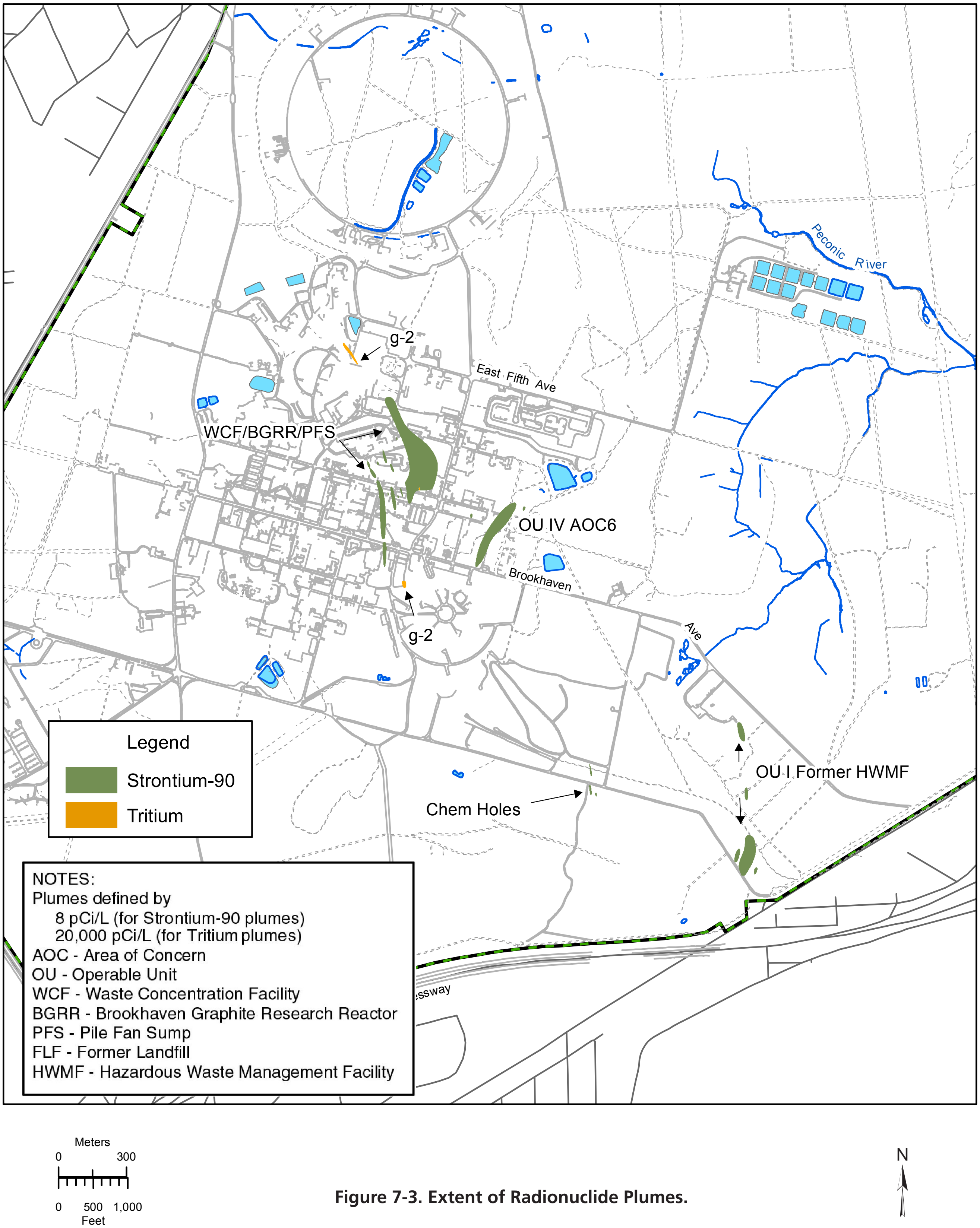

Figure 7-3. Extent of Radionuclide Plumes.

ing this program were documented in the *Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012).

- Groundwater characterization work in the off-site Industrial Park area identified a deep zone of VOC contamination, with total VOC concentrations up to 149 µg/L. This deeper zone of contamination cannot be effectively remediated using the existing Industrial Park Treatment System. During 2014, additional groundwater characterization will be performed to determine the location for the installation of a deeper extraction well(s).
- Significant reductions in VOC concentrations have been observed in the Building 96 source area monitoring wells following the 2010 excavation of contaminated source area soils. In a monitoring well located immediately downgradient of the excavation, total VOC concentrations decreased from a maximum of 2,435 µg/L in early 2011, to 201 µg/L in late 2013.
- During 2012 and 2013, approximately 85 pounds of Freon-11 were removed from the aquifer, and significant reductions in Freon-11 concentrations were observed in the source area and downgradient portions of the plume. Freon-11 concentrations in groundwater have decreased from a maximum concentration of 38,000 µg/L when the plume was discovered 2011, to less than 251 µg/L in November 2013.
- Although Sr-90 concentrations in the groundwater immediately downgradient of the BGRR had decreased to less than 10 pCi/L by the end of 2012, Sr-90 levels increased to as high as 487 pCi/L in 2013. It is believed that the increase is related to a 2010 rise in the water table which flushed residual Sr-90 from the unsaturated zone soils located beneath the building. The amount of Sr-90 in this deep soil zone is expected to diminish over time, and the engineered cap installed in 2011 was designed to prevent rainwater infiltration into contaminated soils immediately below the BGRR.
- Tritium concentrations in the groundwater immediately downgradient of the HFBR exceeded the 20,000 pCi/L drinking water standard only once during 2013, with a concentration of 39,700 pCi/L detected in one well.
- Tritium continued to be detected in the g-2 source area monitoring wells at concentrations above the 20,000 pCi/L DWS, with a maximum concentration of 45,600 pCi/L. Natural radioactive decay and dispersion has significantly reduced the size of the downgradient portion of the g-2 tritium plume, which is now located west of the National Synchrotron Light Source II facility. This small plume segment, which had tritium concentrations up to 31,400 pCi/L during 2013, is expected to naturally attenuate to less than the 20,000 pCi/L drinking water standard within several years.

7.5 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems to remediate contaminant plumes both on- and off-site. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. 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 and tritium 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 2013, 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 7-1 provides a summary of the amount of VOCs and Sr-90 removed from the aquifer

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2013.

Remediation System	Start Date	1997-2012 Water Treated (Gallons)	1997-2012 VOCs Removed (Pounds) (e)	2013 Water Treated (Gallons)	2013 VOCs Removed (Pounds) (e)
OU I South Boundary	12/1996	4,138,473,000	368	39,000,000	1
OU III HFBR Tritium Plume (a)	05/1997	699,295,000	180	225,000,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	339,602,416	117	39,805,000	10
OU III Middle Road	10/2001	2,323,348,550	1,026	224,000,000	56
OU III South Boundary	06/1997	4,107,751,850	2,900	276,000,000	54
OU III Western South Boundary	09/2002	1,152,784,000	105	124,000,000	10
OU III Industrial Park	09/1999	1,940,798,330	1,059	36,000,000	2
OU III Industrial Park East (g)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street	06/2004	1,441,617,000	327	61,500,000	2
OU III North Street East	06/2004	852,558,000	41	103,000,000	2
OU III LIPA/Airport	08/2004	2,006,529,000	334	255,000,000	29
OU III Building 452 Freon-11	03/2012	26,812,000	71	31,500,000	17
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	1,253,664,000	(f)	157,000,000	(f)
Total		**20,793,963,221**	**6,950**	**1,369,305,000**	**183**

Remediation System	Start Date	2003–2012 Water Treated (Gallons)	2003–2012 Sr-90 Removed (mCi)	2013 Water Treated (Gallons)	2013 Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	44,835,826	4.6	6,500,000	0.11
OU III BGRR/WCF Sr-90	06/2005	59,582,000	22.85	19,500,000	1.17
Total		**104,417,826**	**27.45**	**26,000,000**	**1.28**

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 and decommissioned in 2009.
(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 = volatile organic compounds
WCF = Waste Concentration Facility

since the start of active remediation in December 1996. During 2013, approximately 183 pounds of VOCs and approximately 1.3 mCi of Sr-90 were removed from the groundwater, and approximately 1.4 billion gallons of treated groundwater were returned to the aquifer.

To date, 7,133 pounds of VOCs have been removed from the aquifer and noticeable improvements in groundwater quality are evident in a number of on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 29 mCi of Sr-90.

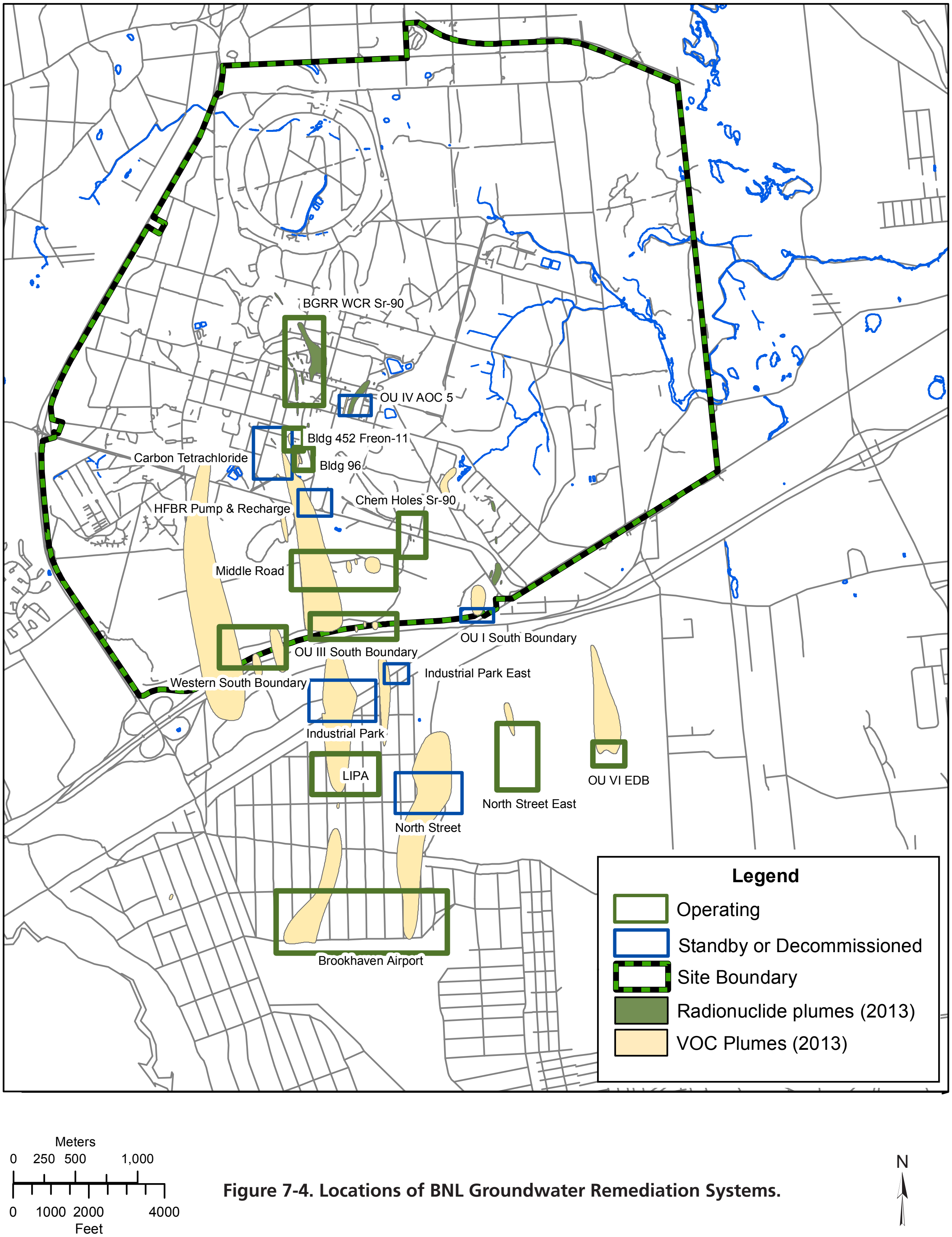

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

During 2013, BNL received regulatory agency approval to shut down four groundwater treatment systems: the OU I South Boundary Treatment System, OU III Industrial Park Treatment System, OU III North Street Treatment System, and the HFBR Tritium Pump and Recharge System. These systems met their active remediation goals for reduction of contaminant concentrations. A period of standby monitoring of these plumes will be performed to detect any rebound of contaminant concentrations. The OU III Industrial Park East Treatment System, which was placed in standby mode in late 2009, was decommissioned in 2013. Furthermore, a Petition for Shutdown for the North Street East Treatment System will be submitted to the regulatory agencies in early 2014. Monitoring of the remaining portion of the OU V VOC plume was concluded in 2013. Detailed information on the groundwater treatment systems can be found in *SER Volume II, Groundwater Status Report*.

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Radiological Dose Assessment 8

BNL's annual radiological dose assessment assures stakeholders that on-site facilities and BNL operations are in compliance with federal, state, and local regulations, and that the public is protected. The potential radiological dose to members of the public is calculated at an off-site location closest to an emission source as the maximum dose that could be received by an off-site individual, defined as the "maximally exposed off-site individual" (MEOSI). Based on MEOSI dose calculation criteria, members of the public will receive a dose less than the MEOSI under all circumstances. The dose to the MEOSI is the sum total from direct and indirect dose pathways via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat. In 2013, the total effective dose (TED) of 2.55 mrem (26 µSv) from Laboratory operations was well below the EPA and DOE regulatory dose limits for the public, workers, and the environment.

The effective dose equivalent (EDE) from air emissions in 2013 was estimated as 3.65E-01 mrem (3.6 µSv) to the MEOSI. The BNL dose from the inhalation pathway was less than 4 percent of the EPA's annual regulatory dose limit of 10 mrem (100 µSv). In addition, the dose from the ingestion pathway was estimated as 2.02 mrem (20 µSv) from the consumption of deer meat and 1.64E-01 mrem (1.6 µSv) from the consumption of fish caught in the vicinity of the Laboratory. In summary, the total annual dose to the MEOSI from all pathways was estimated as 2.55 mrem (26 µSv), which is less than 3 percent of DOE's 100-mrem limit. The aggregate population dose was 17.21 person-rem among approximately 6 million persons residing within a 50-mile radius of the Laboratory. On average, this is less than half the equivalent of an airport whole body security scan.

Dose to the maximally exposed individual (MEI) on site and outside of controlled areas calculated from TLD (thermoluminescent dosimeter) monitoring records in 2013 was 10 mrem above the natural background radiation. The average annual external dose from on-site ambient sources was 66 ± 8 mrem (660 ± 80 µSv) and 61 ± 7 mrem (610 ± 70 µSv) from off-site ambient sources. Both on- and off-site external dose measurements include the contribution from natural terrestrial and cosmic background radiation. A statistical comparison of the average doses measured using 49 on-site TLDs and 11 off-site TLDs showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level in 2013. An additional nine TLDs were used to measure on-site areas known to have radiation dose slightly above the natural background radiation. These areas were in close proximity to buildings where some of the highest-energy beams were striking barriers, a fence-controlled area in the process of soil remediation, and a building that houses radiation-generating devices and neutron sources.

Doses to aquatic and terrestrial biota were also evaluated in 2013 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 from these activities was below regulatory limits and there was minimal radiological risk to the public, workers, or the environment. In summary, the overall dose impact from all Laboratory activities in 2013 was comparable to natural background radiation levels.

8.0 INTRODUCTION

This chapter discusses the dose risk consequences from research activities, radiation generating devices, facilities, and minor bench-top radiation sources at BNL. It is important to understand the health impacts of radiation to the public and workers, as well as radiation effects to the environment, fauna, and flora. The Laboratory's routine operations, scientific experiments, and new research projects are evaluated for their radiological dose risk. The dose risks from decommissioned facilities and decontamination work are also evaluated for dose impact. All environmental pathway scenarios that can cause a dose to humans, aquatic life, plants, and animals are evaluated to calculate the dose risks on site. Because all research reactors at BNL have been shut down, defueled, and partly or fully decommissioned, there was no dose risk from these facilities in 2013. The Laboratory's current radiological risks are from very small quantities of radionuclides used in science experiments, radiopharmaceuticals produced at the Brookhaven Linac Isotope Producer (BLIP), at the BNL accelerators: Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source (NSLS), and the National Synchrotron Light Source II (NSLS-II), which is scheduled to begin start-up operations in 2014. The radiological dose assessments are performed to ensure that dose risks from all Laboratory operations meet regulatory requirements and remain "As Low As Reasonably Achievable" (ALARA) to members of the public, workers, and the environment.

8.1 DIRECT RADIATION MONITORING

A direct radiation-monitoring program is used to measure the external dose contribution to the public and workers from radiation sources at BNL. This is achieved by measuring direct penetrating radiation exposures at both on- and off-site locations. Direct measurements at the off-site locations quantify off-site exposure, which represents true natural background radiation, including both cosmic and terrestrial sources) with no contribution from Laboratory operations. On- and off-site external dose measurements are averaged and then compared using the statistical t-test to assess the contribution, if any, from Laboratory operations.

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 releases, 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 2013, a total of 58 environmental TLDs were deployed on site and were deployed at off-site locations (see Figures 8-1 and 8-2). An additional 30 TLDs were stored in a lead-shielded container for use as reference and control TLDs for comparison purposes. The average of the control TLD values, reported as "075-TLD4" in Tables 8-1 and 8-2, was 29 ± 1 mrem. This dose accounts for any small "residual" dose not removed during the TLD chip annealing process and the natural background and cosmic radiation sources that are not completely shielded. The on- and off-site TLDs were collected and read quarterly to determine the external radiation dose.

Table 8-1 shows the quarterly and yearly on-site radiation dose measurements for 2013. The on-site average external doses for the first through fourth quarters were 17.1 ± 2.2, 16.3 ± 1.7, 15.4 ± 1.4, and 17.6 ± 1.6 mrem, respectively. The on-site average annual external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 66 ± 8 mrem (660 ± 80 µSv).

Table 8-2 shows the quarterly and yearly off-site radiation dose measurements for 2013. The off-site average external doses for the first through fourth quarters were 14.9 ± 1.65, 15.1 ± 1.38, 14.5 ± 0.76, and 17.0 ± 1.93 mrem, respectively. The off-site average annual ambient dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 61 ± 7 mrem (610 ± 70 µSv).

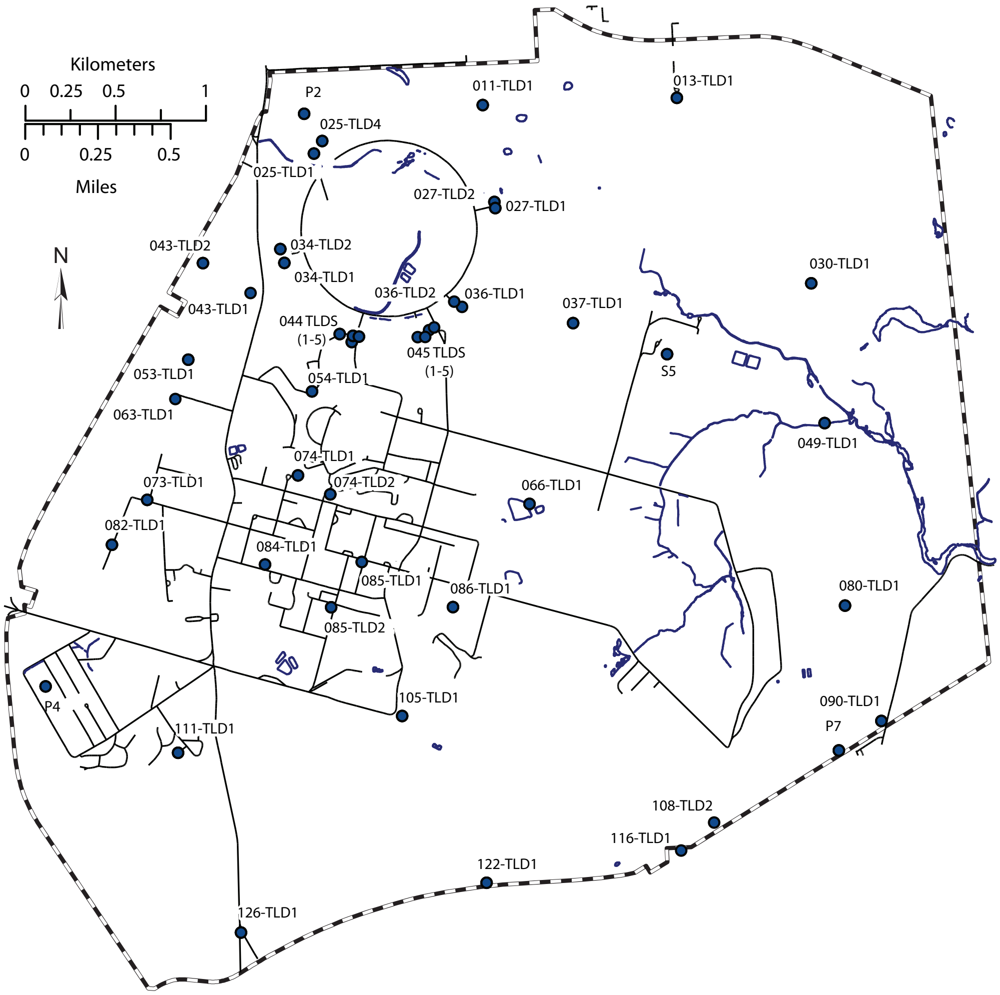

Figure 8-1. On-Site TLD Locations.

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 (66 ± 8 mrem) and on-site dose (61 ± 7 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 2013. The dose to the MEI on site and outside of controlled areas (i.e., in the vicinity of Building 356) was measured at 2 mrem (first quarter), 2 mrem (second quarter), 0 mrem (third quarter), and 6 mrem (fourth quarter) for 2013. The total dose to the on-site MEI was 10 mrem, which is less than the dose received from three round-trip flights from Los Angeles, California to New York, New York.

8.1.2 Facility Area Monitoring

Nine on-site TLDs were designated as facility-area monitors (FAMs) because they were posted in known radiation areas. Table 8-3 shows the external doses measured with the FAM-TLDs. Environmental TLDs 088-TLD1 through 088-TLD4 are posted at the S-6 blockhouse

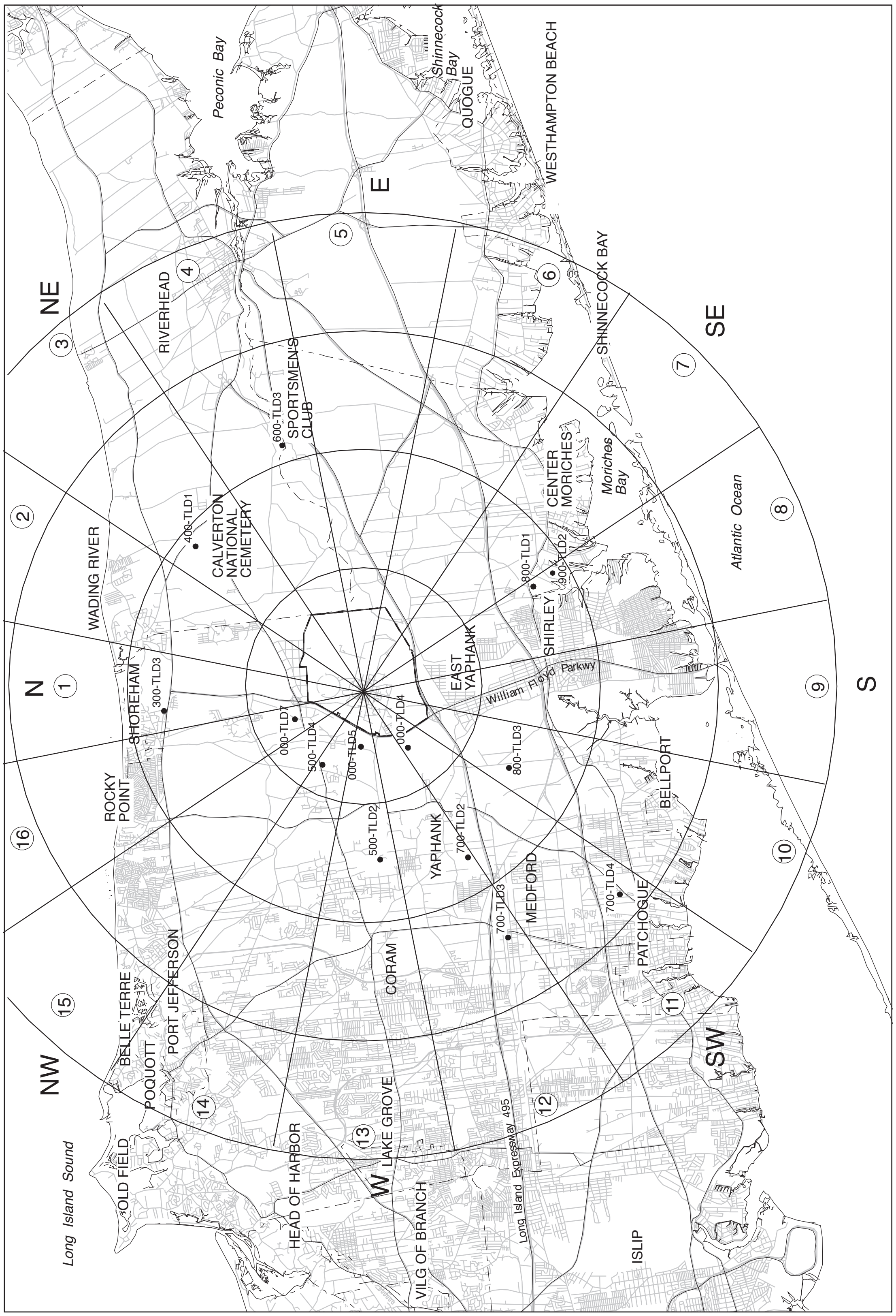

Figure 8-2. Off-Site TLD Locations.

Table 8-1. On-Site Direct Ambient Radiation Measurements for 2013.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ±2σ (95%)	Annual Dose ±2σ (95%)
		(mrem)					
011-TLD1	North Firebreak	13.3	13.9	14.8	15.2	14 ± 2	57 ± 5
013-TLD1	North Firebreak	18.3	15.8	14.9	18.7	17 ± 3	68 ± 11
025-TLD1	Bldg. 1010, Beam Stop 1	16.5	16.0	15.0	16.0	16 ± 1	64 ± 4
025-TLD4	Bldg. 1010, Beam Stop 4	15.3	16.1	14.4	15.9	15 ± 1	62 ± 5
027-TLD1	Bldg. 1002A, South	15.9	13.9	14.7	14.9	15 ± 2	59 ± 5
027-TLD2	Bldg. 1002D, East	16.3	14.5	13.8	13.6	15 ± 2	58 ± 7
030-TLD1	Northeast Firebreak	15.1	15.2	15.1	17.0	16 ± 2	62 ± 6
034-TLD1	Bldg. 1008, Collimator 2	17.2	16.2	14.8	18.2	17 ± 2	66 ± 8
034-TLD2	Bldg. 1008, Collimator 4	18.2	16.8	14.5	19.3	17 ± 3	69 ± 12
036-TLD1	Bldg. 1004B, East	16.6	14.0	17.1	15.6	16 ± 2	63 ± 8
036-TLD2	Bldg. 1004, East	16.0	15.6	14.2	17.7	16 ± 2	63 ± 8
037-TLD1	S-13	15.6	16.4	14.6	16.6	16 ± 2	63 ± 5
043-TLD1	North Access Road	16.5	17.3	15.6	18.9	17 ± 2	68 ± 8
043-TLD2	North of Meteorology Tower	16.5	14.8	17.9	18.7	17 ± 3	68 ± 10
044-TLD1	Bldg. 1006	17.8	16.1	13.9	17.3	16 ± 3	65 ± 10
044-TLD2	South of Bldg. 1000E	19.9	16.3	16.5	16.7	17 ± 3	69 ± 10
044-TLD3	South of Bldg. 1000P	16.9	15.0	13.2	15.1	15 ± 2	60 ± 9
044-TLD4	Northeast of Bldg. 1000P	18.4	17.2	15.3	18.1	17 ± 2	69 ± 8
044-TLD5	North of Bldg. 1000P	17.7	17.6	15.7	17.1	17 ± 2	68 ± 6
045-TLD1	Bldg. 1005S	17.5	15.4	14.3	15.9	16 ± 2	63 ± 8
045-TLD2	East of Bldg. 1005S	18.3	15.5	14.8	17.5	17 ± 3	66 ± 10
045-TLD3	Southeast of Bldg. 1005S	17.1	16.4	14.9	17.4	16 ± 2	66 ± 6
045-TLD4	Southwest of Bldg. 1005S	16.9	16.2	17.2	17.8	17 ± 1	68 ± 4
045-TLD5	West-Southwest of Bldg. 1005S	17.2	17.1	15.0	16.9	17 ± 2	66 ± 6
049-TLD1	East Firebreak	17.2	16.0	14.4	18.7	17 ± 3	66 ± 10
053-TLD1	West Firebreak	16.5	16.9	17.4	19.2	18 ± 2	70 ± 7
054-TLD1	Bldg. 914	18.8	24.1	15.9	18.1	19 ± 5	77 ± 20
063-TLD1	West Firebreak	18.7	17.4	17.4	18.7	18 ± 1	72 ± 4
066-TLD1	Waste Management Facility	14.6	13.9	13.0	15.6	14 ± 2	57 ± 7
073-TLD1	Meteorology Tower	16.0	17.0	16.9	19.0	17 ± 2	69 ± 7
074-TLD1	Bldg. 560	21.0	18.1	16.1	18.7	18 ± 3	74 ± 11
074-TLD2	Bldg. 907	16.5	15.8	13.9	20.7	17 ± 4	67 ± 16
080-TLD1	East Firebreak	7.5	17.4	15.4	18.6	15 ± 7	59 ± 28
082-TLD1	West Firebreak	22.2	18.3	17.4	20.5	20 ± 3	78 ± 12
084-TLD1	Tennis courts	16.6	16.4	15.3	17.9	17 ± 2	66 ± 6
085-TLD1	TFCU	18.4	17.0	15.6	18.6	17 ± 2	70 ± 8
085-TLD2	Upton Gas Station	17.5	16.1	15.9	18.0	17 ± 2	67 ± 6
086-TLD1	Baseball Fields	16.6	16.3	14.8	17.2	16 ± 2	65 ± 6
090-TLD1	North St. Gate	19.5	14.2	13.7	16.7	16 ± 4	64 ± 15
105-TLD1	South Firebreak	18.6	17.5	16.4	20.1	18 ± 3	73 ± 9

(continued on next page)

Table 8-1. On-Site Direct Ambient Radiation Measurements for 2013 *(concluded).*

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ±2σ (95%)	Annual Dose ±2σ (95%)
		(mrem)					
108-TLD1	Water Tower	17.6	16.7	NP	18.4	18 ± 1	70 ± 5
108-TLD2	Tritium Pole	20.5	19.7	19.7	20.9	20 ± 1	81 ± 4
111-TLD1	Trailer Park	17.8	17.8	16.1	18.7	18 ± 2	70 ± 6
122-TLD1	South Firebreak	17.4	15.6	15.7	16.7	16 ± 2	65 ± 5
126-TLD1	South Gate	18.4	17.6	16.7	18.9	18 ± 2	72 ± 6
P2	NW Corner, BNL Site	13.4	13.8	12.7	14.5	14 ± 1	54 ± 5
P4	SW Corner, BNL Site	17.1	15.3	15.2	16.8	16 ± 2	64 ± 6
P7	SE Corner, BNL Site	17.5	16.1	16.0	17.8	17 ± 2	67 ± 6
S5	Sewage Treatment Plan	17.6	15.9	13.6	15.0	16 ± 3	62 ± 10
On-site average		**17.1**	**16.3**	**15.4**	**17.6**	**17 ± 2**	**66 ± 8**
Std. dev. (2 σ)		**2.2**	**1.7**	**1.4**	**1.6**		**17 ± 3**
075-TLD4	**Control TLD average**	**7.39**	**7.29**	**7.1**	**7.46**	**7.3 ± 0.3**	**29 ± 1**

Notes:
See Figure 8-1 for TLD locations.
NP = TLD not posted
TLD = Thermoluminescent dosimeter

location and on the fence of the Former Hazardous Waste Management Facility (FHWMF). The TLDs measured external doses that were slightly elevated compared to the normal natural background radiation doses measured from other areas on site. This can be attributed to the presence of small amounts of contamination in soil. However, a comparison of the current ambient dose rates to doses from previous years shows that the dose rates have significantly declined since the removal of contaminated soil within the FHWMF. As shown in Table 8-3, the 2013 dose is just slightly above natural background levels. The FHWMF is fenced, access to it is controlled, and only trained radiological employees are allowed inside the fenced area.

Two TLDs (075-TLD3 and 075-TLD5) near Building 356 showed slightly higher quarterly averages of 21 ± 3 mrem (210 ± 30 µSv) and 21 ± 7 mrem (210+-70 µSv), respectively, which were just above the normal ambient background radiation. The yearly doses were measured at 83 ± 11 mrem (830 ± 110 µSv) for 075-TLD3, and 84 ± 27 mrem (840 ± 270 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. This building also contains several californium-252 (Cf-252) neutron sources in a cask near the corner of the building where 075-TLD5 is located. Although it is conceivable that individuals who use the parking lot adjacent to Building 356 could receive a dose from these sources, the dose would be small due to the low occupancy factor.

Two FAM-TLDs placed on fence sections northeast and northwest of Building 913B (the AGS tunnel access) showed slightly elevated above-average ambient external dose. The first-quarter dose at the site was measured at 25.4 mrem for 054-TLD2 and 18.0 mrem for 054-TLD3 (compared to the site-wide first-quarter dose of 17.1 ± 2.2 and off-site dose of 14.9 ± 1.65 mrem). The second-quarter dose at the site was measured at 19.2 mrem for 054-TLD2 and 20.4 mrem for 054-TLD3 (compared to the site-wide first-quarter dose of 16.3 ± 1.7 and off-site dose of 15.1 ± 1.4 mrem). For the remaining two quarters, both TLDs showed dose comparable to natural background radiation.

Table 8-2. Off-Site Direct Radiation Measurements for 2013.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ± 2 σ (95%)	Annual Dose ± 2 σ (95%)
		(mrem)					
000-TLD4	Private property	13.5	13.8	13.8	17.2	15 ± 3	58 ± 10
000-TLD5	Longwood Estate	13.7	14.4	13.5	15.0	14 ± 1	57 ± 4
000-TLD7	Mid-Island Game Farm	15.7	NP	14.6	17.5	16 ± 2	64 ± 8
300-TLD3	Private property	NP	L	L	L	0.00	0
400-TLD1	Calverton Nat. Cemetery	18.0	17.3	15.7	21.7	18 ± 4	73 ± 14
500-TLD2	Private property	14.9	13.7	L	L	14 ± 1	58 ± 4
500-TLD4	Private property	NP	L	L	L	0.00	0
600-TLD3	Sportsmen's Club	15.1	14.7	14.8	15.2	15 ± 1	60 ± 2
700-TLD2	Private property	NP	L	L	L	0.00	0
700-TLD3	Private property	13.8	15.2	14.4	15.5	15 ± 2	59 ± 5
700-TLD4	Private property	14.5	15.3	L	NP	15 ± 1	60 ± 3
800-TLD1	Private property	13.3	14.0	14.5	17.2	15 ± 3	59 ± 10
800-TLD3	Suffolk County CD	17.9	18.0	15.5	17.6	17 ± 2	69 ± 7
900-TLD2	Private property	13.1	14.4	13.4	15.7	14 ± 2	57 + 7
Off-site average		**14.87**	**15.09**	**14.46**	**16.95**	**15 ± 2**	**61 ± 7**
Std. dev. (2 σ)		**1.65**	**1.38**	**0.76**	**1.93**		
075-TLD4	**Control TLD average**	**7.39**	**7.29**	**7.10**	**7.46**	**7.3 ± 0.3**	**29 ± 1**

Notes:
See Figure 8-2 for TLD locations.
CD = Correctional Department
L = TLD Lost
NP = TLD not posted for the quarter
TLD = Thermoluminescent dosimeter

Table 8-3. Facility Area Monitoring, 2013.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Average ± 2σ (95%)	Annual Dose ± 2σ (95%)
		(mrem)					
054-TLD2	Northeast of Bldg. 913B	25.4	19.2	16.5	18.5	20 ± 6	80 ± 22
054-TLD3	Northwest of Bldg. 913B	18.0	20.4	14.7	16.0	17 ± 4	69 ± 14
S6	FHWMF	19.0	17.1	16.2	17.8	18 ± 2	70 ± 7
088-TLD1	FHWMF, 50' East of S6	17.6	18.4	19.7	22.8	20 ± 4	78 ± 13
088-TLD2	FHWMF, 50' West of S6	19.7	19.4	18.7	20.0	19 ± 1	78 ± 4
088-TLD3	FHWMF, 100' West of S6	19.7	18.6	18.3	20.2	19 ± 2	77 ± 5
088-TLD4	FHWMF, 150' West of S6	17.6	17.8	17.2	18.6	18 ± 1	71 ± 4
075-TLD3	Bldg. 356	21.3	20.8	18.5	23.0	21 ± 3	83 ± 11
075-TLD5	North Corner of Bldg. 356	25.9	18.4	15.5	24.3	21 ± 7	84 ± 27

Notes:
FHWMF = Former Hazardous Waste Management Facility
TLD = Thermoluminescent dosimeter

The operating period for the AGS is typically in the first half of the calendar year, so the slightly higher readings in the first and second quarters are expected; however, these dose levels are still comparable to recent years overall.

The AGS accelerates protons to energies up to 30 GeV and heavy ion up to 15 GeV/amu. RHIC has two beams circulating in opposite directions and is capable of accepting either protons or heavy ions up to gold. At the RHIC, protons and heavy ions received from the AGS are further accelerated up to final energies of 250 GeV for protons and 100 GeV per nucleon for gold ions. Under these high-energy conditions, facilities such as AGS and RHIC have the potential to generate high-energy neutrons when the charged particles leave the confines of the accelerator and produce nuclear fragments along their path or when they collide with matter. A passive monitoring TLD provides dose information from the neutron interactions when placed at strategic locations. In 2013, 12 neutron-monitoring TLDs (Harshaw Badge 8814) were posted at these strategic locations to measure the dose contribution from the high-energy neutrons (see Figure 8-3 for locations). The technical criteria used for the placement of the neutron TLDs is based on design aspects such as the thickness of the berm shielding, location of soil activation areas, beam stop areas and beam collimators, and proximity to the site boundary. In the first quarter of 2013, three passive monitors for neutron dose, 043-TLD-N1, 054-TLD-N2, and 054-TLD-N3, showed neutron doses of 1 mrem, 1 mrem, and 2 mrem, respectively. A neutron TLD at 042-TLD-N2 showed neutron dose of 1 mrem in the third quarter. Finally, four neutron TLDs at 025-TLD-N2, 043-TLD-N1, 054-TLD-N3, and 064-TLD-N1 all showed neutron doses of 1 mrem in the fourth quarter. Annual operating records for the RHIC/BLIP in 2013 show that an adjustment in

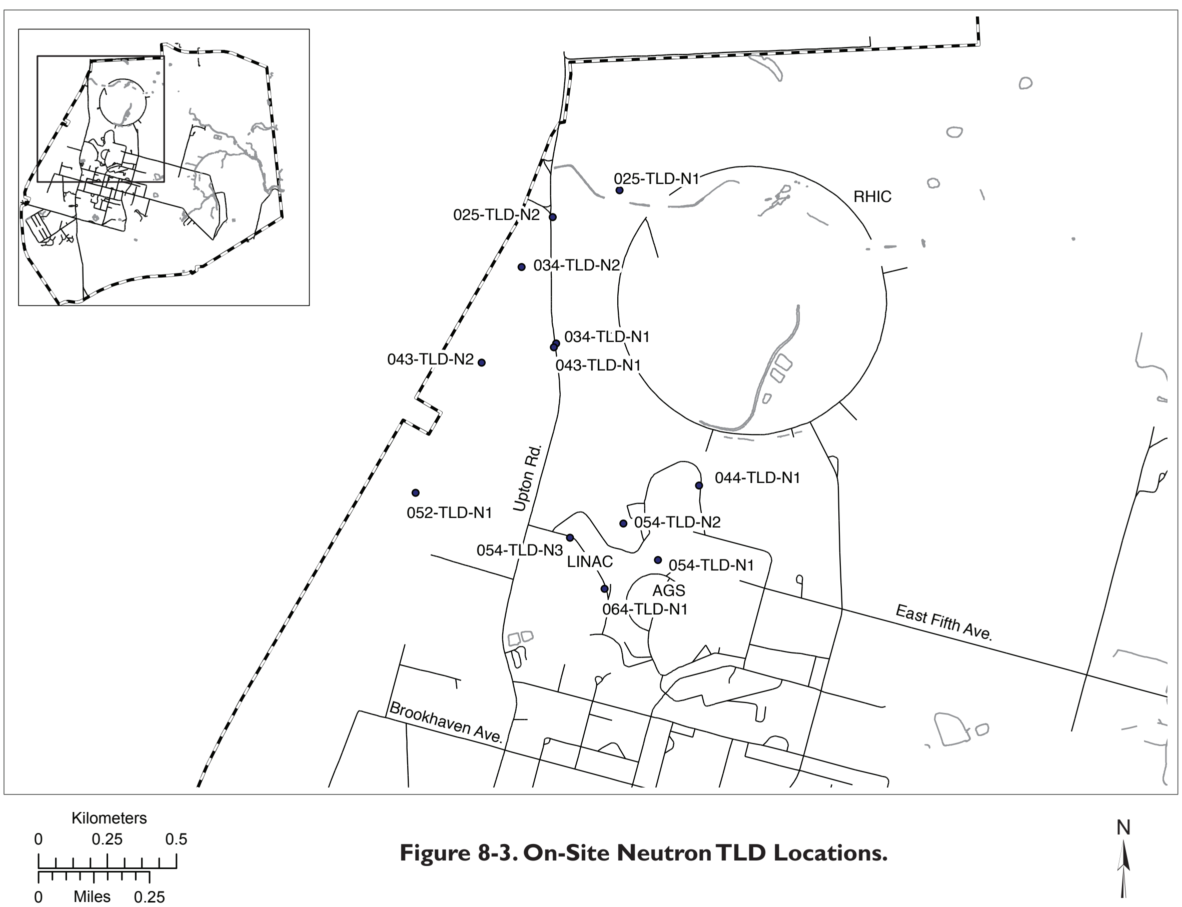

Figure 8-3. On-Site Neutron TLD Locations.

the shielding was made at the beginning of the second quarter. The RHIC/BLIP runs at slightly higher current and energy in the beginning of the third quarter for approximately 1 month, but is turned off for the remainder of the third quarter. In the fourth quarter, the RHIC/BLIP runs for a 2-week period at the end of the calendar year. These low-level neutron doses indicate that engineering controls (e.g., berm shielding) in place at AGS and RHIC are effective.

8.2 DOSE MODELING

EPA regulates radiological emissions from DOE facilities under the requirements set forth in 40 CFR 61, Subpart H, entitled, "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 that is greater than 10 mrem (100 µSv) in a year from airborne emissions. 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 MEOSI. The dose estimates from various facilities are given in Table 8-4, and the air emissions for 2013 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 by the Laboratory's Environmental Restoration Program were exempt under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), these activities were also monitored and assessed for any potential to release radioactive materials and to determine their potential dose contribution, if any, to members of the public. Any new or proposed radiological processes or activities are also 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 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 reason, the results are considered to be conservative.

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), Version 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 MEOSI 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 MEOSI, all emission points are co-located at the BLIP Facility located in the developed portion of the 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 towers. These measurements include wind speed, direction, frequency, and air temperature (see Chapter 1 for details). A population of approximately 6 million people, based on the geographical information system design population survey performed by Oak Ridge National Laboratory for BNL, was used in the model (ORNL 2012).

Table 8-4. Maximally Exposed Off-site Individual Effective Dose Equivalent From Facilities or Routine Processes, 2013.

Building No.	Facility or Process	Construction Permit No.	MEOSI Dose (mrem) (a)	Notes
197	Nonproliferation & Nuclear Safety	None	7.70E-12	(b)
197B	Nonproliferation & Nuclear Safety	None	1.69E-08	(b)
348	Instrumentation & Calibration	None	ND	(i)
463	Biology	None	7.43E-09	(b)
480	Condensed Matter Physics	None	ND	(b)
490	Radiation Therapy Facility	BNL-489-01	ND	(e)
490/490A	Medical Research	None	2.04E-08	(b)
491	Brookhaven Medical Research Reactor	None	ND	(e)
510	Calorimeter Enclosure	BNL-689-01	ND	(f)
510A	Physics	None	ND	(i)
535	Instrumentation	None	ND	(i)
555	Chemistry Facility	None	ND	(i), (k)
703	Analytical Laboratory	None	ND	(d)
725	National Synchrotron Light Source	None	1.25E-08	(b)
750	High Flux Beam Reactor	None	1.38E-04	(c)
801	Target Processing lab	None	4.32E-03	(b), (c)
802B	Evaporator Facility	BNL-288-01	ND	(e)
815	Environmental Chemistry	None	ND	(b)
820	Accelerator Test Facility	BNL-589-01	ND	(d)
830	Environmental Science Department	None	ND	(d)
865	Waste Managerment Facility	None	7.73E-09	(j)
901	BioSciences Department	None	7.61E-07	(b)
906	Medical-Chemistry	None	ND	(i)
911	Alternate Gradient Syncrotron	None	ND	(d)
925	Accelerator Department	None	ND	(i)
931	Brookhaven Linac Isotope Producer	BNL-2009-01	3.65E-01	(c)
938	REF/NBTF	BNL-789-01	ND	(f), (g)
942	Alternate Gradient Syncrotron Booster	BNL-188-01	ND	(h)
---	Relativisitc Heavy Ion Collider	BNL-389-01	ND	(d)
Total Potential Dose from BNL Operations			**3.65E-01**	
EPA Limit (Air Emissions)			**10 mrem**	

Notes:
MEOSI = Maximally Exposed Off-Site Individual
ND = No Dose from the emission sources in 2013
(a) "Dose" in this table means effective dose equivalent to MEOSI.
(b) Dose is based on emissions calculated using 40CFR61, Appendix D methodology.
(c) Emissions are continuously monitored at the facility.
(d) No Dose from emissions source in 2013.
(e) Not Operational in 2013.
(f) This facility was decommissioned and has been a zero-emission Facility.
(g) This facility is no longer in use; it produces no radioactive emissions.
(h) Booster ventilation system prevents air release through continuous air recirculation.
(i) No radiological dispersible material inventory in 2013.
(j) No detectable emissions from the Waste Management Facility in 2013.
(k) Sealed sources were excluded from this inventory—no emission.

8.2.2 Dose Calculation Methods and Pathways

8.2.2.1 Maximally Exposed Off-site and On-site Individual

The MEOSI is defined as a person who resides at a residence, office, or school beyond the BNL site boundary such that no other member of the public could receive a higher dose than the MEOSI. This person is assumed to reside 24 hours a day, 365 days a year, off site, and close to the nearest BNL emission point. This person is also assumed to consume significant amounts of fish and deer meat containing radioactivity assumed to be attributable to Laboratory operations based on consumption projections developed by 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. The location of the MEOSI who could receive any dose outside of BNL's radiological control areas was determined by the on-site TLD measurements.

8.2.2.2 Effective Dose Equivalent

The EDE to the MEOSI from low levels of radioactive materials dispersed into the environment was calculated using the CAP88-PC dose modeling program, Version 3.0. Site meteorology data were used to calculate annual dispersions for the midpoint of a given wind sector and distance. Facility-specific radionuclide emission 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. As stated above, these dose and risk calculations to the MEOSI 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. The term "Intake" is defined as the average amount of fish consumed by a person engaged in recreational fishing on 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). No other radionuclides associated with Laboratory operations have been detected in deer meat. The total quantity of deer meat ingested during the course of a year was estimated at 64 pounds (29 kg) (NYSDOH 1999).

8.3 SOURCES: DIFFUSE, FUGITIVE, "OTHER"

Diffuse sources, also known as nonpoint or area sources, are described as sources of radioactive contaminants which diffuse into the atmosphere but do not have well-defined emission points. Fugitive sources include leaks through window and door frames, as well as unintended releases to the air through vents or stacks which are supposedly inactive (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 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 2013 for potential contribution to the overall site dose: Building 801, Building 750 complex (High Flux Beam Reactor [HFBR]), and Building 906 (Scanner Rooms 5 and 6).

8.3.1 Remediation Work

There was no remediation work performed in 2013 that could have resulted in a dose to the public.

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 BLIP facility is the only emission source with the 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 is considered a major emission source in accordance with the ANSI N13.1-1999 standard's graded approach; that is, a Potential Impact Category (PIC) of II. The emissions are directly and continuously measured in real time with an in-line, low-resolution sodium iodide (NaI) gamma spectrometer connected to the exhaust ventilation system. The particulate emissions are sampled, with a weekly frequency, using a conventional fiberglass filter, which is analyzed at an off-site contract analytical laboratory. Tritium samples are also collected continuously using a silica gel absorbent and are then analyzed at an off-site contract analytical laboratory on a biweekly basis.

In 2013, the BLIP facility operated over a period of 29 weeks. During the year, 1,620 Ci of carbon-11 (C-11, half-life: 20.4 minutes) and 3,300 Ci of oxygen-15 (O-15, half-life: 122 seconds) were released from the BLIP facility. A small quantity (2.68E-04 Ci) of tritiated water vapor from activation of the targets' cooling water was also released. The EDE to the MEOSI was calculated to be 3.61-01 mrem (3.6 µSv).

8.4.2 High Flux Beam Reactor

In 2013, the residual tritium emissions from the HFBR Facility were measured as 0.522 Ci, and the estimated dose attributed was 1.38E-04 mrem (1.4 nSv) in a year.

8.4.3 Brookhaven Medical Research Reactor

In 2013, the Brookhaven Medical Research Reactor (BMRR) facility remained in a cold-shutdown mode as a radiological facility with institutional controls in place. There was no dose contribution from the BMRR.

8.4.4 Brookhaven Graphite Research Reactor

In 2013, long-term surveillance of the remediated reactor complex commenced, as well as the maintenance and periodic refurbishment of structures, systems, and components, which will continue throughout the period of radioactive decay. There were no radionuclides released to the environment from the complex.

8.4.5 Waste Management Facility

In 2013, there were no detectable levels of emissions from the Waste Management Facility.

8.4.6 Unplanned Releases

There were no unplanned releases in 2013.

8.5 DOSE FROM INGESTION

Radionuclides in the environment bio-accumulate in deer and fish tissues, bones, and organs; consequently, samples from deer and fish are analyzed to evaluate the dose contribution to humans from the ingestion pathway. Monitoring results for 2013 are discussed in Chapter 6. The maximum tissue concentration in the deer meat (flesh) collected "off site and more than 1 mile" was used to calculate the potential dose to the MEOSI. Potassium-40 (K-40) and cesium-137 (Cs-137) were detected in the tissue samples. K-40 is a naturally-occurring radionuclide and is not related to BNL operations.

In 2013, the average K-40 concentrations in deer tissue samples (off site > 1 mile) were 3.13 ± 0.30 pCi/g (wet weight) in the flesh and 2.64 ±0.30 pCi/g (wet weight) in the liver. The maximum Cs-137 concentrations were 1.39 ± 0.02 pCi/g (wet weight) in the flesh (off site > 1 mile) and 0.14 ± 0.01 pCi/g (wet weight) in the liver (off site <1 mile) (see Table 6-2). Although the average Cs-137 concentration from all samples was calculated at 0.54 ± 0.06 pCi/g, the maximum detected concentration of 1.39 pCi/g was used for the purpose of MEOSI dose calculations. The maximum estimated dose to humans from consuming deer meat containing the maximum Cs-137 concentration was estimated to be 2.02 mrem (20 µSv) in a year. This dose is below the health advisory limit of 10 mrem (100 µSv) established by NYSDOH.

In collaboration with the New York State Department of Environmental Conservation (NYSDEC) Fisheries Division, the Laboratory maintains an ongoing program of collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. In 2013, a Chain Pickerel species had the highest measured concentration of Cs-137 at 0.47 ± 0.08 pCi/g; this was used to estimate the EDE to the MEOSI. The potential dose from consuming 15 pounds of such fish annually was calculated to be 1.64E-01 mrem (1.6 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 and terrestrial plants and animals, using site-specific environmental surveillance data (DOE 2002). The RESRAD-BIOTA 1.5, biota dose level 2 computer program was used to evaluate compliance with the requirements for protection of biota specified in DOE Order 458.1, *Radiation Protection of the Public and the Environment*.

In 2013, the terrestrial animal and plant doses were evaluated based on 0.26 pCi/g of Cs-137 (see Table 6-10) found in surface soils around the old incinerator (former site of Building 428) and a strontium-90 (Sr-90) concentration of 0.42 pCi/L (see Table 5-5) in the surface waters collected at the HM-N location. The dose to terrestrial animals was calculated to be 12.5 µGy/day, and to plants, 1.18 µGy/day. The doses to terrestrial animals were well below the biota dose limit of 1 mGy/day, and below the limit for terrestrial plants.

To calculate the dose to aquatic and riparian animals, Sr-90 radionuclide concentration values for surface water from the HM-N location (see Table 5-5) and the Cs-137 in sediments found at ST1-80-U20 were used (see Table 6-7). The Cs-137 sediment concentration at ST1-80-U20 was 0.51 pCi/g and the Sr-90 concentration in surface water at HM-N was 0.42 pCi/L. The calculated dose to aquatic animals was 9.92 µGy/day, and the dose to riparian animals was 25.6 µGy/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 2013. The total dose to the MEOSI from air and ingestion pathways was estimated as 2.55 mrem (25 µSv). In comparison, the EPA regulatory limit for the air pathway is 10 mrem (0.10 mSv) and the DOE limit from all pathways is 100 mrem (1 mSv). The cumulative population dose was 17.21 person-rem (0.02 person-Sv) in a year. The effective dose is well below the DOE and EPA regulatory limits, and the ambient TLD dose is within normal background levels seen at the Laboratory site. The potential dose from drinking water was not estimated, because most 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 estimated dosed from other sources of radiation. The annual dose from all natural background sources and radon is approximately 311 mrem (3.11 mSv). A mammogram gives a dose of 250 mrem (2.5 mSv) and a dental x-ray gives a dose of approximately 160 mrem (1.6 mSv) to an individual. Therefore, a dose of 2.55 mrem from all environmental pathways is a small fraction of the dose from one routine dental x-ray.

Table 8-5. BNL Site Dose Summary, 2013.

Pathway	Dose to Maximally Exposed Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose per year
Inhalation			
Air	3.65E-01	<1%	17.21 Person-rem
Ingestion			
Drinking water	None	None	None
Fish	1.64E-01	<1%	Not Tracked
Deer	2.02	<3%	Not Tracked
All Pathways	2.55 mrem (25.5µSv)	<3%	17.21 Person-rem

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9 Quality Assurance

Quality assurance is an integral part of every activity at Brookhaven National Laboratory. 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. The 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 2013 Site Environmental Report are reliable and of high quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by DOE Order 458.1, *Radiation Protection of the Public and Environment* and Order 436.1, *Departmental Sustainability*, 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 414.1D, *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 operations in a reliable and effective manner to minimize any impact on the environment, safety, security, and health of the staff and public
- Standardize processes and support continual improvement
- Enable the delivery of products and services that meet customers' requirements and expectations
- Support an environment that facilitates scientific and operational excellence

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 2006) 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.

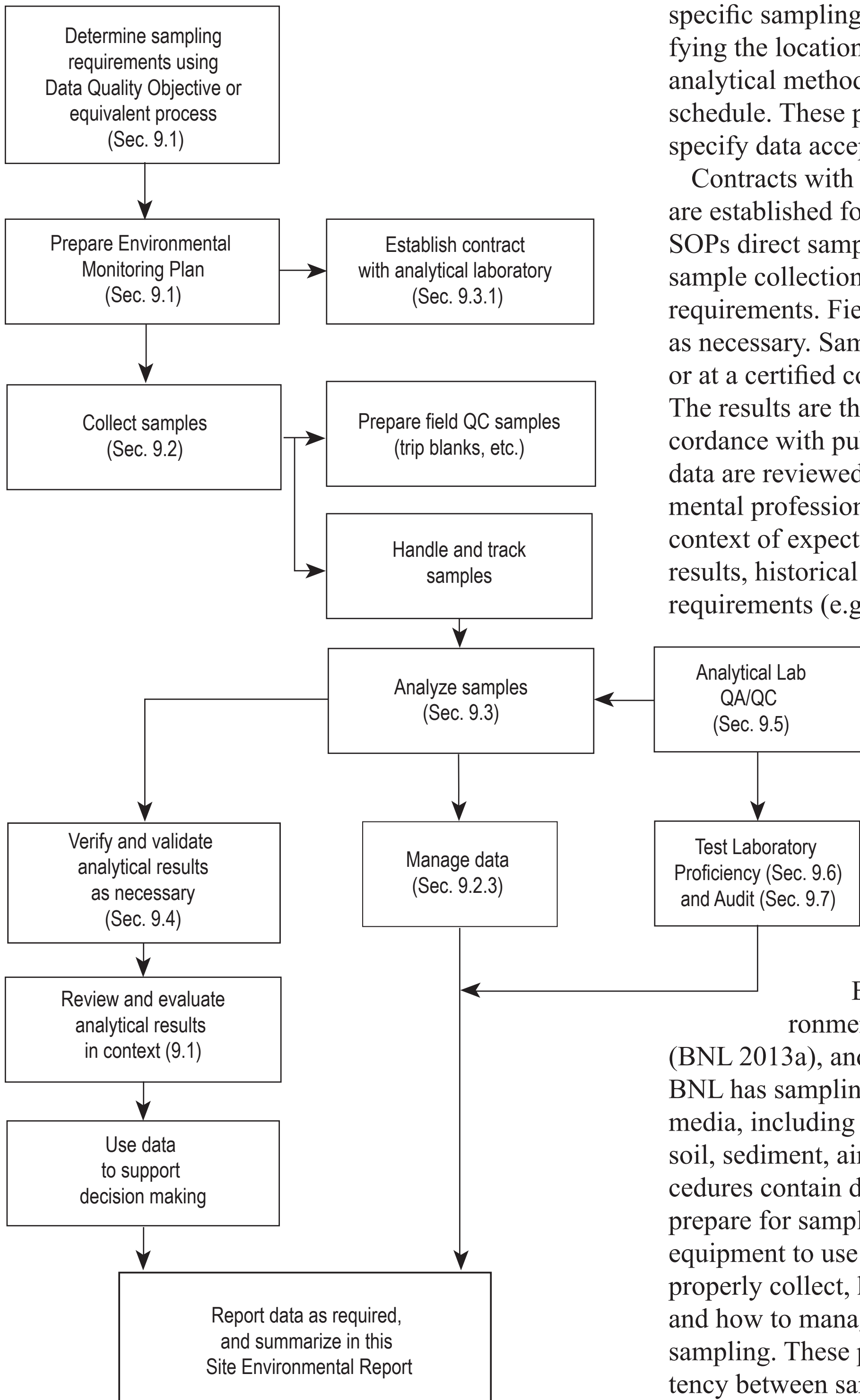


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

An environmental monitoring plan or project-specific sampling plan is then prepared, specifying the location, frequency, type of sample, analytical 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 a certified contract analytical laboratory. 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.). the data are used to support decision making, reported as required, and summarized in this annual report.

9.2 SAMPLE COLLECTION AND HANDLING

In 2013, environmental monitoring samples were collected, as specified, by EM-SOPs, the BNL Environmental Monitoring Plan Update (BNL 2013a), and project-specific work plans. 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. These procedures also ensure consistency between samples collected by Laboratory sampling personnel and contractors used to support 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.

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 2013. A sample is considered to be in the custody of a person if any or all 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 2010a). All environmental monitoring samples collected in 2013 maintained a valid COC from the time of sample collection through sample disposal by the contract analytical laboratories used by BNL.

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 2012a), field sampling technicians are also required to maintain bound, weatherproof field logbooks, which are used to record sample ID numbers, collection times, descriptions, collection methods, and COC numbers. Daily weather conditions, field measurements, and other appropriate site-specific observations also are recorded in the logbooks.

9.2.1.2 Preservation and Shipment

Before sample collection, 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, and samples are refrigerated as necessary. For example, samples collected for methyl mercury are cooled immediately and shipped to a 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, "Chain-of-Custody, Storage, Packaging, and Shipment of Samples."

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, Quality Assurance. Equipment blanks and trip blanks were collected for all appropriate media in 2013.

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 non-dedicated 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 container during shipment from the manufacturer, while the container was in storage, contamination of a sample occurred during shipment to a contract analytical laboratory, or during analysis of a sample at a contract analytical laboratory. 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 contract analytical laboratory, 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 2013.

Field blanks are collected to check for cross-contamination that may occur during sample collection. A field blanks consist of an aliquot of laboratory-grade water that is poured into a sample container in the field. 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 2013 (as in other years), the most common contaminants detected in the trip, field, and equipment blanks included trace to low levels of chloroform, methyl chloride, and methylene chloride. 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 methyl bromide and toluene, 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 2013 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 2012, 2013). 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 2013, a total of 56 duplicate samples were collected for non-radiological analyses and 42 duplicates were collected for radiologic analyses. Not all parameters were analyzed in every duplicate. The parameters in each duplicate were consistent with those required for the specific program the duplicate was monitoring. Of the 4,418 parameters analyzed, only 23 (0.52 percent) of the non-radiologic analyses failed to meet QA criteria. For the radiologic parameters, only 6 of the 116 parameters (5.2 percent) failed to meet QA criteria. The results are indicative of consistency with the contract analytical laboratories and sampling methods, resulting in valid, reproducible data.

Matrix spike and *matrix spike duplicates* are used 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 2013 for routine matrices such as water and soil. Non-routine 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 BNL's Environmental Information Management System (EIMS), a database system used to store, manage, verify, protect, retrieve, and archive BNL's environmental data. A small number of environmental samples that were not tracked in the EIMS were analyzed at Chemtex Lab, which cannot produce the electronic data deliverables needed to enter the data into the EIMS. Tracking is initiated when a sample is recorded on a COC form. Copies of the COC forms and supplemental forms are 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 maintains 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. 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 2013, environmental samples were analyzed by six contract analytical laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available. 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 2013:

- 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), based in St. Louis, Missouri, for radiological and nonradiological analytes
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes
- Caltest Analytical in Napa, California, for mercury and methyl mercury analyses
- American Radiation Services (ARS) in Port Allen, Louisiana, for radiological analyses

The process of selecting contract analytical laboratories involves the following 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 2013 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 undergo data verification, whereas analytical results 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 2013 were verified and/or validated, when project DQOs required, using BNL EM-SOPs and EPA contract laboratory program guidelines (EPA 2012, EPA 2013). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 2012b). During 2013, the verifications were conducted using a combination of manually checking hard copy data packages and the use of a computer program developed at the Laboratory to verify that the information reported electronically is stored in the EIMS.

9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2013, 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 occur, nonconformance reports are generated. Following investigation into the root causes, corrective actions are taken and tracked to closure.

9.6 PERFORMANCE OR PROFICIENCY EVALUATIONS

Five of the contract analytical laboratories (GEL, TA, H2M, ARS, and Caltest) participated in several national and state PE testing programs in 2013. Chemtex Lab did not participate in PE testing because there is no testing program for the specific analytes Chemtex analyzed for BNL: 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 DOE required Mixed Analyte Performance Evaluation Program (MAPEP), Resource Technology Corporation (RTC), Phenova, and NYSDOH Environmental Laboratory Accreditation Program (ELAP). The results from these tests are summarized in Section 9.6.1. Because Caltest only analyzed samples for mercury and methyl mercury, their PE results are not summarized.

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, MAPEP, and ELAP programs. GEL, TA, and ARS had average overall satisfactory scores of 97, 92, and 100 percent, respectively. Additional details about the radiological assessments are discussed in Section 9.6.1.1.

Figure 9-3 summarizes the nonradiological performance results of three of the four participating laboratories (GEL, H2M, and TA) in the ERA, RTC, MAPEP, Phenova, and ELAP tests. For nonradiological tests, the average overall satisfactory results ranged from 95 to 98 percent for the three laboratories. Since the fourth laboratory, Caltest, only analyzed mercury samples, its passing proficiency results were not graphed. Additional details on nonradiological evaluations are discussed in Section 9.6.1.2.

9.6.1.1 Radiological Assessments

Since ARS only analyzed tritium in water samples during 2013, only PE results for tritium were reviewed. GEL and TA participated in the ERA and MAPEP radiological PE studies. Of GEL's tests on radiological samples, 97.1 percent were in the Acceptable range and 92.3 percent of TA's tests were Acceptable. TA and ARS participated in the ELAP evaluations; 95.5 percent of TA's ELAP tests on radiological samples were in the Acceptable range and 100 percent of ARS's ELAP test results were in the Acceptable range.

9.6.1.2 Nonradiological Assessments

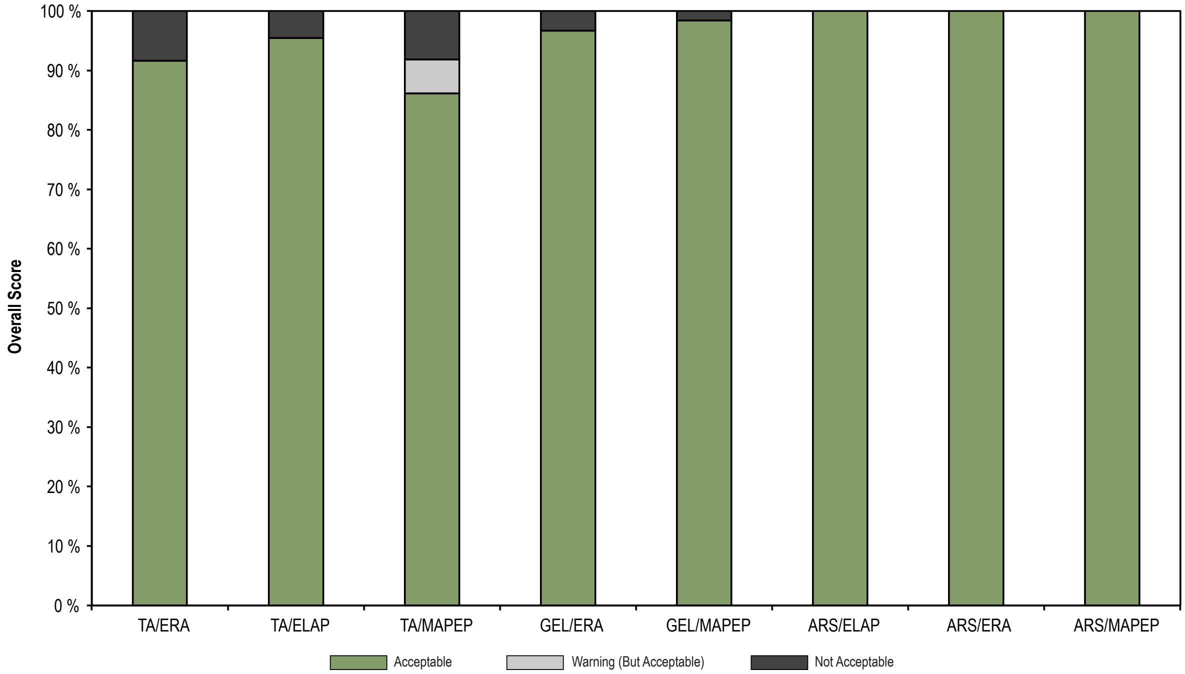
During 2013, H2M and TA participated in the NYSDOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 98.3 percent of H2M's nonradiological tests to be in the Acceptable range and 100 percent of TA's nonradiological tests to be in the Acceptable range. TA and GEL participated in the ERA water supply and water pollution studies. ERA found that 100 percent of TA's tests were in the Acceptable range, as were 95.3 percent of GEL's tests. TA and GEL participated in the MAPEP water supply and water pollution studies. MAPEP found that 97.6 percent of TA's results were in the Acceptable range, while 99.0 percent of GEL's results were in the Acceptable range. TA and GEL participated in the Phenova Soil/Hazardous Waste and Water pollution proficiency testing programs. Phenova found that 98.0 percent of TA's results were in the Acceptable range, while 98.9 percent of GEL's results were in the acceptable range. GEL also participated in RTC nonradiological evaluations, which showed that 93.1 percent of GEL's results were in the Acceptable range.

9.7 AUDITS

As part of DOE's Integrated Contract Procurement Team Program, TA, GEL, and ARS were audited during 2013 (DOE 2013a,b,c). During 2013, BNL conducted its periodic audit of H2M. 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 during 2013 that affected samples analyzed for BNL.

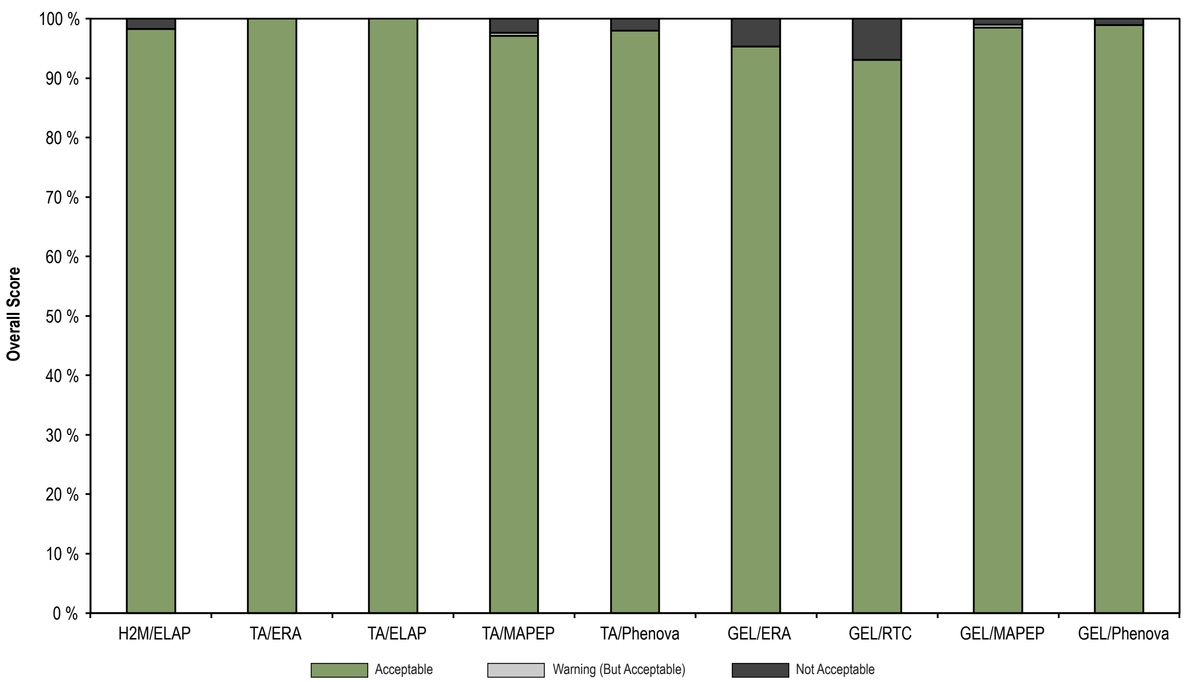
The results of the TA audit included nine Priority II findings. The Priority II findings were in the following departments: five in Quality Assurance Management Systems, one in the Data Quality for Organic Analyses, two in the Inorganic and Wet Chemistry Department, and one in Hazardous and Radioactive Materials Management.

The results of the GEL audit included 11 Priority II findings. The Priority II findings were in the following departments: four in the Quality Assurance Department, four in the Data Quality for Organic Analyses, one in Data Quality for Radiochemistry Analyses, and two in Hazardous and Radioactive Materials Management. All findings from the 2012 audit, including two Priority I findings that did not affect



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs.



Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.

BNL samples, were closed in 2013.

The results of the ARS audit included 11 Priority II findings. The Priority II findings were in the following departments: two Priority II findings in the Quality Assurance Department, six in Data Quality for Radiochemistry Analyses, and three in Hazardous and Radioactive Materials Management.

As part of the BNL quality control process, H2M is periodically audited to assure that their technical and environment, safety, and health programs meet BNL requirements. BNL staff conducted the Audit in September 2013 and issued its final report in October 2013 (BNL 2013b). During the audit, four minor nonconformances were noted. The nonconformances were related to record keeping and housekeeping.

Based on the audits, the analytical laboratories met DOE and BNL 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 2013 Site Environmental Report are of acceptable quality.

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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.

ACTS	DOE Academies Creating Teacher Scientists
AFYs	Alterntaive Fuel Vehicles
AEC	Atomic Energy Commission
AGS	Alternating Gradient Synchrotron
ALARA*	"As Low As Reasonably Achievable"
AMSL	above mean sea level
AMU	atomic mass unit
AOC*	area of concern
APG	Analytical Products Group
ARARs	Applicable, Relevant, and Appropriate Requirements
ARPA*	Archeological Resource Protection Act
ARRA	American Recovery and Reinvestment 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
CCWF	Central Chilled Water Facility
CEDR	Consolidated Energy Data Report
CEGPA	Community, Education, Government and Public Affairs
CERCLA*	Comprehensive Environmental Response, Compensation and Liability Act
Cf-252	californium-252
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
CVO	Contractor Vendor Orientation
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
EBIS	Electron Beam Ion Source
ECM	Energy Conservation Measures
EDB*	ethylene dibromide
EDE*	Effective Dose Equivalent
EDTA	ethylenediaminetetraacetic acid
EE/CA	Engineering Evaluation/Cost Analysis
EE-IOCPA	Energy Employees Occupational Illness Compensation Program Act
EIMS*	Environmental Information Management System
EISA	Energy Independence and Security Act

ELAP	Environmental Laboratory Approval Program
EML	Environmental Measurements Laboratory
EMP	Environmental Monitoring Plan
EMS*	Environmental Management System
EO	Executive Order
EPA*	U.S. Environmental Protection Agency
EPCRA*	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPD	Environmental Protection Division
EPP	Environmentally Preferable Products
ERP	Environmental Restoration Projects
ERA	Environmental Resource Associates
ERD	Environmental Restoration Division
ES*	environmental surveillance
ESPC	Energy Savings Performance Contract
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
FaST	Facility and Student Teams Program
FAMS	Facility area monitors
FEMP	Federal Emergency Management Program
FERN	Foundation for Ecological Research in the Northeast
FFCA*	Federal Facilities Compliance Act
FFA	Federal Facilities Agreement
FHWMF	Former Hazardous Waste Management Facility
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
GHG	Greenhouse Gas
GIS	Geographical Information System
GPG	Groundwater Protection Group
GSF	gross square feet
GWh	gigawatt hour
GWP	Global warming potential
H2M	H2M Labs, Inc.
HEPA	high efficiency particulate air
HFBR	High Flux Beam Reactor
HFCs	Hydrofluorocarbons
HITL	Heavy Ion Transfer Line
HPRS	Health Physics Reporting System
HPSB	High Performance and Sustainable Buildings
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
IGA	Investment Grade Audit
ISB	Interdisciplinary Science Building
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
LISF	Long Island Solar Farm
LSTPD	Laboratory Science Teacher Professional Development
LTRA	Long Term Remedial Action
mA	milli-amperes
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
MEOSI	maximally exposed off-site 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
MPO	Modernization Project Office
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
nm	nanometer
NNSS	Nevada National Security Site
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
NSERC	Northeast Solar Energy Research Center
NSF-ISR	NSF-International Strategic Registrations, Ltd.
NSLS	National Synchrotron Light Source
NSLS-II	National Synchrotron Light Source II
NSPS	new source performance standards
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
OFIs	opportunities for improvement
OHSAS	Occupational Health and Safety Assessment Series
OMC	Occupational Medical Clinic
ORC	oxygen-releasing compound
ORNL	Oak Ridge National Laboratory
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
PFCs	Perfluorocarbons
PIC	potential impact category
ppb	parts per billion
ppm	parts per million
PPTRS	Pollution Prevention Tracking System
PRAP	Proposed Remedial Action Plan
PUE	Power Utilization Effectiveness
PV	photovoltaic
QA*	quality assurance
QAPP	Quality Assurance Program Plan
QC*	quality control
QCU	quantum chromodynamics
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
REC	Renewable Energy Credit
RF	resuspension factor
RHIC	Relativistic Heavy Ion Collider
ROD*	Record of Decision
RPD	relative percent difference
RSB	Research Support Building
RTF	Radiation Therapy Facility

RWMB Radioactive Waste Management Basis
RWP Radiological Work Permit
S&M surveillance and maintenance
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
SSP Site Sustainability Plan
SSPP Strategic Sustainablility Performance Plan
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
TED Total Effective Dose
TEDE Total Effective Dose Equivalent
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
UESC Utility Energy Services Contract
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.

CO_2 equivalent (CO_2e) – The universal unit of measurement to indicate the GWP of each of the six GHGs expressed in terms of the GWP of one unit of CO_2. It is used to evaluate the release (or the avoided release) of different GHG emissions against a common basis, and is commonly expressed as metirc tons carbon dioxide equivalent ($MtCO_2e$), which is calculated by multiplying the metric tons of GHG by its GWP.

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.

greenhouse gas (GHG) – Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

global warming potential (GWP) – A factor describing the ratiative forcing impact of one unti of a given GHG relative to one unti of CO_2.

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.

hydrofluorocarbons (HFCs) – One of six primary GHGs primarily used as refrigerants; a class of gases containing hydrogen, fluorine, and carbon, and possessing a range of GWP values from 12 to 11,700.

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.

perfluorocarbons (PFCs) – One of the six primary GHGs consisting of a class of gases containing carbon and fluorine typically emitted as by-products of industrial and manufacturing processes, and possessing GWPs ranging from 5,700 to 11,900.

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, interlaboratory 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.

Scope 1 emissions – Direct greenhouse gas emissions from sources that are owned or controlled by a Federal agency.

Scope 2 emissions – Indirect greenhouse gas emissions resulting from the generation of electricity, heat, or steam purchased by a Federal agency.

Scope 3 emissions – Greenhouse gas emissions from sources not owned or directly controlled by a Federal agency, but related to agency activities such as vendor supply chains, delivery services, and employee travel and commuting.

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**).

sulfur hexafluoride (SF_6) – One of six primary GHGs, consisting of a single sulfur atom and six fluoride atoms, a GWP of 23,900, and primarily used in electrical transmission and distribution systems.

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

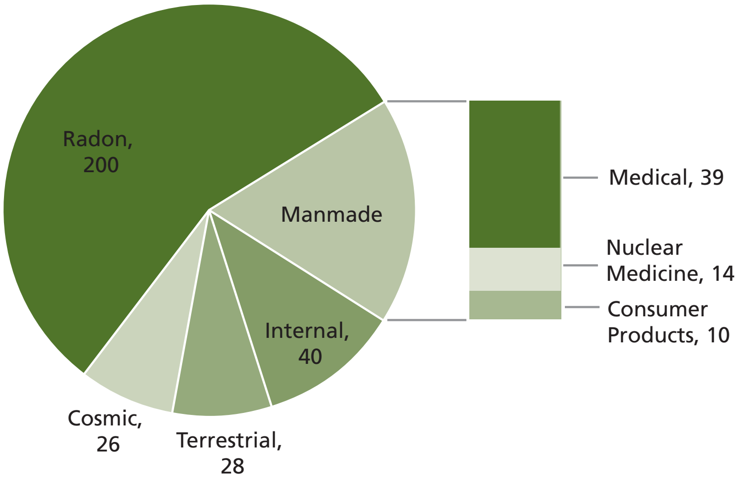

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 93 (NCRP 1987)*

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 (man-made) radiation include consumer products such as static eliminators (containing polonium-210), smoke detectors (containing americium-241), cardiac pacemakers (containing plutonium-238), fertilizers (containing isotopes 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.

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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 x 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 x 10^{12}	1,000,000,000,000	E+12	Tera-	T
1 x 10^{9}	1,000,000,000	E+9	giga-	G
1 x 10^{3}	1,000	E+03	kilo-	k
1 x 10^{-2}	0.01	E-02	centi-	c
1 x 10^{-3}	0.001	E-03	milli-	m
1 x 10^{-6}	0.000001	E-06	micro-	µ
1 x 10^{-9}	0.000000001	E-09	nano-	n
1 x 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

Federal, State, and Local Laws and Regulations Pertinent to BNL

DOE DIRECTIVES, REGULATIONS, AND STANDARDS

DOE O 231.1B	Order: Environment, Safety and Health Reporting 06/27/2011
DOE O 414.1D	Order: Quality Assurance 08/16/2001
DOE O 435.1	Order: Change 1: Radioactive Waste Management 07/09/1999
DOE P 450.5	Policy: Line Environment, Safety, and Health Oversight 06/26/1997
DOE O 458.1	Order: Radiation Protection of the Public and the Environment 02/11/2011
DOE O 436.1	Order: Departmental Sustainability 05/02/2011

FEDERAL LAWS AND REGULATIONS

EO 13148	Greening of the Government Through Leadership in Environmental Management
EO 13423	Strengthening Federal Environmental, Energy and Transportation Management
EO 13514	Federal leadership in Environmental, Energy, and Economic Performance
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


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