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2017 Site Environmental Report

J. Remien,

October 2018

Environmental Protection Division
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Health, Safety and Security (HSS), Environmental Protection, Sustainability Support Corporate Safety Analysis (HS-20)

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BROOKHAVEN NATIONAL LABORATORY

Site Environmental Report 2017

VOLUME 1

Found mainly east of the Great Plains, and the East Coast's most common hummingbird, the Ruby-throated Hummingbird *(Archilochus colubris)* can be seen in the summer months in such habitats as woodland edges and gardens, as well as visiting hummingbird feeders, hanging plants, and feeders on porches. The Eastern United States' only breeding hummingbird, this species is known for its vast, non-stop track across the Gulf of Mexico to reach Central America, a trip it makes in the early fall each year.

This hummingbird measures in length from seven to nine cm (2.8 to 3.5 in) long and has wingspan of eight to 11 cm (3.1 to 4.3 cm). The females average slightly larger than the males, with adult males showcasing an emerald green back, near-black wings, a greyish-white belly, and of course an irridescent red throat (also known as a gorget). The male's tail is forked with no white. The females also sport an emerald green back, mostly white breast and throat, and rounded tail with white tips. The female's bill is longer than the male's.

Ruby-throats are known to be inquisitive and so can be seen swooping down to investigate backyard feeders, planters, and other potential sources of food, such as red objects which they find attractive (like the red and orange flowers they prefer to feed on and which they can see due to their good color vision). They also feed on small flying insects and spiders. Male red-throats are aggressively territorial and can often be seen guarding their territory by perching nearby or chasing intruders.

This bird has extremely short legs which prevent it from walking or hopping—in fact, its taxonomic order, Apodiformes, means "without feet"—which is how the bird often looks! [1]

At Brookhaven National Laboratory, this species is routinely documented along the western edge of the northern solar array of the Long Island Solar Farm. It is known to nest in the area and makes its nest using a variety of materials including thistle or dandelion seeds held together with spider silk; it hides its nest using hidden pieces of lichens and/or moss.The female lays one to three eggs and incubates them for about two weeks. Nestlings fledge in about three weeks after hatching. The adults may produce one or two broods each summer. [1]

[1] The Cornell Lab of Ornithology

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2017

SITE ENVIRONMENTAL REPORT

BROOKHAVEN NATIONAL LABORATORY

Volume I

October 2018

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Executive Summary

Brookhaven National Laboratory (BNL) is managed on behalf of the Department of Energy (DOE) by Brookhaven Science Associates (BSA), a partnership between the Research Foundation for the State University of New York on behalf of Stony Brook University and Battelle. For almost 70 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 (ESSH) Policy reflects the commitment of BNL's management to fully integrate environmental stewardship into all facets of its mission and operations.

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

Volume II of the SER, the Groundwater Status Report, also is prepared annually to report on the status of groundwater protection and restoration efforts.Volume II includes detailed technical summaries of groundwater data and treatment system operations and is intended for 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 https://www.bnl.gov/esh/env/ser/.

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 (ES&H) 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 Health and Safety 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 fully 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 the ESSH Policy. The policy makes clear the Laboratory's commitment 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. 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 DOE Office of Science Laboratory to become officially registered to this standard. BNL was also the first 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 2017, EMS assessments determined that BNL remains in conformance with the ISO 14001: 2004 Standard.

Executive Order 13639, *Planning for Federal Sustainability in the Next Decade*, establishes goals for federal agencies and focuses on greenhouse gas (GHG) reduction across the government. In addition to guidance, recommendations, and plans, which must be prepared by specific due dates, EO 13693 has set numerical targets for agencies. DOE Order 436.1, *Departmental Sustainability,* provides requirements and responsibilities for managing sustainability within DOE to ensure facilities are working towards sustainability goals established in its Strategic Sustainability Performance Plan (SSPP) pursuant to EO 13639. Each DOE facility is required to have a Site Sustainability Plan (SSP) in place detailing the strategy for achieving these long-term goals and due dates and to provide an annual status. The requirements influence the future of the Laboratory's EMS program and have been incorporated into BNL's SSP.

The Laboratory's Pollution Prevention (P2) Program is an essential element for the successful implementation of BNL's EMS. The P2 Program reflects the national and DOE pollution prevention goals and policies and represents an ongoing effort to make pollution prevention and waste minimization an integral part of the Laboratory's operating philosophy. Pollution prevention and waste reduction goals have been incorporated as performance measures into the DOE contract with BSA and into BNL's ESSH Policy. The overall goal of the P2 Program is to create a systems approach that integrates pollution prevention and waste minimization, resource conservation, recycling, and affirmative procurement into all planning and decision making.

The implementation of pollution prevention opportunities, recycling programs, and conservation initiatives continues to reduce both waste volumes and management costs. In 2017, these efforts resulted in nearly $3.5 million in cost avoidance or savings and approximately 9.3 million pounds of materials being reduced, recycled, or reused annually. Chapter 2 of this report describes the elements and implementation of BNL's EMS and P2 Program.

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 2017 is provided below.

COMPLIANCE MONITORING PROGRAM

BNL has an extensive program in place to ensure compliance with all applicable 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 2017, the Laboratory operated in compliance with most of the requirements, and any instance of noncompliance was reported to regulatory agencies and corrected expeditiously.

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility were all well within permit limits in 2017. There were two recorded excess opacity measurements due to unknown causes, five due to a temporary failure of the transmissometer blower motor, and a single excess opacity reading that occurred during quarterly quality assurance tests of the Boiler 6 and 7 opacity monitors. All of the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to the New York State Department of Environmental Conservation (NYSDEC).

In 2017, 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 part of an ongoing program to phase out the use of chlorofluorocarbons as extinguishing agents. Monitoring of BNL's potable water system indicated that all drinking water requirements were met during 2017. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System permit requirements. Only two excursions above permit limits were reported for the year: one non-compliance event for Biological Oxygen Demand (BOD5) occurred at the Sewage Treatment Plant, and one non-compliance event was reported for a 1-Hydroxyethylidene-1, 1-diphosphonic acid (HEDP) at Outfall 002 (HN). The permit excursions were reported to NYSDEC and the Suffolk County Department of Health Services and corrective measures were taken. Groundwater monitoring at the Laboratory's Major Petroleum Facility, Sewage Treatment Plant, and Waste Management Facility continued continued to demonstrate that current operations at these facilities were not affecting groundwater quality. Efforts to minimize impacts of spills of materials continued in 2017. There were 21 spills and 11 of those spills met regulatory agency reporting criteria. The severity of releases were minor and all releases were cleaned up to the satisfaction of NYSDEC.

BNL participated in ten environmental inspections or reviews by external regulatory agencies in 2017. These inspections included Sewage Treatment Plant operations; hazardous waste management facilities; regulated petroleum bulk storage facilities; and the potable water system. Immediate corrective actions were taken to address all issues raised during these inspections.

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs during 2017 and participated as an observer of the BSA Multi-Topic Assessment of BNL's environmental protection programs. BHSO participation comprised of observing BSA's scoping, assessment conduct, and reporting. BHSO also performed a surveillance of Groundwater Treatment System Carbon Replacement at the Operable Unit IV Ethylene Dibromide treatment system. No findings were identified and all operations were observed to be conducted in a safe and environmentally sound manner. 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 its site to ensure compliance with the requirements of the Clean Air Act. Environmental Protection Agency (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 2017, Laboratory facilities released a total of 10,660 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 99.99 percent of radiological air emissions on site.

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 2017 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 non-radiological 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. In 2017, emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the CSF were all well within permit limits.

In 2017, residual fuel prices exceeded those of natural gas for most of the year. As a result, natural gas was used to supply 98.3 percent of the heating and cooling needs of BNL's major facilities. By comparison, in 2009, residual fuel satisfied 42.6 percent of the major facility heating and cooling needs. Consequently, 2017 emissions of particulates, NOx, and sulfur dioxide (SO2) were 6.7, 25.2, and 43.2 tons less than the respective totals for 2009, when No. 6 oil was used to supply a much higher percent of site 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

Wastewater generated from BNL operations is treated at the Sewage Treatment Plant (STP) before it is discharged to nearby groundwater 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.

In 2017, 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 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. Non-radiological 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.

Stormwater and cooling water 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 2017, the average concentrations of gross alpha and beta activity in stormwater and cooling water discharged to recharge basins were within typical ranges and no gamma-emitting radionuclides were detected. Disinfection byproducts continue to be detected in the discharges at concentrations just above the method detection limit 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 runoff in stormwater discharges.

With the exception of the most upstream sampling location (Station HY), the onsite portions of the Peconic River were dry throughout 2017 due to drought conditions. When available, radiological data from Peconic River surface water sampling show that the average concentrations of gross alpha and gross beta activity from on-site locations (one sample) were indistinguishable from off-site and control locations, and all detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected, and tritium was not detected above method detection limits in any of the samples. Samples collected upstream, downstream, and at control locations demonstrated that elevated amounts of aluminum and iron 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.

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 one mile of the Laboratory contain higher concentrations of cesium-137 (Cs-137) than deer sampled from more than one 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. In 2017, Cs-137 concentrations in deer meat samples were obtained from two deer on site with a range of values from 1.16 pCi/g, wet weight, to 1.34 pCi/g, wet weight, and an arithmetic average of 1.25 pCi/g, wet weight. The wet weight concentration is before a sample is dried for analysis and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values.

The highest on-site sample in 2017 (1.34 pCi/g, wet weight) was about 21 percent lower than the highest on-site sample reported in 2016 (1.69 pCi/g, wet weight) and nearly nine 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 one mile of BNL (ten samples) and samples taken farther away (six samples).

Concentrations in meat samples taken within one mile ranged from 0.06 pCi/g, wet weight to 3.33 pCi/g, wet weight, with an arithmetic average of 1.15 pCi/g, wet weight. Because deer on site may routinely travel up to one mile off site, the arithmetic average for deer taken on site and within one mile of the Laboratory is also calculated; for 2017, this was 1.17 pCi/g, wet weight. The six deer sampled from greater than one mile from BNL had Cs-137 concentrations ranging between 0.02 pCi/g, wet weight, to 2.91 pCi/g, wet weight, with an arithmetic average of 0.67 pCi/g, wet weight.

BNL has periodically conducted population reductions of the white-tailed deer on-site. In 2017, population reductions resulted in the removal of 202 animals. The meat provided by these animals was donated to food pantries. Prior to release, the meat is tested for Cs-137 content. All samples was below BNL administrative release criteria of 1.0 pCi/g, wet weight. The average content was 0.26 pCi/g, wet weight.

During 2017, grassy vegetation samples were collected from 12 locations around the Laboratory and a control location at the NYSDEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137. Cs-137 content in vegetation ranged from non-detectable to 10.00 pCi/g, wet weight. Only one of the 12 samples and the control location sample had detectable levels of Cs-137. All values were consistent with historic monitoring. 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 12 locations where the grassy vegetation was collected and analyzed for Cs-137. The area is known to have residual Cs-137 levels below 23 pCi/g, dry weight in soils. This is confirmed as the associated soil contained a concentration of 10.8 pCi/g, dry weight of cesium. Other soil samples had Cs-137 levels from non-detect to 4.31 pCi/g, dry weight. These values were also consistent with past soil monitoring results.

During 2017, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 and analyzed for total mercury. Historically and through 2015, BNL analyzed precipitation for radiological content. However, with no emissions of significantly long-lived radionuclides from Laboratory operations, the monitoring program objectives were modified to remove testing of precipitation for radiological content beginning in 2016. Mercury concentrations in

precipitation have been measured at BNL since 2007. 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 distribution of mercury within the Peconic River watershed. Mercury was detected in all of the precipitation samples collected at both sampling stations. Mercury ranged from 2.07 ng/L at station S5 in January to 45.1 ng/L at station P4 in July. The 45.1 ng/L concentration is nearly two times higher than the previous high value of 24.6 ng/L, recorded in 2013.

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 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 2017, BNL hosted 17 student interns and two faculty members within the Natural Resources program (two during the spring, two during the fall, and the remaining 13 during the summer). Two interns worked with a faculty member from the Statue University of New York at Westbury; two interns worked with a faculty member from Hofstra University as part of the BNL Visiting Faculty Program (VFP); three interns worked under a faculty member from Southern University of New Orleans; and 12 interns participated in research associated with various projects including several related to the Long Island Solar Farm (LISF), turtles, and pollinators.

The VFP team from Hofstra University continued a second year of gathering basic information on small mammals, tick loads, and the incidence of Lyme disease in the ticks. This work is being done in preparation for coyotes *(Canis latrans)* migrating to Long Island. Once established, coyotes are expected to alter ecosystems due to competition with other carnivores.

Work associated with the LISF involved tracking 20 eastern box turtles outfitted with transmitters to determine home range sizes. Many of the turtles were captured in or near the LISF to determine if they utilize habitats found in the facility. Interns also conducted surveys in and around the LISF to study the relationship and impacts of this facility on the local ecosystem. Since 2011, interns have followed a total of 42 turtles; as a result, BNL is building a thorough understanding of their habits. For a detailed description of this and other student-led research projects, see Chapter 6, Section 6.5 Wildlife Programs.

BNL utilizes prescribed fire as part of its forest management. To accurately develop burn plans, data on vegetation and fuel loads is necessary. In 2017, summer interns worked to collect and analyze fuel loads within current and planned burn units. Three growing season fires were conducted and fire effects monitoring on vegetation are planned for 2018.

In 2017, BNL continued to participate in several events in support of ecological education programs on Long Island. On separate days, over 30 partner organizations and agencies, over 40 schools, and over 2,400 students collected scientific information for analysis to be used to portray the status of the rivers and estuary systems. These events provide students hands-on experience with field techniques in catching fish, invertebrate sampling, biodiversity inventory, and water chemistry. In addition, BNL is in the 13th year of the Open Space Stewardship Program (OSSP) and worked with 30 schools and over 3,000 students in 2017. The OSSP enables students to engage in activities to solve problems within their local community through scientific discovery, conservation, and stewardship. Participation in OSSP creates an opportunity for many students to enhance their educational experiences as well as to promote the realization that a career in science and technology is accessible with the proper academic coursework and interaction with teachers and field experts who have a passion for discovery and mentorship.

The Laboratory also hosts 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 that includes the use of prescribed fire for fuel and forest management and worked with NYSDEC to conduct three growing season fires in northern and eastern sections of the BNL property. These first three successful fires provided significant experience and training for fire crews working in Pine Barrens habitat, improving capabilities of these crews to conduct and manage fire within the Long Island Central Pine Barrens. 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 25 years and continues to make progress in achieving its goal of preventing new groundwater impacts and remediating previously contaminated groundwater. he Laboratory's extensive groundwater monitoring well network is used to evaluate progress in restoring groundwater quality, comply with regulatory permit requirements, and monitor active research and support facilities where there is a potential for environmental impact.

During 2017, several Per- and Polyfluoroalkyl Substances (PFAS) were detected in water samples collected from three BNL water supply wells. The Suffolk County Department of Health Services conducted the analyses as part of the Safe Drinking Water Act program known as the Third Unregulated Contaminant Monitoring Rule (UCMR3). Preliminary assessment of possible sources for the PFAS contaminants indicates that they were related to the historical use of firefighting foam at the BNL site. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

Groundwater quality at BNL is routinely monitored through a network of approximately 650 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 of the wells to assess variations in the direction and velocity of groundwater flow.

During 2017, the Facility Monitoring program monitored 93 permanent wells during 121 individual sampling events. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) groundwater monitoring program monitored 558 permanent wells during 1,309 individual groundwater sampling events. Twenty-seven temporary wells were also installed as part of the CERCLA program.

During 2017, the North Street Treatment System, North Street East Treatment System, Operable Unit I South Boundary Treatment System, and the High Flux Beam Reactor Tritium Pump and Recharge System remained in standby mode because they met their active remediation goals for reduction of contaminant concentrations. The Building 452 Freon-11 Groundwater Treatment System, which had been placed in standby mode in March 2016, was reactivated in November 2016 due to a short-term rebound in Freon-11 concentrations. The system was returned to standby mode in March 2017. A period of standby monitoring for the plumes associated with these treatment systems will be performed to detect any rebound of contaminant concentrations.

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 and remediation performed in 2017.

RADIOLOGICAL DOSE ASSESSMENT PROGRAM

The Laboratory routinely reviews its operations to ensure that any potential radiological dose to members of the public, workers, and the environment is "As Low As Reasonably Achievable" (ALARA). 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). 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 2017, the total effective dose (TED) of 5.61 mrem (56 μSv) from Laboratory operations was well below the EPA and DOE regulatory dose limits for the public, workers, and the environment.

To measure direct radiation from Laboratory

operations, 54 on-site thermo-luminescent dosimeters (TLDs) and 16 off-site TLDs were deployed and showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level. An additional nine TLDs were used to measure on-site areas known to have radiation dose slightly above the natural background radiation.

Dose to aquatic and terrestrial biota were also evaluated and found to be well below DOE regulatory limits. In summary, the overall dose impact from all Laboratory activities in 2017 was comparable to that of natural background radiation levels.

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, of high quality, and meet quality assurance and quality control objectives. Samples are collected and analyzed in accordance with EPA methods and BNL 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 2017, the Laboratory used five off-site contract analytical laboratories to analyze environmental samples. All analytical laboratories were certified by the New York State Department of Health for the tests they performed for BNL and were subject to oversight that included state and national performance evaluation 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.

2017 SITE ENVIRONMENTAL REPORT TEAM

The SER Team thanks the many Lab employees who contributed to and assisted with this report.

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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 *https://www.bnl.gov/esh/env/ser/.*

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1 Introduction

Established in 1947, Brookhaven National Laboratory (BNL) is one of ten national laboratories overseen and primarily funded by the U.S. Department of Energy's (DOE) Office of Science. The only multi-program national laboratory in the Northeast, the Laboratory is operated and managed by Brookhaven Science Associates (BSA), which was founded by the Research Foundation for the State University of New York on behalf of Stony Brook University, and Battelle, a non-profit applied science and technology organization. BNL is committed to longstanding partnerships with researchers, academic institutions, industry, students, teachers, and the surrounding community.

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 and after World War I and from 1940 to 1946 during World War II.

BNL has a history of outstanding scientific achievements. For over 70 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 AND POLICY

BNL advances fundamental research in nuclear and particle physics to gain a deeper understanding of matter, energy, space, and time; applies photon sciences and nanomaterials research to solve energy challenges of critical importance to the Nation; provides capabilities in computational science and data management for large-scale research and experimental endeavors; and performs cross-disciplinary research on computation, sustainable energy, national security, and earth's climate and ecosytems.

The fundamental elements of the Laboratory's role in support of DOE's strategic missions are the following:

- To conceive, design, construct, and operate complex, leading-edge, user-oriented research facilities in response to the needs of DOE and the international community of users.
- To carry out basic and applied research in long-term, high-risk programs at the frontier of science.
- To develop advanced technologies that address national needs and transfer them to other organizations and the commercial sector.
- To disseminate technical knowledge, educate future generations of scientists and engineers, maintain technical capabilities in the nation's workforce, and encourage scientific awareness in the general public.

Brookhaven produces transformative science and advanced technologies, and does it safely, securely, and environmentally responsibly, with the cooperation and involvement of the local, state, and international scientific communities. BNL's Environmental, Safety, Security, and Health (ESSH) Policy states 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; and maintain an open, proactive, and constructive relationship with employees, neighbors, regulators, DOE, and other stakeholders.

In 2001, BNL was the first DOE Office of Science National Laboratory to achieve full registration under the 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 discussed in Chapter 2 of this report.

1.2 RESEARCH AND DISCOVERIES

The Laboratory operates cutting-edge large-scale facilities for studies 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. The Laboratory integrates sustainable operations and environmental stewardship into all facets of its research and operations and is committed to managing its programs in a manner that protects the local ecosystem and public health.

Current research includes energy security to help address the world's need for new, more efficient, and sustainable energy sources powered by solar, wind, hydrogen, and other renewable sources; photon sciences, focusing ultra-bright light to reveal the structures of materials critically important to biology, technology, and more; quantum chromodynamics, using colliding subatomic particles to recreate matter from the dawn of time, and study the source that gives shape to visible matter in the universe today; physics of the universe, to explore cosmic mysteries across the smallest and largest scales, from neutrinos to dark energy; and climate, environment, and biosciences, to map climate change, greenhouse gas emissions, and plant biology to protect the planet's future. In addition to major research activities, the Laboratory provides expertise and smaller programs in a range of areas including accelerator science and technology, biological imaging, homeland and national security, and advanced computation.

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 programs 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. The 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. In operation from 1950 to 1968, the reactor's primary mission was to produce neutrons for scientific experimentation and to refine reactor technology. Decommissioning of the BGRR was completed in June 2012, and the remaining structures are currently undergoing long-term routine inspection and surveillance.

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. The HFBR also allowed researchers to study the basic nature of chemical structures, including the hydrogen

bond that holds much of our world together. 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.

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. 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) has been in operation since 1972. Positioned at the forefront of research into radioisotopes used in cancer treatment and diagnosis, the BLIP produces commercially unavailable radioisotopes for use by the medical community and related industries. BLIP consists of an accelerator beam line and target area for generating radioisotopes already in high demand and for developing those required at the frontiers of nuclear medicine. In conjunction with this mission, scientists also perform irradiations for non-isotope applications and explore opportunities for emerging radioisotope applications.

High-energy particle physics research at BNL began in 1952 with the Cosmotron, the first particle accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Nobel Prize in 1957. After 14 years of service, the Cosmotron ceased operation in 1966 and was dismantled in 1969. Knowledge gained from the Cosmotron led to design improvements and paved the way for construction of the Alternating Gradient Synchrotron (AGS). The AGS is a much larger particle accelerator and 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. 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 large electrostatic accelerator can provide researchers with beams of more than 40 different types of ions ranging from hydrogen to uranium. By simulating the effects of radiation both in space and on the ground, scientists and engineers from several other laboratories and companies are improving the reliability of computers.

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. By smashing particles together to recreate the conditions of the early universe, scientists can explore the most fundamental building blocks of matter as they existed just after the Big Bang. This research unlocks secrets of the force that holds together 99 percent of the visible universe—everything from stars to planets and people—and triggers advances in science and technology that have applications in fields from medicine to national security. Planned upgrades to RHIC will expand the facility's research capabilities. The first upgrade, RHIC II, is complete, and will increase the collider's

Researchers in biology, chemistry, physics, and medicine together with applied mathematicians and computer scientists—from Brookhaven, Stony Brook University, Columbia University, and other collaborating institutions—use these tools to address questions in computational biology, nanoscience, sustainable energy, environmental science, and homeland security.

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 consisting of the following:

- 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 groundwater recharge beds, similar to the operations of a municipal sewage treatment plant. The plant has a design capacity of three million gallons per day. Effluent is monitored and controlled under a permit issued by the New York State Department of Environmental Conservation.
- *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 five million gallons per day. Potable water is obtained from five on-site wells. Water pumped from three supply wells located in the western section 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 are at or below New York State drinking water standards. Water from two supply wells located in the eastern section of the developed site is 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

collision rates as well as improve the sensitivity of the large detectors it uses. A current accelerator upgrade is the Low-Energy RHIC Electron Cooling Project, which is in commissioning.

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 to simulate space radiation and study the effects on biological specimens, such as cells, tissues, and DNA, as well as industrial materials. Studies are conducted to identify materials and methods that would reduce the risks astronauts will face on future long-term space missions.

The National Synchrotron Light Source (NSLS) used 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. Using beams of very intense light in the x-ray, ultraviolet, and infrared spectra, the NSLS allowed scientists to study the structure of proteins, investigate the properties of new materials, and understand the fate of chemicals in the environment. Although the NSLS had been continually updated since its commissioning in 1982, the practical limits of its performance had been reached and operations permanently ceased in September 2014.

To continue advances in these fields, the NSLS-II was constructed. The NSLS-II generates intense beams of x-ray, ultraviolet, and infrared light and offers an array of sophisticated imaging techniques to capture atomic-level "pictures" of a wide variety of materials, from biological molecules to semiconductor devices. NSLS-II has a nanometer-scale resolution—a key resource for researchers at BNL's Center for Fundamental Nanomaterials (CFN)--that will enhance the development of next-generation sustainable energy technologies and improve imaging of complex protein structures.

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.

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 is a focal point of the Northeast Solar Energy Research Center at BNL.

BNL's CFN is one of five Nanoscale Science Research Centers funded by DOE's Office of Science and provides state-of-the-art tools for creating and exploring the properties of materials with dimensions spanning just billionths of a meter. CFN scientists are dedicated to atomic-level tailoring that addresses a wide range of energy challenges. CFN focus areas include: improving solar cells and other electronic nanomaterials; designing more efficient catalysts; developing new capabilities and uses for electron microscopy; and nanofabrication based on soft and biological nanomaterials—all aided by theory and advanced computation. 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.

The Computational Science Center (CSC), established in 2016, houses two supercomputers with collectively more than 45,000 core processors and a suite of tools developed specifically for interactive visual and statistical data analysis.

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. Tandem to Booster (TTB)
7. Interdisciplinary Science Building (ISB)
8. Center for Functional Nanomaterials (CFN)
9. National Synchrotron Light Source II (NSLS-II)
10. Computational Science Initiative
11. Tandem Van de Graaff and Cyclotron
12. Accelerator Test Facilities (ATF)
13. ATF-II
14. Medical Isotope Research Laboratories

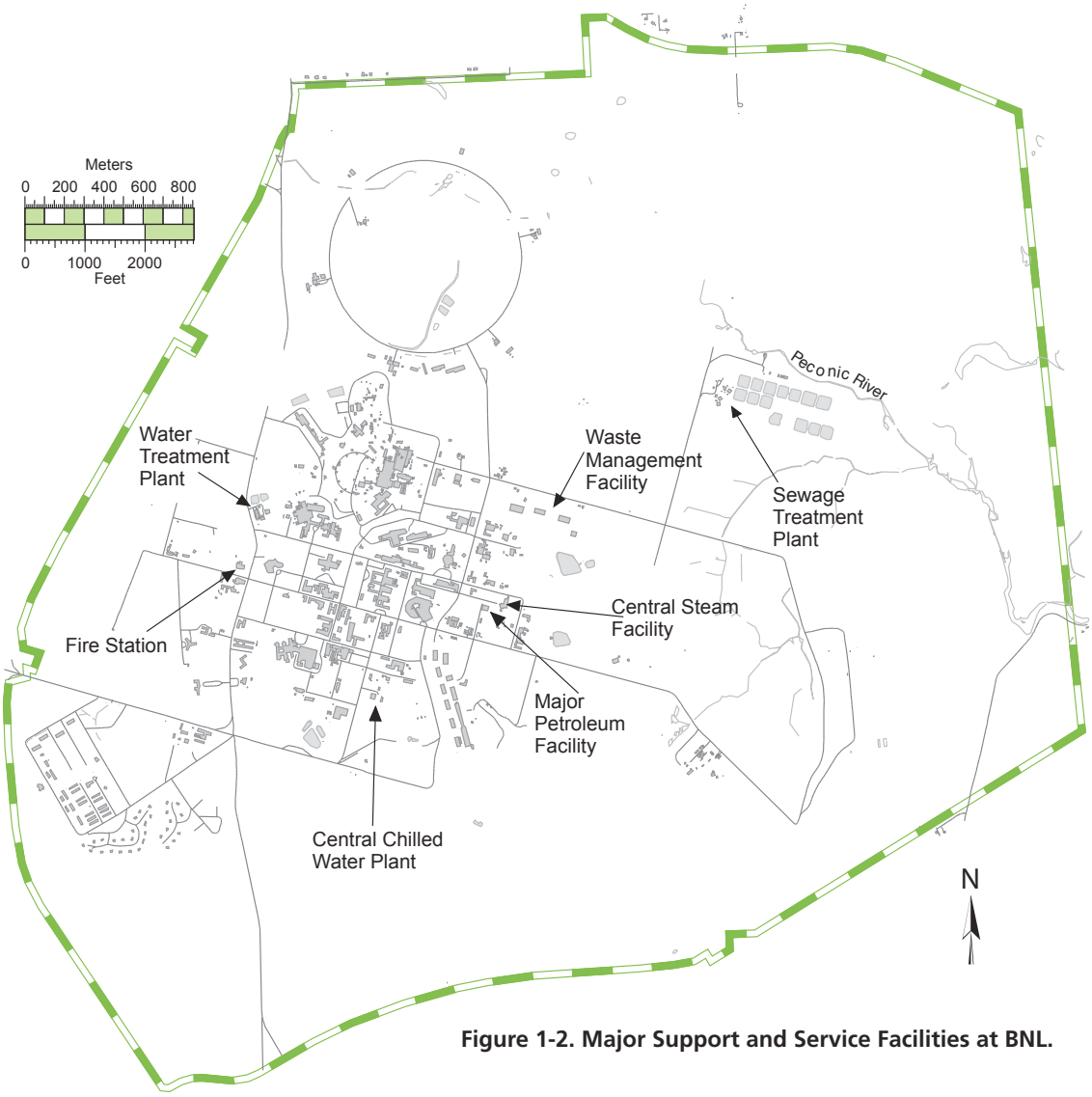


Figure 1-2. Major Support and Service Facilities at BNL.

control bacteria. BNL's potable water met all drinking water standards in 2017.

Past operations and research at the BNL site, dating back to the early 1940s when it was Camp Upton, have resulted in localized environmental contamination. As a result, the Laboratory was added to the federal Comprehensive Environmental Response, Compensation and Liability Act 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

Brookhaven Lab is the only national laboratory located in the Northeast and one of New

York State's largest centers of scientific research, and places special emphasis on growing the technology-based elements of the Long Island economy. The future competitiveness of New York's economy depends on its capacity for innovation, and Brookhaven represents a uniquely valuable resource—both as a major science-based enterprise in its own right, and as a source of discoveries that drive entrepreneurs and innovators.

BNL is located near the geographical center of Suffolk County, Long Island, New York. The Laboratory's 5,320-acre site is located in Brookhaven Town, approximately 65 miles east of midtown Manhattan. Brookhaven Lab employs 2,555 employees who include scientists, engineers, technicians, and support staff. In addition, the Laboratory annually hosts almost 5,000 visiting scientists and students from universities, industries, and government agencies, who often stay in apartments and dormitories onsite or in nearby communities.

BNL strengthens Long Island's position as a center of innovation in energy, materials sciences, nanotechnology, and other fields crucial to the growth of New York State's economy.

With a budget of more than $582 million in 2017, the Laboratory had a significant economic impact on New York State. Employee salaries, wages, and fringe benefits accounted for more than $383 million, or 66 percent of its total fiscal year budget. Supporting local and state businesses whenever possible, BNL spent more than $180 million in 2017 on goods and services, $13.5 million of that with Long Island companies.

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 Labo- ratory indicate that the uppermost Pleistocene deposits, composed of highly permeable glacial sands and gravel, are between 120 and 250 feet thick (Warren et al., 1968; Scorca et al., 1999). Water penetrates these deposits readily and there is little direct runoff into surface streams unless precipitation is intense. The sandy deposits store large quantities of water in the Upper Glacial aquifer. On average, 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 & McClymonds, 1972; Aronson & 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 onsite contributes to deep-flow recharge has been confirmed using 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 U.S. Environmental Protection Agency.

The Laboratory's five in-service drinking water wells draw up to 1,000 gallons per minute, or approximately 1.34 million gallons of water per day from the aquifer to supply drinking water, process cooling water, or fire protection. This water is treated to remove contaminants and is then returned to the aquifer by way of recharge basins or injection wells. In 2017,

approximately 390 million gallons of water were pumped for use on site.

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, Suffolk County, New York, 1994-97 (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.

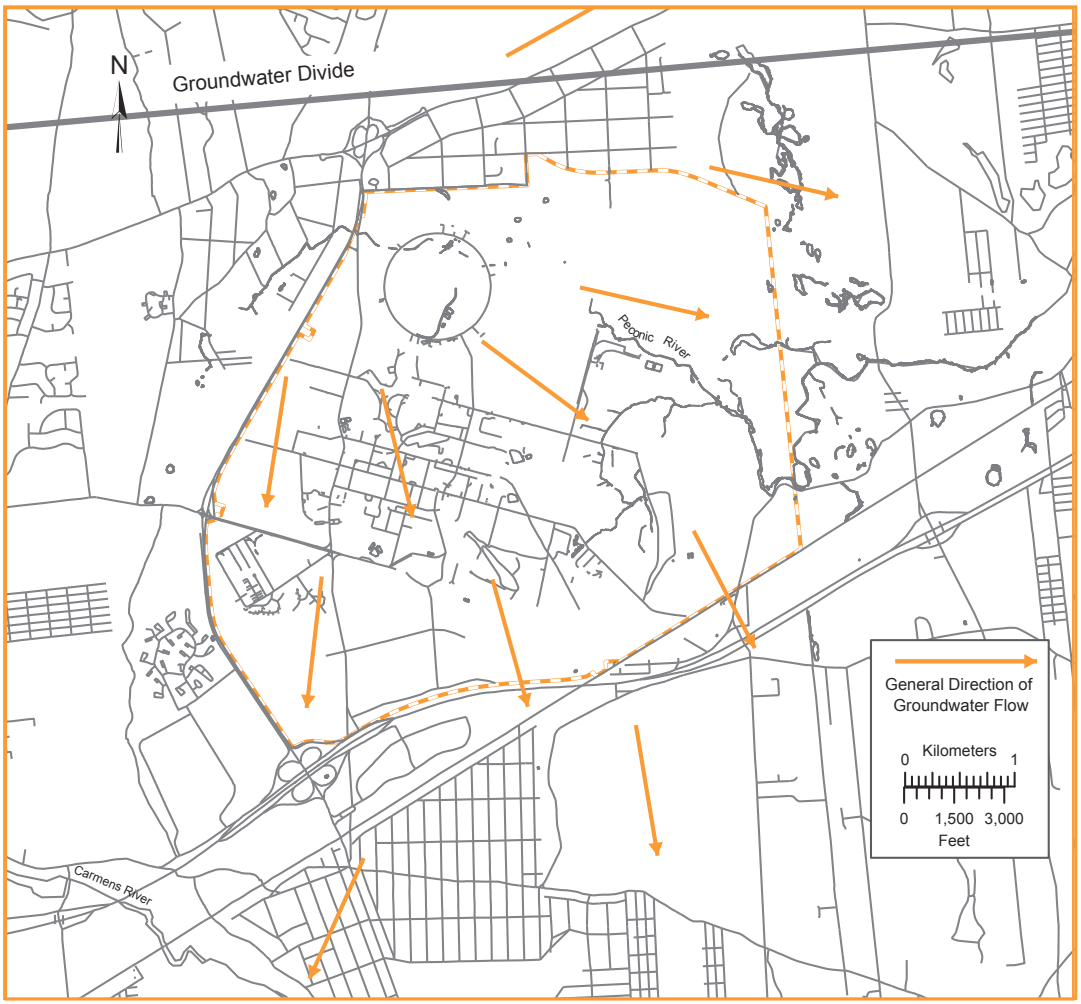


Figure 1-3. BNL Groundwater Flow Map.

1.7 CLIMATE

Meteorological Services (MET Services) at BNL has been recording on-site weather data since August 1948. MET Services is responsible for the maintenance, calibration, data collection, and data archiving for the weather instrumentation network at BNL. Measurements include wind speed, wind direction, temperature, rainfall, barometric pressure, and relative humidity.

The Laboratory is broadly influenced by continental and maritime weather systems. Locally, the Long Island Sound, Atlantic Ocean, and associated bays influence wind directions and humidity and provide a moderating influence on extreme summer and winter temperatures. The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from those two directions during the spring and fall (Nagle 1975, 1978). Figure 1-4 shows the 2017 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 yearly temperature for this area of Long Island was 51.95 °F. The coolest month of the year, January, had a monthly average temperature of 34.6ºF while the warmest month of the year, July, had a monthly average temperature of 71.9ºF. Figures 1-5 and 1-6 show the 2017 monthly mean temperatures and the historical annual mean temperatures, respectively. The total annual precipitation in 2017 was 50.35 inches. Figures 1-7 and 1-8 show the 2017 monthly and the 65-year annual precipitation data. The yearly total snowfall for 2017 was 45.4 inches, well above the 32.94 inches average yearly snowfall for this area of Long Island.

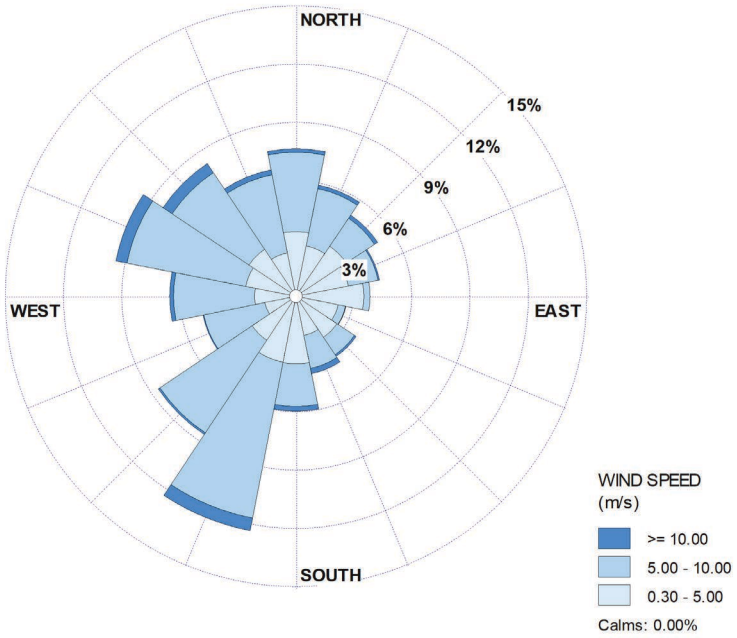
1.8 NATURAL RESOURCES

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

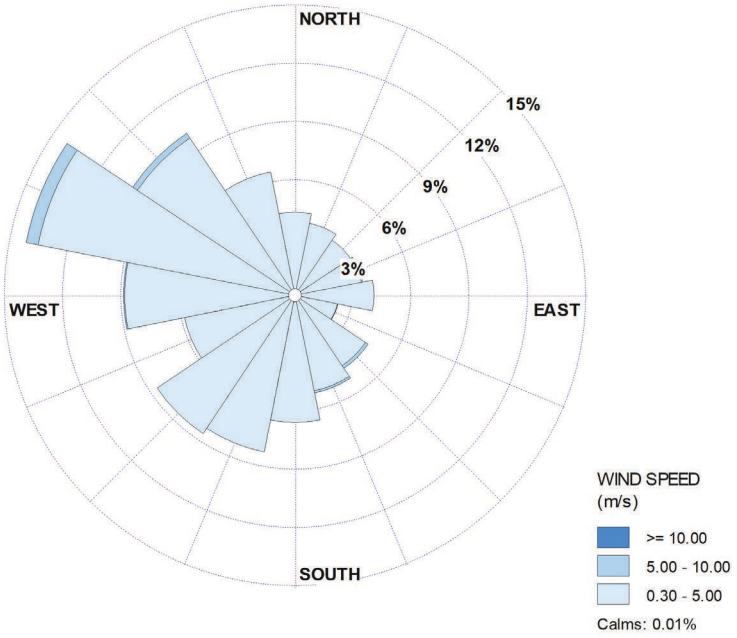
Vegetation on site is in various stages of succession, which reflects a history of disturbances to the area. For example, when Camp Upton was constructed in 1917, the site was entirely cleared of its native pines and oaks. Although portions of the site were replanted in the 1930s, portions were cleared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

More than 350 plant, 30 mammal, 131 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 (ten 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



Wind Rose for Jan 1st to Dec 31st 2017 taken at the 85m height



Wind Rose for Jan 1st to Dec 31st 2017 taken at the 10m height

Explanation: Wind direction was measured at heights of 10 (bottom) and 85 (top) meters above the ground. 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 7 percent of the time. The predominant wind direction in 2017 was from the northwest at the 10-m level, and from the southwest at the 85-m level.

Figure 1-4. BNL Wind Rose (2017).

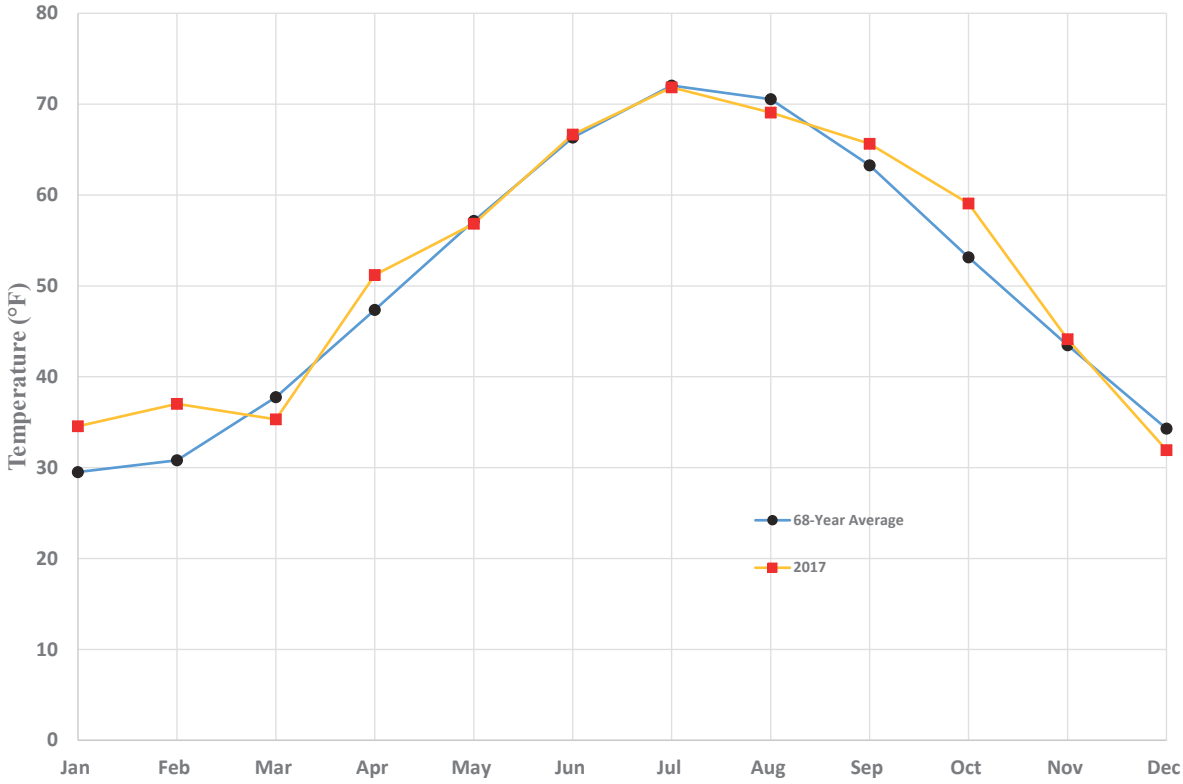


Figure 1-5. BNL 2017 Monthly Mean Temperature versus 68-Year Monthly Average.

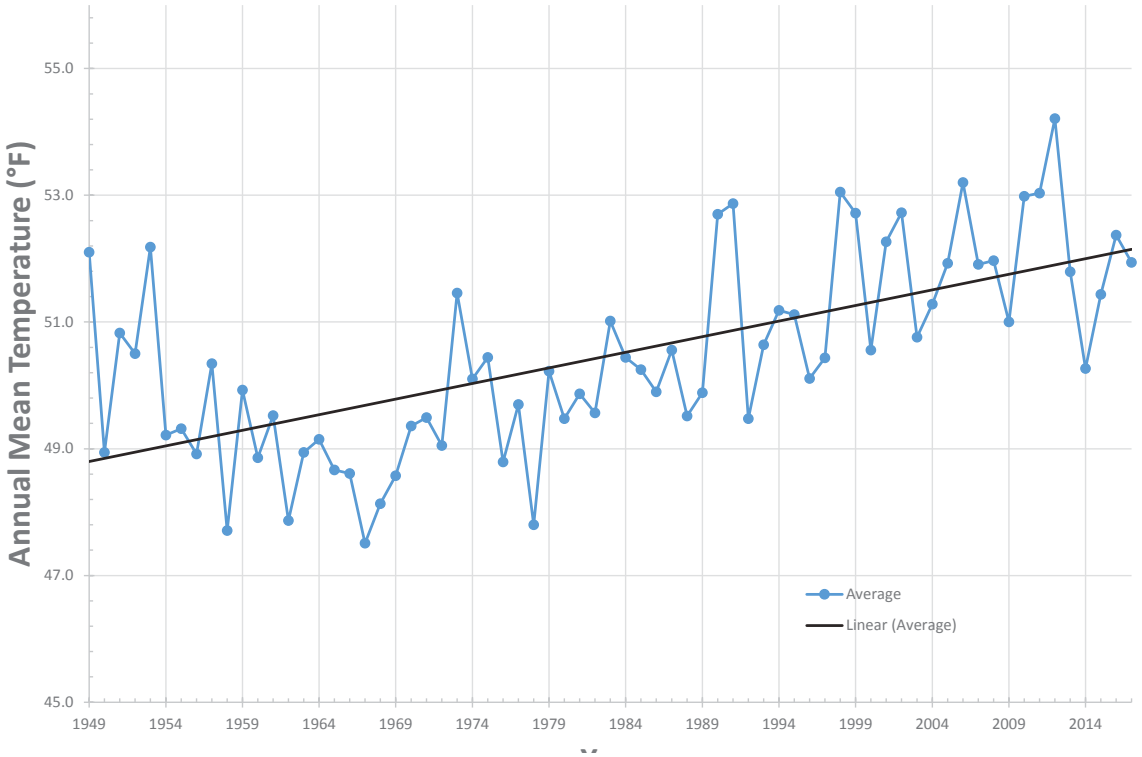


Figure 1-6. BNL 2017 Annual Mean Temperature Trend (68 Years).

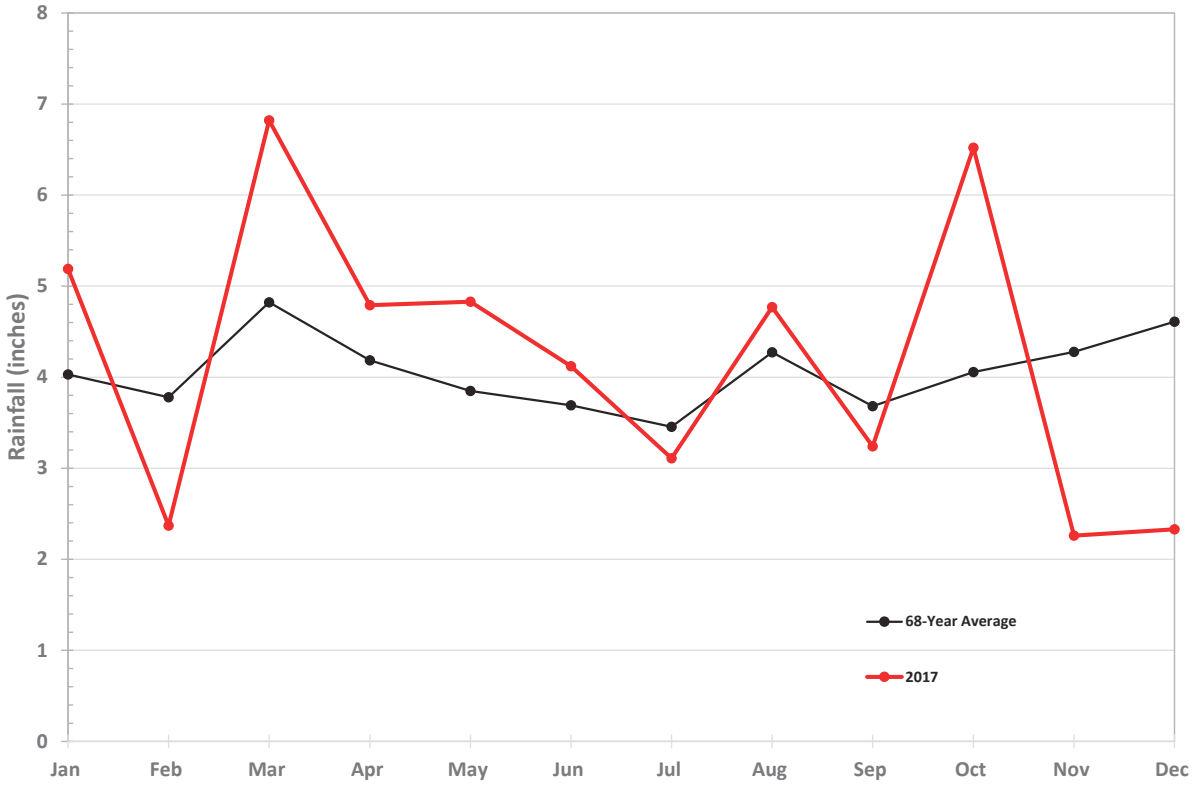


Figure 1-7. BNL 2017 Monthly Precipitation versus 68-Year Monthly Average.

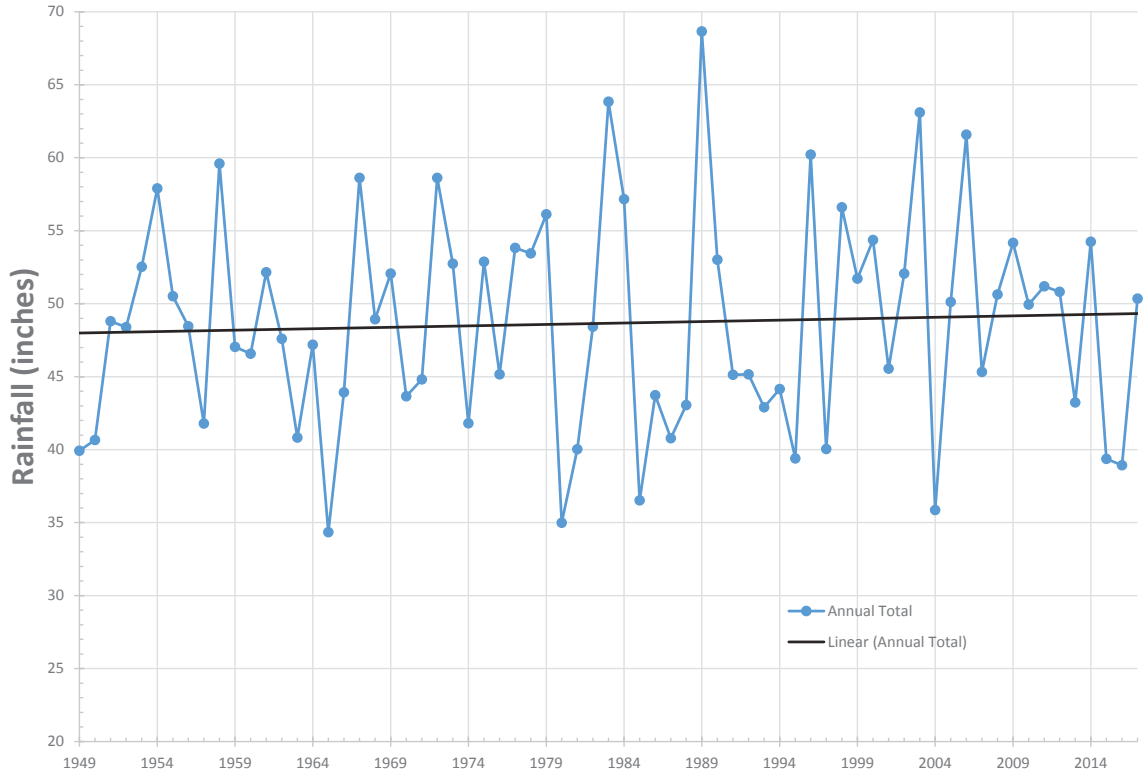


Figure 1-8. BNL 2017 Annual Precipitation Trend (68 Years).

ecological values and as an area for ecological research (BNL 2016). 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 2013). These resources include World War I trenches; Civilian Conservation Corps features; World War II buildings; and historic structures, programs, and discoveries associated with high-energy physics, research reactors, and other science conducted at BNL. The Laboratory currently has four 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, the 1960s era apartments, and the World War I training trenches associated with Camp Upton. Further information can be found in Chapter 6.

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2 Environmental Management System

Brookhaven Science Associates (BSA), the contractor operating the Laboratory on behalf of the Department of Energy (DOE), takes environmental stewardship very seriously. As part of its commitment to environmentally responsible operations, BSA has established the Brookhaven National Lab (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, which encompasses ideals such as compliance, pollution prevention, and community involvement. Annual audits are required to maintain an EMS registration; an audit of the entire EMS occurs every three years. In 2017, EMS assessments determined that BNL remains in conformance with the ISO 14001: 2004 Standard.

The Laboratory continues its strong support of its Pollution Prevention Program, which seeks ways to eliminate waste and toxic materials on site. In 2017, pollution prevention projects resulted in nearly $3.5 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 9.3 million pounds of waste. An additional $5,000 was spent on funding lab cleanouts and disposal of chemicals.

The ISO 14001-registered EMS continues to contribute to the Laboratory's success in promoting pollution prevention. As a testament to its strong environmental program, the Lab received two environmental awards in 2017: the DOE's Gold Level Green Buy Award and the Green Electronics Council's Electronic Product Environmental Assessment Tool (EPEAT) Award.

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 (environmental protection and pollution prevention), Safety, Health, and Quality (ESH&Q) management into all work planning and execution. The purpose of BNL's ISMS is to ensure that the way we 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 as defined by DOE P 450.4, are:
- *Line manager clearly responsible for ES&H:* Line management is directly responsible for the protection of the public, workers, and environment.
- *Clear ES&H roles and responsibilities:* Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels within the Department and with its contractors.
- *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 ES&H 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, as a whole, 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.

A new external certification organization, ERM Certification Verification Services, was procured to conduct external verification of BNL's conformance to the ISO 14001 and OHSAS 18001 Standards in 2017. They conducted an initial desk assessment of BNL's systems in December with no issues identified; a follow-up on-site assessment will occur in 2018. BNL also conducted an internal assessment that verified continued conformance to the Standards.

2.2 ENVIRONMENTAL, SAFETY, SECURITY, AND HEALTH POLICY

The cornerstone of an EMS is a commitment

to environmental protection at the highest levels of an organization. BNL's environmental commitments are incorporated into a comprehensive Environmental, Safety, Security, and Health (ESSH) Policy. The policy, issued and signed by the Laboratory Director, states 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; to create action plans to achieve the objectives and targets; and to identify and address risks and opportunities that can impact the success of the EMS.

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 uses its work planning process to identify and review environmental aspects associated with activities. A "Process Assessment Procedure" is used for facilities and equipment or for deeper analysis of activities not sufficiently covered by work planning. Evaluations are documented on work plans and Process Assessment Forms (PAFs).

Environmental professionals work closely with Laboratory personnel to ensure that work plans, PAFs, and other related reviews thoroughly capture all aspects, requirements, and associated environmental controls. Aspects and impacts are evaluated annually to ensure that they continue to reflect stakeholder concerns and changes in regulatory requirements.

2.3.2 Compliance Obligations

To implement the compliance commitments of the ESSH Policy and meet its legal requirements, BNL has systems in place to review changes in federal, state, or local environmental regulations and 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 March 2015, Executive Order (EO) 13693, *Planning for Federal Sustainability in the Next Decade*, establishes sustainability goals for federal agencies and focuses on greenhouse gas (GHG) reductions across the government. In addition to guidance, recommendations, and plans, which are due by specific due dates, EO 13693 has set numerical targets for the agencies.

DOE Order 436.1, *Departmental Sustainability,*

provides requirements and responsibilities for managing sustainability within DOE to ensure facilities are working towards sustainability goals established in its Strategic Sustainability Performance Plan (SSPP) pursuant to EO 13639. Each DOE facility is required to have a Site Sustainability Plan (SSP) in place detailing the strategy for achieving these long-term goals and due dates, and to provide an annual status. The requirements influence the future of the Laboratory's EMS program and have been incorporated into BNL's SSP. Table 2-1 identifies the DOE SSP goals, the Laboratory's performance in 2017, and future planned actions and contributions.

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 (PEMP). 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 13693;
- Significant environmental aspects;
- Risk and vulnerability (primarily, threat to the environment);
- Compliance obligations (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 2017, BNL's environmental objectives included maintaining ISO 14001 and OHSAS 18001 certifications, improving the Laboratory's performance in purchasing environmentally preferable items, and improving spill response capabilities.

2.3.4 Environmental Management Programs

The Environmental Protection Division takes on the largest role for developing action plans for implementing institutional environmental priorities, with other organizations within BNL developing action plans as applicable to their operations. The plans detail how the organization 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 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

Table 2-1. BNL Site Sustainability Plan: Status Summary for Fiscal Year 2017.

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Goal 1: Greenhouse Gas (GHG) Reduction		
50% Scope 1 & 2 GHG reduction by FY 2025 from a FY 2008 baseline	Scope 1 & 2 GHG Emissions BNL had a 50% reduction (~118,000 MtCO2e) in Scope 1 and 2 GHG emissions for FY17. The 32-MW LISF reduced GHGs on Long Island by 32,109 MtCO2e. Fugitives and Refrigerants The bulk of BNL's process and fugitive GHG emissions were due to periodic purging of carrier gases used in STAR detector subsystems during the FY17 RHIC experimental run. In May, BNL revised its Refrigerant Management Plan, fully incorporating all of the modified and new 40 CFR 82 Subpart F provisions. In July, three training sessions were held with refrigeration and air conditioning technicians and their supervisors on the changes. The Electric Distributions Group follows provisions within the High Energy Equipment Management Plan to account for and effectively manage leaks of SF6 associated with gaseous dielectric used in high voltage electric equipment.	Scope 1 & 2 GHG Emissions BNL will continue to pursue ongoing initiatives to reduce GHG emissions (e.g., hydropower, REC purchases, energy intensity reductions). Fugitives and Refrigerants BNL will conduct self-audits of its Refrigerant Management Plan in December and July to assess the effectiveness of the Refrigerant Management Plan, identify any deficiencies in the plan, and resolve them in a timely manner.
25% Scope 3 GHG reduction by FY 2025 from a FY 2008 baseline	Overall Scope 3 GHG emissions are down 26.1% from FY 2016 (6,023 MtCO2e), and 14.5% lower than the FY 2008 baseline value. In Sept, BNL proposed to the DOE SPO an alternative methodology of calculating GHG emissions from commuting. SPO responded that programming changes would be required to the DOE Sustainability Dashboard first. Commuting GHG emissions rose 12.6%, or 701 MtCO2e,. Since 2008, GHG emissions from contracted waste are down 32%. GHG emissions from employees using their personal vehicles for business use have decreased 25.6% since FY08. GHG emissions from rental vehicles used for employee business travel rose by 11 MtCO2e or 3.4% from the FY16 total, but are 2.3% lower than the FY08 total. Air travel GHG emissions rose by 54 MtCO2e, a 1.5% increase from the FY16 total and 4.1% higher than the FY08 baseline.	BNL will continue to strive to reduce Scope 3 GHG emissions. The EPD will continue to work with BHSO to advocate for the SPO to update the Dashboard and enable BNL to use the alternative methodology for estimating commuting GHG emissions that was proposed in September. EPD and ITD will conduct a survey of recent Blue Jeans videoconference service users. EPD will reach out to HR to jointly explore how the resources and recommendations in the Sustainable Commuting US DOE National Laboratories Report & Toolkit can be used to engage employees and managers on the benefits of ride-sharing, telework, and alternative work schedules.

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Table 2-1. BNL Site Sustainability Plan: Status Summary for Fiscal Year 2017. *(continued).*

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Goal 2: Sustainable Buildings		
25% energy intensity (Btu per gross square foot) reduction in goal-subject buildings, achieving 2.5% reductions annually, by FY 2025 from an FY 2015 baseline	BNL's energy intensity for FY17 was 226,029 Btu/gsf and was 7% lower than the new base year of 2015. Energy savings from UESC were verified for the second year and contributed to the lower energy intensity value. The Temperature Setback Policy is continually communicated to the Lab via several methods, including Earth Day events and presentations to FPMs, FCMs, and Lab management.	One of the biggest challenges for BNL will be to meet the new 25% energy intensity reduction goal by FY25. BNL has begun a UESC Phase II effort. If enough cost-effective projects can be identified for Phase II, BNL may be able to meet or make progress toward the new 25% reduction goal. BNL will continue to pursue an aggressive Temperature Setback Policy in FY18 and communicate its importance to the Lab population. BNL will continue all of the best practices currently in place, including HVAC setback, steam charge-back, and lighting upgrades.
EISA Section 432 energy and water evaluations	Energy audits of HVAC systems, lighting, and office equipment continued in FY17. They are being performed in conjunction with ongoing condition assessment surveys in order to reduce additional costs and administrative oversight needs. All information has been placed in EPA's Portfolio Manager Program for benchmarking.	BNL will continue with the cost effective Energy Survey/ Facility Condition Assessment (FCA) approach in FY18 and beyond.
Meter all individual buildings for electricity, natural gas, steam and water, where cost effective and appropriate	BNL is meeting the metering goals for electricity, natural gas, and chilled water. During FY17, 12 advanced electric meters were installed; 3 advanced chilled water meters were replaced; 2 advanced steam meters were installed; and 2 existing advanced meters were connected to the building automation system.	Additional meters will be installed as opportunities become available.
At least 15% (by building count) of existing buildings greater than 5,000 gross square feet (GSF) to be compliant with the revised Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter	Currently 24% of non-excluded buildings have achieved 100% of the Guiding Principles and an additional 11% are at 90% or higher.	Projects currently in various stages of planning (such as the SUSC and the CFR major renovation of Building 725) will be designed to meet the Guiding Principles.
Efforts to increase regional and local planning coordination and involvement	**Discovery Park** Discussions continued with LIRR staff on the Discovery Park vision and funding was approved in the State budget. **Deer Management** FY17 Deer Management Plan was implemented, removing 202 deer. **Pollinator Task Force** The pollinator support plants at the LISF included 21 total species of wildflowers, mostly non-native, and hosted 19 butterfly species and 9 bee species.	**Discovery Park** Efforts toward the realization of Discovery Park will continue with support from local, regional, and federal stakeholders. BNL will continue to work closely with LIRR, Suffolk County, and the Town of Brookhaven to determine the best possible site for the relocation of the Yaphank Train Station. **Deer Management** Deer management strategy will be reassessed with NYSDEC and Lab management to find a cost alternative to the current culling program and determine the feasibility of an on-site hunt in FY18 to minimize herd to ~250 deer. **Pollinator Task Force** The Lab will continue to work to implement best management practices established by the Pollinator Task Force and continue pollinator-related research.

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Table 2-1. BNL Site Sustainability Plan: Status Summary for Fiscal Year 2017. *(continued).*

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Net Zero Buildings: 1% of the site's existing buildings above 5,000 gross square feet intended to be energy, waste, or water net-zero buildings by FY 2025	Discussions continued with BHSO and DOE-HQ. BNL has the option of applying the output of the NSERC to make it net-zero. The determination will be made in concert with BHSO.	BNL will continue to engage the national lab community on techniques to economically meet the net zero requirements. Starting in 2020, where economically viable, BNL will ensure net-zero requirements are included in future designs.
Net Zero Buildings: All new buildings (>5,000 GSF) entering the planning process designed to achieve energy net-zero beginning in FY 2020	MPO hosted net-zero energy training in FY17. Based on the training, 3 future buildings will be evaluated for net-zero designation.	BNL will consider net-zero concepts in the preliminary design of the SUSC.
Goal 3: Clean & Renewable Energy		
"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than: 10% in FY 2016-2017, working towards 25% by FY 2025	BNL's "Clean Energy" requirement for 2017 was 53,990,000 kWh. BNL purchased 60,800,000 kWh of RECs for 2017 to meet the "Clean Energy" requirement.	BNL will continue to operate the NSERC facility and provide for expansion to a full MW when sufficient funds are identified. REC purchases will continue to meet the renewable energy and clean energy goals.
"Renewable Electric Energy" requires that renewable electric energy account for not less than 10% of a total agency electric consumption in FY16-17, working towards 30% of total agency electric consumption by FY 2025	BNL's "Renewable Energy" requirement for 2017 was 38,358,000 kWh. BNL purchased 60,800,000 kWh of RECs for 2017 to meet the "Clean Energy" requirement, thereby exceeding the "Renewable Energy" requirement. All of BNL's RECs have been and will continue to be purchased through a competitive solicitation process. In 2017, the Northeast Solar Energy Research Center (NSERC) facility produced 968,485 kWh on-site.	Renewable energy systems, especially solar hot water, will continue to be considered in all new construction projects and major building renovations (including the Science and User Support Center [SUSC]).
Goal 4: Water Use Efficiency and Management		
36% potable water intensity (Gal per gross square foot) reduction by FY 2025 from a FY 2007 baseline	Potable-water usage fell from 931 million gallons/year in FY 1999 (average of 2.55 million gallons per day) to about 407 million gallons/year in FY 2017 (average of 1.12 million gallons per day), a reduction of 56.3%.	BNL will continue to implement BNL's Water Management Plan. BNL will continue to utilize water-efficient processes and plumbing fixtures to conserve water in new construction buildings and renovations.
30% water consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA) water by FY 2025 from a FY 2010 baseline		
Goal 5: Fleet Management		
30% reduction in fleet-wide per- mile greenhouse gas emissions reduction by FY 2025 from a FY 2014 baseline (2017 target: 4%)	For FY17, we achieved total GHG emissions of 422.37 gCO2e/mile. This represents a 47% reduction from our FY14 baseline. We achieved this by replacing older, less fuel-efficient gasoline vehicles with newer alternative fuel vehicles, most with E-85 capabilities.	BNL will continue to work with GSA to obtain the newest vehicles with alternative fuel capabilities wherever possible. Fleet management will work with GSA to ensure that plug-in hybrids and zero emissions vehicles replace at least 20% of new passenger vehicle acquisitions by FY 2020 and 50% by FY 2025. BNL intends to implement Telematics in Light Duty Vehicles on or before 2/1/18.

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Table 2-1. BNL Site Sustainability Plan: Status Summary for Fiscal Year 2017. *(continued).*

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter		
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter		
75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV)		
50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025		
Goal 6: Sustainable Acquisition		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in 95% of applicable contracts	BNL has incorporated contract clauses within its vendor contracts that designate environmentally preferred products (EPP), services, and equipment. BNL completed implementation of its online purchasing system—the Vinimaya system ("E-Buy"). In 2017, BNL established EMS objectives to improve EPP purchasing performance for the Electronic Product Environmental Assessment Tool (EPEAT) electronics and office products. BNL also promoted the EPP program during this past year's Earth Day activities.	During 2018, BNL will continue to work on the Commonly Ordered Items page, provide E-Buy training specific to EPP purchasing requirements, and provide feedback to the user community on EPP products. BNL will also write new EMS objectives to promote that program and drive improvement.
Goal 7: Pollution Prevention and Waste Reduction		
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris	During FY17, BNL's recycling rate (annual diversion rate for non-hazardous solid waste) was approximately 73%.	BNL's waste diversion program is expected to remain intact in the future years and may grow with the addition of food waste composting pending the start-up of a commercial food waste composter in relatively close proximity to the Lab.
Divert at least 50% of construction and demolition materials and debris	BNL diverts 95%+ of its construction debris to an on-site borrow pit for future conversion to recycled concrete aggregate (RCA). In FY17, BNL brought a concrete crusher on-site and generated approximately 3,500 tons of RCA.	This practice will continue.

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Table 2-1. BNL Site Sustainability Plan: Status Summary for Fiscal Year 2017. *(continued).*

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Goal 8: Energy Performance Contracts		
Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of E.O. 13693	Internally funded energy conservation and sustainability-related initiatives include a continuation of various best practices, such as temperature setback and small lighting and water conservation projects. As a result of a budget constrained environment, BNL, like other DOE sites, has been increasingly using third-party financing options that utilize cost savings to pay for the projects. BNL completed its first UESC in 2015, which is performing well and meeting the original energy savings estimates. As a result, a second UESC project is being planned and will incorporate lessons learned from UESC Phase I. The manager of Energy Management at BNL is a Certified Energy Manager. All BNL Facility Complex Managers have the Certified Facility Manager recognition from the International Facilities Management Association.	BNL is in the process of developing a UESC Phase II project that will likely including various energy conservation measures, such as lighting, HVAC controls, solar preheating, energy (chilled water) storage, efficient boilers, and others. While it is not possible to estimate energy savings at this early stage, we anticipate savings to be equal to or greater than the recent UESC Phase I project.
Goal 9: Electronic Stewardship		
Purchases – 95% of eligible acquisitions each year are EPEAT-registered products	The contract governing the procurement of printers, laptops, and desktop computers ordered through the BNL E-Pro system requires that they have an EPEAT "Gold" certification.	The Laboratory will continue to require that all printers, laptops, and desktop computers ordered through the E-Pro system have an EPEAT "Gold" certification.
Power management – 100% of eligible PCs, laptops, and monitors have power management enabled	All systems in the BNL domain that are capable of power management have the setting enabled.	BNL will continue to evaluate the feasibility of extending the desktop computer power management policy to other operating systems.
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled	The majority of printers and copiers are not centrally managed. BNL has published Managed Printing guidelines, which recommend the use of network/department-wide printers configured for black ink only and duplex printing.	BNL will continue to communicate the importance and benefits of duplex printing.
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year	BNL disposed of approximately 21 tons of electronic equipment through an R2 certified recycler during 2017.	BNL will continue to evaluate methods of increasing computer useful life and will continue to dispose of electronic waste in an environmentally sound manner through a certified R2 recycler.
Data Center Efficiency. Establish a power usage effectiveness target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers	BNL completed an evaluation of our existing data centers in response to the Data Center Optimization Initiative (DCOI) from the summer of 2016. Our internal assessment identified 8 data centers that meet the new DCOI criteria. Additional resources will be needed to meet the goal of PUE < 1.5. The Core Facility Revitalization (CFR) project is being designed to renovate Building 725. This project includes repurposing a significant portion of the building for use as a new computing facility with associated support space and new infrastructure.	Meeting the PUE of 1.5 for the existing data centers will require a significant investment. Further, 4 of the 8 existing data centers will require the installation of new metering to determine their actual PUE. The data center associated with the CFR project is in the design phase and is targeting a PUE of < 1.3 in accordance with the recent DCOI. The CFR project has received CD-1 approval and could start construction in FY19.

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Table 2-1. BNL Site Sustainability Plan: Status Summary for Fiscal Year 2017. *(concluded).*

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Goal 10: Climate Change Resilience		
Update policies to incentivize planning for, and addressing the impacts of climate change Update emergency response procedures and protocols to account for projected climate change, including extreme weather events Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change Ensure site/lab management demonstrate commitment to adaptation efforts through internal communications and policies Ensure that site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary	**Emergency Response and Local/Regional Coordination** During FY17, the BNL OEM revised and edited all emergency management plans and procedures to meet the requirements of the new DOE O151.1D. During major weather events, OEM participates on the National Weather Service regional severe weather calls. BNL is also part of Suffolk County's Comprehensive Emergency Plan. **Risk/Vulnerability Assessment** During implementation of DOE O 151.1D, OEM changed the BNL Hazards Survey to an All-Hazards Survey for effects of severe weather phenomenon on the BNL site. BNL OEM has also developed a THIRA program that meets the DOE requirement for extreme events and includes severe weather phenomenon. **Workforce Protocols** The Lab's Flexible Work Arrangements policy provides many options for employees to manage their work schedules during times of severe weather events and potentially limit commuting on-site. In January 2017, HR launched its new Recognition and Reward Program, which includes additional non-cash mechanisms for recognizing staff members who exhibit the Lab Values, including the value of Environmental Stewardship. **Climate-Resilient Design of New or Newly Retrofitted Buildings** BNL does not currently have design guidelines specifically for climate-resilient design. However, as a retrofit projects are designed using higher and lower temperatures than required by ASHRAE as a means of incorporating forward-looking climate data into the design of our capital improvement projects.	**Emergency Response and Local/Regional Coordination** All OEM plans and procedures will continue to be reviewed and updated as required by DOE O151.1D. Additionally, OEM will continue to engage with local and regional partners in information-sharing and coordination activities regarding emergency management and response. **Workforce Protocols** BNL will continue to evaluate its workforce policies and programs in light of our understanding of climate change and its projected impact on human health and safety. **Climate-Resilient Design of New or Newly Retrofitted Buildings** BNL will evaluate the applicability of the draft Climate Resiliency Design Guidelines developed by NYC's Office of Recovery and Resiliency, and plans to utilize them on Laboratory projects once finalized.

Contingency Plan that defines an orderly process for quickly verifying the results and taking corrective actions in response to unexpected monitoring results (BNL 2013c). 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 2017.

2.3.4.3 Waste Management

Due to 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, industrial, and mixed waste (i.e., mixed waste is hazardous waste that is also radioactive). 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,

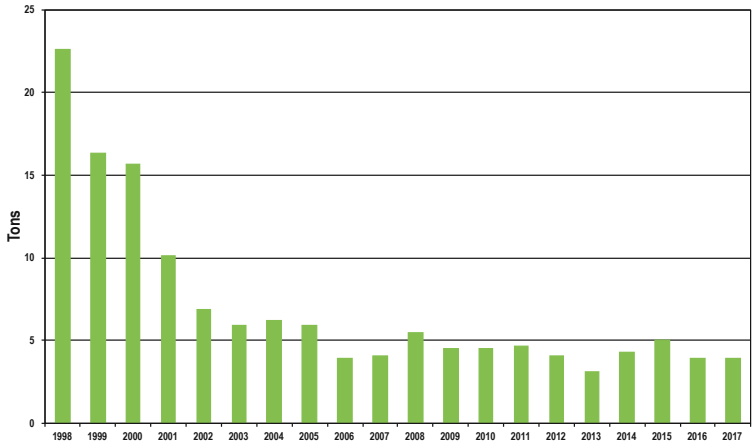

Figure 2-1a. Hazardous Waste Generation from Routine Operations, 1998 – 2017.

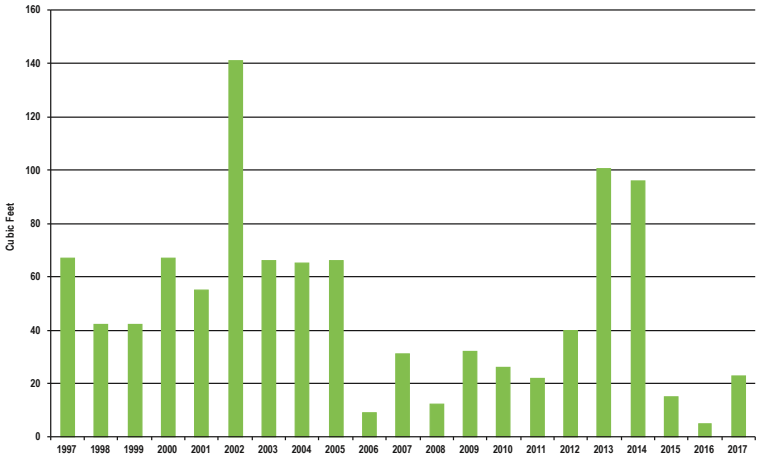

Figure 2-1b. Mixed Waste Generation from Routine Operations, 1998 – 2017.

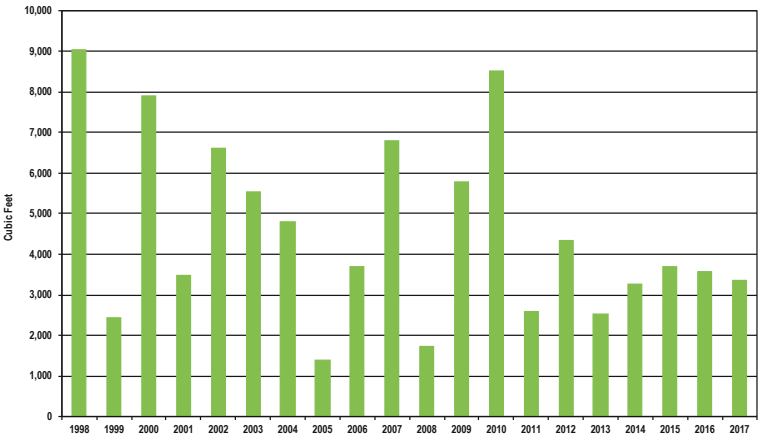

Figure 2-1c. Radioactive Waste Generation from Routine Operations, 1998 – 2017.

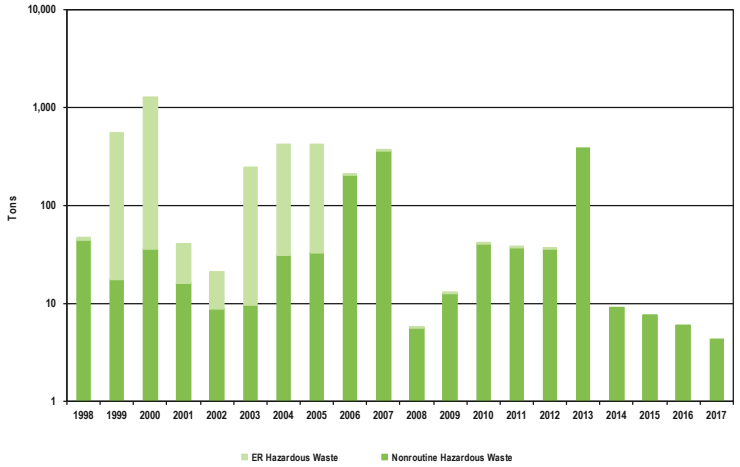

Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 1998 – 2017.

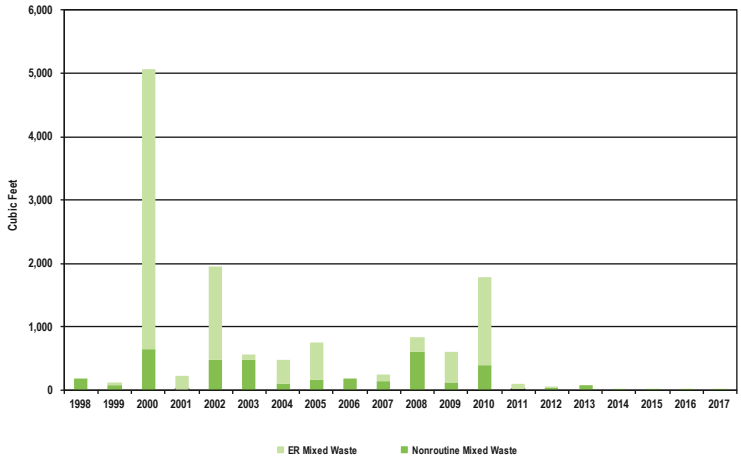

Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 1998 – 2017.

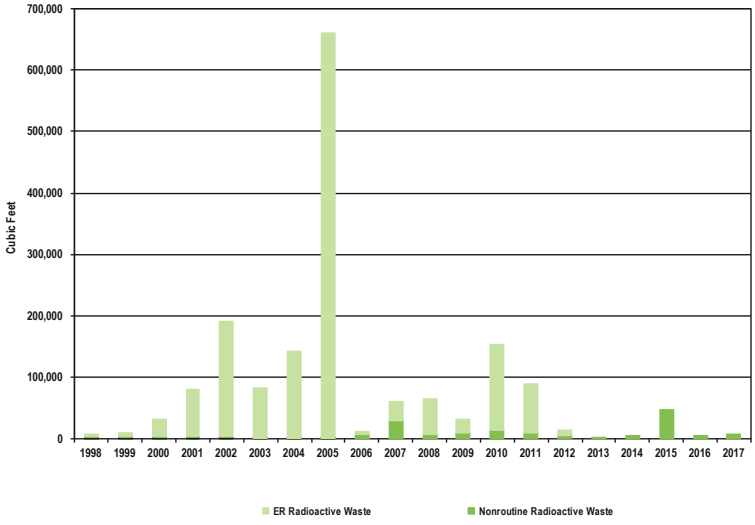

Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 1998 – 2017.

radioactive, and mixed waste and is comprised of two staging areas: a facility for hazardous, industrial, and mixed waste 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. In 2017, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 3.9 tons
- Mixed waste: 23 ft^3
- Radioactive waste: 3,345 ft^3

Hazardous waste from routine operations in 2017 stayed consistent from 2016 generation rates, as shown in Figure 2-1a, based on stable generating activities over the year as compared to the year before. Mixed waste generation increased from 2016 rates, as shown in Figure 2-1b. The change is due to fluctuations in operations at BNL's accelerator facilities. As shown in Figure 2-1c, the radioactive waste quantity for routine operations decreased slightly from the year before. 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

cleanouts) are considered non-routine.

BNL's inventory of legacy waste has been significantly reduced over the years. Small quantities of legacy waste were associated with small-scale facility cleanouts, such as the partial cleanout of Building 820 and the demolition of the Biology green houses and the Fleming House. Figures 2-1d through 2-1f show waste 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 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 PEMP 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, as practicable;
- 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.

The BNL P2 and recycling programs have achieved 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 2017, 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 reduced both waste volumes and management costs. In 2017, these efforts resulted in nearly $3.5 million in cost avoidance or savings and approximately 9.3 million pounds of materials being reduced, recycled, or reused annually.

The Laboratory has an active and successful solid waste recycling program, which involves all employees. In 2017, BNL collected approximately 621 tons of scrap metal for recycling. Cardboard, office paper, bottles and cans, construction debris, motor oil, 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. The baseline recycling rate goal for federal facilities is 50 percent; since 2000, BNL's annual average recycling rate has consistently ranged above this baseline. The 2017 annual recycling rate equaled the previous year at 74 percent.

During 2017, BNL's sustainability program was honored by receiving two Environmental Awards:

- US DOE's Gold Level Green Buy Award for voluntarily purchasing "greener products" that reduce environmental impacts. This award acknowledges the efforts of Laboratory Divisions (such as Staff Services, Grounds, Custodial Services, and the Modernization Project Office) that make sustainable product purchasing decisions.
- The Green Electronics Council's EPEAT (Electronic Product Environmental Assessment Tool) Award for purchasing EPEAT-registered electronic products which meet

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2016	Waste Type	Potential Costs for Treatment and Disposal	Revenue/(Cost) of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Building 452 Oil Skimmer	Source Reduction	3,000	Industrial Waste	$1,030	$0	$1,030	Reduces oily-water waste stream (non-halogenated oil) from air compressors by skimming off oil and leaves water phase. Water may be discharged to sanitary system. Resulting oil sent to vendor for reprocessing/reuse at no cost for 2017.
Electronic Reuse	Reuse	38,000	Electronic Waste	$2,978,000	($15,200)	$2,962,800	The Laboratory tracks electronic equipment and takes a reuse credit for transfer of equipment to another user. Savings is based on the cost to purchase a new version of the item minus the scrap value of that item.
Building Demolition Recycling	Recycling	N/A	Industrial Waste	$0	$0	$0	On-site demolition products (steel and concrete) are segragated, recycled, and reused. Materials collected during 2017 (Biology Greenhouses, B180 Fleming House, B820 Cleanout) were not tracked seperately this year, but are captured in other recycling streams in this table.
Animal Bedding Conveying System	Composting	4,600	Medical Waste	$1,192	$0	$1,192	Animal bedding material is conveyed to a dumpster that is emptied and composted at the stump dump. Savings is calculated on the assumption that otherwise, the material would be disposed on as Regulated Medical Waste.
Lead Acid Batteries	Recycled	1,280	Universal Waste	$346	$0	$346	Avoids universal waste disposal costs for lead and sulfuric acid batteries.
Blasocut Machining Coolant	Recycled/ Reused	15,502	Industrial Waste	$56,256	$0	$56,256	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it Laboratory-wide. In 2017, 1,950 gallons (15,502 lb) of Blasocut lubricant were recycled. Recycling involves aeration, centrifuge, and filtration. This avoids cost of disposal as industrial waste and an avoided cost of buying 35 drums of concentrate ($1315/drum) and empty drums for shipping ($95/drum).
Fluorescent Bulbs	Recycled	5,000	Universal Waste	$5,650	($2,748)	$2,902	Fluorescent bulbs are collected as sent to a recycling facility under the Universal Waste exemption rule. Savings is in comparison to cost to dispose of them as hazardous waste.

(continued on next page)

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

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2016	Waste Type	Potential Costs for Treatment and Disposal	Revenue/(Cost) of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Used Motor Oil	Energy Recovery	18,792	Industrial Waste	$6,755	$0	$6,755	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 2017, they collected 2,610 gallons (18,792 lbs) of oil at no charge to BNL, which avoided the costs for disposal and 53 shipping drums ($95/drum).
Office Paper	Recycled	168,000	Regular Trash	$8,820	$2,100	$10,920	Cost avoidance based on $105/ton for disposal as trash, plus $25/ton revenue.
Cardboard	Recycled	148,000	Regular Trash	$7,770	$2,220	$9,990	Cost avoidance based on $105/ton for disposal as trash, plus $30/ton revenue.
Electronic Waste	Recycled	46,200	Electronic Waste	$2,426	$23,408	$25,834	Cost avoidance based on $105/ton for disposal as trash, plus $23,408 revenue.
Metals	Recycled	1,242,000	Industrial Waste	$65,205	$95,597	$139,725	Cost avoidance based on $105/ton for disposal as trash, plus $95,597 revenue.
Bottles/Cans	Recycled	15,800	Industrial Waste	$830	$0	$830	Cost avoidance based on $105/ton for disposal as trash.
Construction Debris - Concrete	Recycled	7,000,000	C&D Debris	$201,250	$0	$201,250	Concrete crushed and reused onsite. Cost avoidance based on $57.5/ton cost to dispose as C&D debris.
Construction Debris - Other	Recycled	512,000	C&D Debris	$26,880	($14,720)	$12,160	Cost avoidance based on $105/ton for disposal as trash vrs $57.5/ton to dipose as C&D debris.
Food Waste	Reused	7,800	Regular Trash	$410	$0	$410	Rougly 30 lbs of food waste per day is diverted to the STP for use as organic feedstock for the plant. Savings is based on cost to dispose of as trash.
Tires	Recycled	11,095	Regular Trash	$582	$0	$582	Truck tires sent for recycing from the motor pool. Cost savings is based on cost to dispose of as trash.
Garnet	Recycled	41,000	Industrial Waste	$46,330	($2,000)	$44,330	Garnet used in machine shop sent for recycing. Cost savings is based on cost to dispose of as Regulated Industrial Waste.
	TOTALS	9,278,069		3,409,730	88,657	3,477,311	

Table 2-3. BNL Recycled Program Summary, 2000-2017.

Recycled Waste *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mixed paper	336	246	209	182	185	193	184	177	151	127	174	186	142	160	150	91	89	84
Cardboard	132	127	157	176	179	143	135	121	147	152	141	126	100	97	78	12.4	73	74
Bottles/Cans	19.5	29.3	19	23	22	22.1	27.7	24.4	19.6	23.7	24	22.5	18	16.5	17.1	22.1	11	7.9
Tires	0		3.5	12.3	11	12.8	32.5	19.9	34.5	15.5	10.1	9.2	10	7.1	7.6	5.4	6.4	5.5
Construction debris	243	289	304	334	367	350	297	287	302	312	416	256	380	304	351	372	266	256
Used motor oil (gallons)	3,296	3,335	1,920	3,920	3,860	4,590	2,780	2,020	1,500	1,568	1,700	1,145	1,585	1,550	2,000	1,320	2,730	2,610
Metals	534	44	48	193	128	559	158	382	460	91	131	84	278	174	256	737	426	621
Automotive batteries	2.2	4.8	6.3	4.6	5	4.6	5.5	2.5	2.7	4	1.6	2.1	2	2.1	1.4	1.9	1.4	0.6
Printer/Toner cartridges (units)	n/a	363	449	187	105	0	0	0	3,078	1,251	4,132	4,186	4,100	11,233	2,174	2,037	n/a	977
Fluorescent bulbs (units)	5,874	17,112	25,067	13,611	12,592	7,930	11,740	25,448	36,741	10,223	8,839	20,220	15,727	13,540	19,807	15,956	9,604	4,294
Blasocut coolant (gallons)	n/a	n/a	8,180	5,030	6,450	3,890	3,970	2,432	3,340	3,810	4,830	5,660	5,610	5,650	4,850	2,550	2,350	1,950
Tritium exit signs (each)	n/a	n/a	28	181	142	0	0	0	0	0	0	18	0	0	0	0	0	0
Smoke detectors (each)	n/a	n/a	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electronic reuse	n/a	n/a	0	0	0	0	0	0	16.3	11.4	12	11.6	3.2	1.4	10.5	25	17	19
Scrap electronics	n/a	n/a	0	0	0	6.1	70.3	40.5	48.9	17	16.7	19.9	30.9	23	29.3	42	24	23.1
Animal Bedding (composted)	n/a	n/a	0	0	0	0	6.3	19.6	42	41	52	54	3.3	30	10	15	11	2.3
Gamet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0.5
Recycling Rate (%)	65	54	57	60	61	63	62	64	68	59	63	59	63	76	58	77	74	74
Demolition Projects																		
Metals	n/a	n/a	8	23	11	6	35	0	0	0	0	0	60	90	0	0	0	0
Concrete	n/a	n/a	891	590	3,000	328	5,505	6,175	0	0	4,050	0	4,050	3,500	4,000	0	4,200	3,500
Construction and debris	n/a	n/a	790	388	1,200	157	818	0	0	0	0	0	0	0	0	0	0	0

Notes: All units are tons, except where noted.

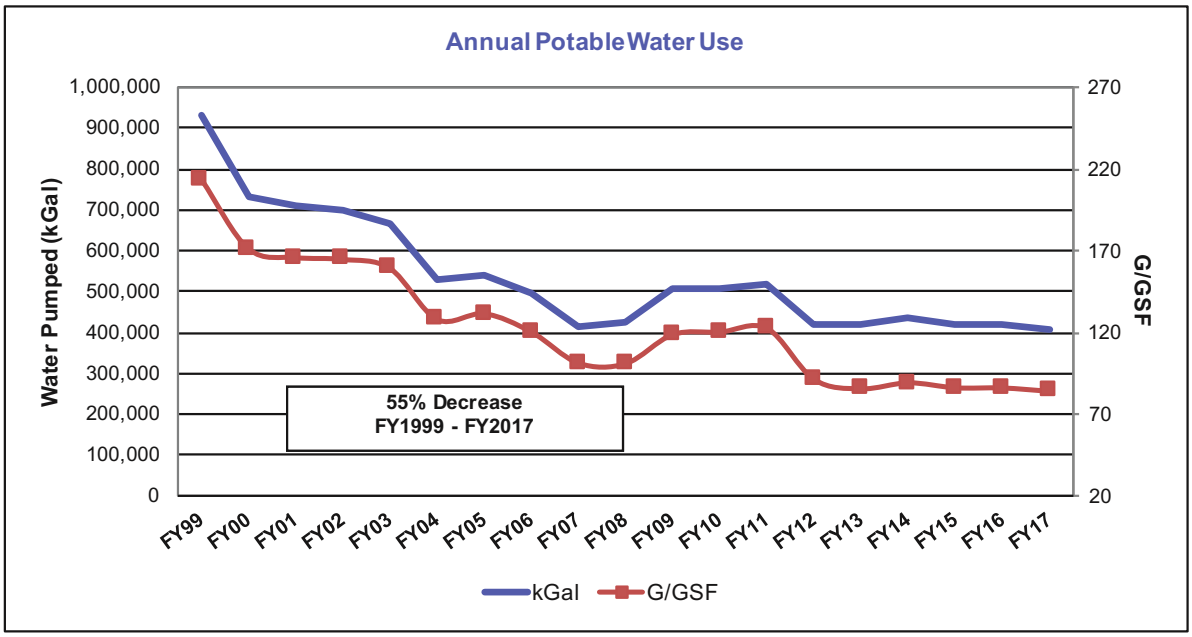

Figure 2-2. Annual Potable Water Use, 1999-2017.

strict environmental criteria that address the full product lifecycle, from energy conservation to toxic materials to product longevity and end-of-life management.

2.3.4.5 Water Conservation

BNL's water conservation program has achieved dramatic reductions in water use since the mid-1990's. 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. Treated effluent (i.e., water that is near drinking quality) from BNL's Sewage Treatment Plant (STP) is recharged (or recycled) back to the aquifer, returning well over 100 million gallons per year. Through an annual maintenance program, conventional plumbing fixtures are replaced with modern low-flow devices.

The Laboratory's goal is to reduce the consumption of water and reduce the possible impact of clean water dilution on STP operations. Figure 2-2 shows the 18-year trend of water consumption. Total water consumption in 2017 was down slightly from 2016. The water intensity (gallon/square foot) also continues to decrease. In each of the past ten 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 13693, DOE Order 436.1, 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 4.9 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 2017, BNL used approximately 270 million kilowatt hours (kWh) of electricity, 105,000 gallons of fuel oil, 14,591 gallons of propane,

and 565 million cft 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 have been historically used whenever each respective fuel is least expensive. In 2017, natural gas prices were lower than fuel oil prices for most of the year. As a result, natural gas was used to meet 98.3 percent of the heating and cooling needs of the Laboratory's major facilities. Given the price disparity between natural gas and oil, the Laboratory will continue to purchase natural gas over oil, further reducing GHG emissions. Additional information on natural gas and fuel oil use can be found in Chapter 4.

BNL continues to participate in available electric load reduction curtailment programs. Through this program, the Laboratory has agreed to reduce electrical demand during critical days throughout the summer when New York Independent System Operator expects customer demand to meet or exceed the available supply. In return, BNL sometimes receives a rebate for each megawatt reduced on each curtailment day. The Laboratory strives to keep electric loads at a minimum during the summer by scheduling operations at the Relativistic Heavy Ion Collider to avoid peak demand periods. In 2017, this scheduling reduced the electric demand by 25 MW, saving approximately $1.0 million in electric demand costs and helping to maintain the reliability of the Long Island Power Authority (LIPA) electric system to meet all of its users' needs. BNL also maintains a contract with the New York Power Authority (NYPA) that resulted in an overall cost avoidance of $27.4 million in 2017. In addition, BNL's energy supply includes approximately 120 million kWh of clean, renewable energy credits (RECs) received through the Long Island Solar Farm (LISF) and purchased 61 million kWh of RECs for 2017. The Laboratory will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

In 2011, BP Solar completed construction of the LISF on BNL property. The array is currently the largest solar photovoltaic (PV) array (32 MW) in the Northeast and spans 195 acres with more than 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 annual output for 2017 was 49.64 million kWh and resulted in an avoidance of approximately 32,100 tons of carbon. At the time of the installation the estimated annual output was 44 million kWh. The actual output for the first six operational years was an average of 51.1 million kWh/year, substantially above the estimated annual average value. As an outcome of constructing this large array on site, the Laboratory has developed a solar research program that looks 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 recognizes the importance of the efforts of BNL and the DOE Brookhaven Site Office to host the LISF, and provides credit toward BNL's SSP renewable energy goal.

In May 2014, the Laboratory completed the installation of the first phase of the solar PV research array as part of the Northeast Solar Energy Research Center (NSERC). In 2016, the array was increased to 816 kW with substantial funding assistance from the Sustainability Performance Office (SPO). In 2017, the NSERC generated 968,445 kWh of electricity. To reduce energy use and costs at non-research facilities, several additional activities were continued or undertaken by the BNL Energy Management Group in 2017:

- *NYPA Power Contract:* Fifth full year of a 10-year contract that includes 15 MW of renewable (nearly zero GHG) hydropower. This contract saved $27.4 million in 2017.
- *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 has developed 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 annual 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 RECs in meeting BNL's SSP goal; and training various parties on energy conservation initiatives.
- *Utility Energy Services Contract (UESC):* A UESC contract/project was completed in 2015 with National Grid that installed energy-efficient lighting, new building controls, and an energy-efficient water chiller. The environmental benefits of this UESC were estimated to include: electrical savings of 3,549,114 kWh/year, fuel savings of 89,541 mmBtu/year, a GHG reduction of 7,022 MT-CO2e, and a building energy intensity reduction of 11 percent. To date, actual energy savings meet or exceed the original estimates. Through a comprehensive Measurement and Verification process, BNL has been able to verify that actual energy savings were within a few percent of the original projections for the first two years of operation.
- *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 meet or exceed the HPSB goal.
- *Renewable Energy:* Continued project support for the LISF and NSERC facilities and annual purchases of REC's to meet targeted goals.
- The Central Chilled Water Facility continues to utilize a 3.2 million gallon chilled water storage tank to reduce peak electric demand by producing and storing chilled water during the night.
- *Natural Gas Purchase Contract:* BNL is currently saving approximately $4 million per year using natural gas compared to oil.
- *Energy Savings:* As mentioned above, 25 MW of demand is rescheduled each year to avoid coinciding with the utility summer peak, saving over $1.0 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 or LED fixtures as appropriate. Typically, 200 to 300 fixtures are 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 2017 was approximately 30 percent less than in 2003, producing annual savings of $2.9 million.

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 of 2007, requires federal agencies to apply energy conservation measures and to improve federal building design to reduce energy consumption per square foot (Energy Intensity). Current goals included with EO 13693 are to reduce energy consumption per square foot, relative to 2015, by 25 percent by the year 2025. As shown in Figure 2-3, BNL's energy use per square foot in 2017 was 30 percent less than in FY 2003. Going forward BNL will be comparing the current Energy Intensity values to the new base year of 2015. It is important to note that energy use for most 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 2016), BNL continues to enhance its Natural Resource Management Program in cooperation with the Foundation for Ecological Research in the Northeast 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

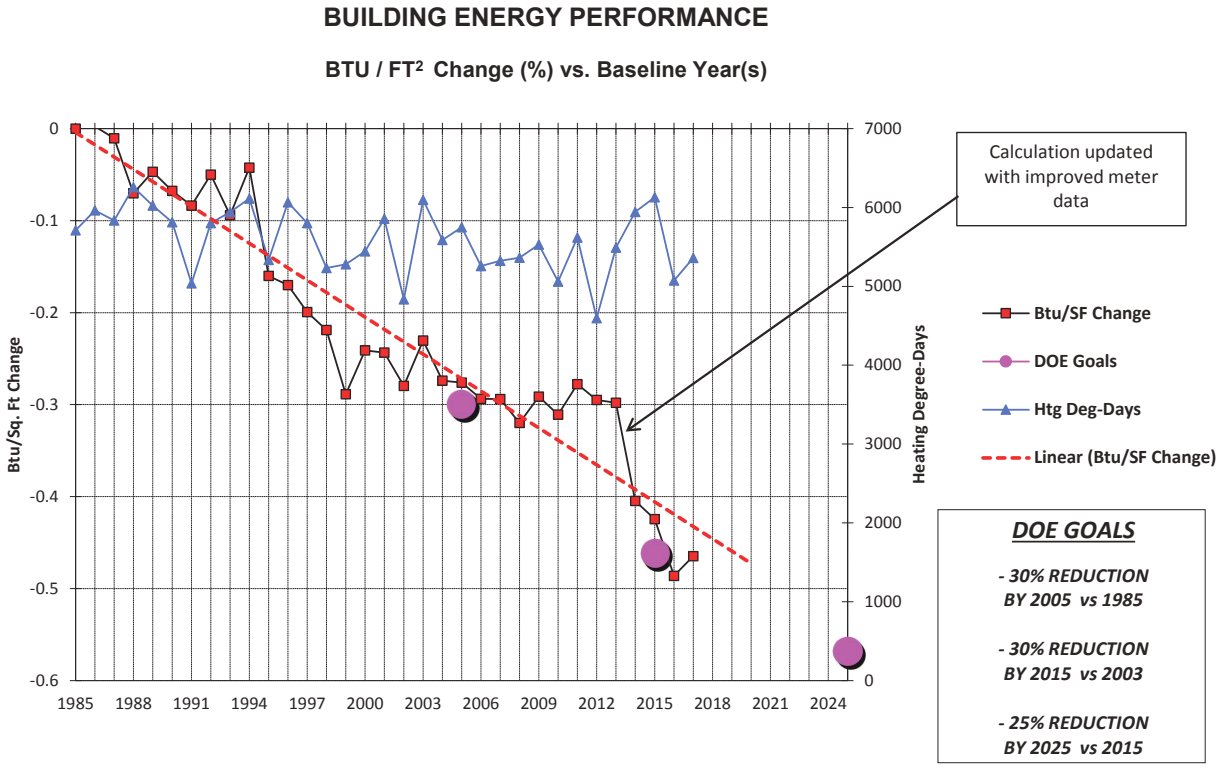

Figure 2-3. BNL Building Energy Performance for 2017 (Btu/SF Change Percent vs. Baseline Years).

eligible for inclusion on the National Register of Historic Places. See Chapter 6 for further information about these programs.

2.3.4.8 Environmental Restoration

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress in 1980. As part of CERCLA, EPA established the National Priorities List, which identifies sites where cleanup of past contamination is required. BNL was placed on the list with 27 other Long Island sites, 12 of which are in Suffolk County. Each step of the CERCLA cleanup process is reviewed and approved by DOE, EPA, and NYSDEC, under an Interagency Agreement (IAG). 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;
- Perform the Remedial Design/Remedial Action, which includes final design, construction specifications, and carrying out the remedy selected.

In 2017, BNL's 11 active groundwater treatment systems removed approximately 71

pounds of volatile organic compounds (VOCs) and 0.5 mCi of strontium-90 (Sr-90) and returned 0.5 billion gallons of treated water to the sole source aquifer. Following the update of the groundwater model with VOC characterization data collected since 2016, additional groundwater extraction wells will need to be installed to ensure that the cleanup goals for the Western South Boundary plume are met. Design of the additional extraction wells was initiated in 2017. As a follow-up to the January 2017 sampling of 22 on and off-site monitoring wells for the solvent stabilizing compound 1,4-Dioxane, SCDHS requested additional samples be collected. Samples from seven additional monitoring wells, the effluent from five treatment systems and the STP effluent were collected by BNL and analyzed for 1,4-Dioxane in December 2017 and January 2018. All 1,4-Dioxane results were below the current New York State standard of 50 µg/L for unspecified organic contaminants.

In the summer of 2017, the excavation and disposal of 108 cubic yards of mercury-contaminated sediment in a small area of the Peconic River on BNL property were performed. Also in 2017, long-term surveillance and maintenance of the Brookhaven Graphite Research Reactor

Table 2-4. Summary of BNL 2017 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 nine groundwater treatment systems that remove volatile organic compounds (VOCs), and two systems that remove strontium-90 (Sr-90). ▪ 71 pounds of VOCs and 0.5 mCi of Sr-90 were removed during the treatment of 0.95 billion gallons of groundwater. Since the first groundwater treatment system started operating in December 1996, approximately 7,526 pounds of VOCs and 33 mCi of Sr-90 have been removed, while treating approximately 27 billion gallons of groundwater. ▪ Collected and analyzed approximately 1,299 sets of groundwater samples from 553 monitoring wells. ▪ Installed 14 temporary wells and collected multiple samples from each location.
Peconic River	OU V	▪ Excavation and disposal of 108 cubic yards of mercury-contaminated sediment in a small area on BNL property was completed in the summer of 2017.
Reactors	Brookhaven Graphite Research Reactor (BGRR)	▪ Continued long-term surveillance and maintenance, including repair to the roof drain and flashing on the below ground duct doghouses, repositioning the cap vehicle weight restriction signs.
	High Flux Beam Reactor (HFBR)	▪ Continued long-term surveillance and maintenance, including repair to the outside roof drain, and removal of a small tree against the foundation.
	Stack (Building 705)	▪ Continued long-term surveillance and maintenance, including pump-out of the stack drain tank, collection and disposal of stack paint chips on the grounds, and repair of the aviation lights on the stack.
	Brookhaven Medical Research Reactor (BMRR)	▪ Continued surveillance and maintenance activities.
Former Buildings 810/811	Former Radiological Liquid Processing Facility	▪ Continued surveillance and maintenance, and maintained institutional controls of the remaining area of contaminated soil to the north of the former facility.
Building 801	Inactive Radiological Liquid Holdup Facility	▪ Performed routine surveillance and maintenance of the facility.
Building 650	Inactive Radiological Decon Facility	▪ Performed routine surveillance and maintenance of the facility.

and the High Flux Beam Reactor (HFBR) continued. In accordance with the ROD, demolition of the HFBR stack will be completed by the end of fiscal year 2020. The groundwater systems operate in accordance with the Operations and Maintenance manuals, while the Peconic and surface soil cleanup areas are monitored via the Soil and Peconic River Surveillance and Maintenance 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 Operable Unit, 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. Supervisors are required to work with their employees to develop and document Roles, Responsibilities, Accountabilities, and Authorities (R2A2). BSA has clearly defined expectations for management and staff which must be included in the R2A2 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 commitment to open communication and community involvement, the External Affairs & Stakeholder Relations (EASR) Office develops best-in-class communications, science education, government relations, and community involvement programs that advance the science and science education missions of the Laboratory. EASR contributes to the public's understanding of science, 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. EASR also works to maintain relationships with BNL employees and external stakeholders, such as neighbors, business leaders, elected officials, and regulators 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, EASR'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.

The EASR's Office of Educational Programs manages various education initiatives and programs that support the scientific mission at BNL and the DOE. Programs include Summer Science Explorations for grades four through 12, the Science Learning Center, internships, contests in science, technology, engineering, or math, and postdoctoral programs.

2.4.2.1 Communication Forums

To create opportunities for effective dialogue between the Laboratory and its stakeholders, several forums for communication and involvement have been established, such as the following:

- 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 comprised of 27 member organizations and individuals representing civic, education, employee, community, environmental, business, and health interests. The CAC sets its own agenda in cooperation with the Laboratory and typically meets monthly, except for July and August. The CAC is one of the primary ways the Laboratory keeps the community informed. Meetings are open to the public and are announced on the BNL homepage calendar and on the Stakeholder Relations website which links to the CAC webpage, meeting agendas, and past meeting presentations and minutes. 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 update them on project status. The calls also provide the opportunity to gather input and feedback and to discuss emerging environmental findings and initiatives.
- 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 to discuss 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 2,125 visitors in 2017.
  - *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 2017, more than 5,000 visitors participated in the program.
  - *PubSci:* BNL's science café and conversation series features distinguished Laboratory scientists who appear at public venues to discuss cutting-edge topics and research in an informal setting. During 2017, science-interested community members and BNL and Stony Brook University researchers discussed "Dark Matter, Dark Energy."
  - *Science on Screen:* This partnership program with the Huntington Cinema Arts Centre presents classic, cult, or documentary movies that provide BNL scientists an opportunity to discuss their research. In 2017, the Centre featured a showing of "Still Alice," a 2014 American independent film based on the true story of a linguistics professor diagnosed with Alzheimer's disease; BNL and Stony Brook University researchers highlighted research on Alzheimer's disease at BNL's National Synchrotron Light Source-II.

The Laboratory also participates in and hosts various outreach events throughout the year such as festivals, workshops, BNL's Earth Day celebration, the World Science Festival, the City of Science, and the Port Jefferson Mini-Maker Faire. 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 printed weekly employee newsletters–*Brookhaven This Week* and *The Brookhaven Digest*. In addition, 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.

Community members can ask questions or comments by clicking on the "Let us know" link found under "Listening to you" on the Stakeholder Relations website at *www.bnl.gov/stakeholder/*. Community members can also subscribe to the weekly e-newsletter, *Brookhaven This Week*, found on the Media Communications webpage at *www.bnl.gov/*, which keeps Lab employees and the community informed about happenings at BNL, explains some of the science behind Laboratory research, and invites subscribers to educational and cultural events.

2.4.2.2 Community Involvement in Cleanup Projects

In 2017, BNL updated stakeholders on the progress of environmental cleanup projects, additional initiatives, and health and safety issues via mailings, briefings, and presentations given at CAC and BER meetings.

These topics included the following:

- *Natural & Cultural Resources Update:* The CAC received updates on BNL's natural resources, including the following: status of flora and fauna on-site; specifics about the Peconic River post cleanup surveillance; Cesium 137 in deer, terrestrial vegetation and soil; and mercury in precipitation. The group was also informed of the implementation of the Lab's cultural resources tagging project; the Annual Groundwater Update; the general status of Plumes and Remediation Systems/ System Optimization; Building 452 freon-11 and g-2 tritium plume status; current groundwater issues and upcoming plans; NYSDEC/ NYSDOH data request; 1,4 Dioxane; and the Five-Year Review Status.
- *Environmental Updates*: The CAC also received updates on the following environmental cleanup topics: Building 811 demolition project; the Former Hazardous Waste Management Facility (Former HWMF); Sr-90 plume update; western south boundary area VOC characterization update; ethylene dibromide detection in off-site monitoring well; Freon-11 treatment system; 1,4-Dioxane planned groundwater sampling; and the Five-Year Review Status.
- *Accelerator Complex Cooling Leak*: In 2017, CAC members were informed of an Accelerator Complex cooling leak with specifics provided on the timing of the leak; technical details of the cooling water system; the source of tritium; environmental impacts; groundwater monitoring plans; repairs to the system; and next steps.
- *Deer Management*: The 2017 Deer Management plan was presented to the CAC with information on the current deer population; implementation of the deer management plan; meat processing and distribution; and path forward.
- *1, 4 Dioxane Sampling*: In response to a recommendation by the NYSDEC/ NYSDOH during their review of the 2015 Groundwater Status Report, BNL agreed to collect samples from 22 representative groundwater monitoring wells on and off site that currently or historically had significant trichloroethane concentrations or are downgradient of those locations. The CAC was provided with the sample data from those sites, which included drinking water supply wells and groundwater monitoring data. The Lab reported it will continue to monitor regulatory discussion and action on this emerging chemical of concern and keep the CAC informed.
- *Environmental Updates*: Information was provided regarding the supplemental Peconic River WC-06 Cleanup and the Deer Management Program.

- *Groundwater Updates*: In June 2017, the CAC was provided with an update on the VOC plume at the Laboratory's western south boundary. Later in the year, the group was presented with a review of plumes, treatment systems, performance and progress on groundwater systems.

2.4.3 Monitoring and Measurement

DOE Order 436.1 requires DOE sites to maintain an EMS which conforms to the ISO14001 Standard for Environmental Management Systems. BNL's EMS specifies requirements for conducting general surveillance to determine impact from site operations to the environment. DOE Order 458.1 Admin Chg 3, (2013), *Radiation Protection of the Public and Environment*, requires DOE sites to maintain surveillance monitoring for determining radiological impacts, if any, to the public and environment from site operations.

BNL's EMS includes an Environmental Monitoring Program (EMP) which 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 EMP defines how the Laboratory will monitor effluents and emissions to ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. 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. The monitoring programs are reviewed and revised, as necessary, 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 shown in Table 2-5, in 2017, there were 5,492 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 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 agencies. 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 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, the RCRA permit

for the Waste Management Facility, and the SPDES permit for the Sewage Treatment Plant. 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 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

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.

Table 2-5. Summary of BNL Sampling Program Sorted by Media, 2017.

Environmental Media	No. of Sampling Events(a)	Purpose
Groundwater	1,450	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	50	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	54 ES 204 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)	122	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	8	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	234	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	328 ES/C 48 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.

(continued on next page)

Table 2-5. Summary of BNL Sampling Program Sorted by Media, 2017. *(concluded).*

Environmental Media	No. of Sampling Events(a)	Purpose
Fauna	18	Fish and deer are monitored to assess impacts on wildlife associated with past or current BNL operations. See Chapter 6 for further detail.
Flora	14	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	197	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	276	Samples are collected periodically from potable water fixtures and dispensers, manholes, spills, to assess process waters, and to assess sanitary discharges.
Groundwater Treatment Systems Monitoring	922	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 11 operating groundwater treatment systems. See discussion in Chapter 7.
State Pollutant Discharge Elimination System (SPDES)	308	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	555	Flowcharts are exchanged weekly as part of BNL's SPDES permit requirements to report discharge flow at the recharge basin outfalls.
Floating Petroleum Checks	102	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	492	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)	110	To ensure that the concentrations of contaminants reported in the Site Environmental Report are accurate, additional samples are collected. These samples detect if contaminants are introduced during sampling, transportation, or analysis of the samples. QA/QC samples are also sent to the contract analytical laboratories to ensure their processes give valid, reproducible results.
Total number of sampling events	5,492	The total number of sampling events includes all samples identified in the Environmental Monitoring Plan (BNL 2017), 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.
C = Compliance
ES = Environmental Surveillance

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 is 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 mediaspecific 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, assessments are conducted as part of BNL's Self-Assessment Program. Self-assessment is the systematic evaluation of internal processes and performance. Two types of assessments are conducted: the ISO 14001 Standard conformance assessment and the regulatory compliance assessments.

- The approach for the ISO14001 program self-assessment includes evaluating programs and processes within organizations that have environmental aspects to verify conformance to the ISO14001 Standard. The assessment is performed by qualified external assessors or BNL staff members who do not have line responsibility for the work processes involved. Progress toward achieving environmental objectives is monitored, as are event-related metrics to determine the overall effectiveness of the EMS. The assessment determines if there are Laboratory-wide issues that require attention, as well as facilitates the identification and communication of "best management" practices used in one part of the Laboratory that could improve performance in other parts.
- Compliance assessments are also 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 that reflect external compliance 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 conducted to identify the root causes of problems, as well as identify corrective actions and lessons learned if regulatory noncompliance or impact occurs to correct the problem and prevent reoccurrence.
- BNL management 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.

The Laboratory's Self-Assessment Program is augmented by programmatic, external audits conducted by DOE. BSA staff and subcontractors also perform periodic independent reviews, and an independent third party conducts ISO 14001 registration audits of BNL's EMS. The Laboratory is 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 on-going 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 over 70 years, the unique, leadingedge 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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3 Compliance Status

Brookhaven National Laboratory (BNL) 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 2017, 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 well within permit limits in 2017. There were two recorded excess opacity measurements due to unknown causes, five due to a temporary failure of the transmissometer blower motor, and a single excess opacity reading that occurred during quarterly quality assurance tests of the Boiler 6 and 7 opacity monitors. All of the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to the New York State Department of Environmental Conservation (NYSDEC).

In 2017, 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 part of an ongoing program to phase out the use of chlorofluorocarbons as extinguishing agents. Monitoring of BNL's potable water system indicated that all drinking water requirements were met during 2017. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System permit requirements. Only two excursions above permit limits were reported for the year; one non-compliance event for Biological Oxygen Demand (BOD5) occurred at the Sewage Treatment Plant and one non-compliance event was reported for a 1-Hydroxyethylidene-1, 1-diphosphonic acid (HEDP) at Outfall 002 (HN). The permit excursions were reported to 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 2017. There were 21 spills and 11 of those spills met regulatory agency reporting criteria. The severity of releases were minor, and all releases were cleaned up to the satisfaction of NYSDEC.

BNL participated in ten environmental inspections or reviews by external regulatory agencies in 2017. These inspections included Sewage Treatment Plant operations; hazardous waste management facilities; regulated petroleum 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 below.

- State Pollutant Discharge Elimination System (SPDES) permits, issued by NYSDEC

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 became subject to 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 a 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 2072, 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. Buildings 50 years old or older are reviewed under Section 106 of NHPA when proposed projects may significantly alter the structure or for building demolition. In 2016, four (4) 1960s era apartments were evaluated under Section 106 requirements and were determined to be eligible for listing on the National Register of Historic Places. The package developed is expected to meet requirements for mitigation once additional documents are provided to the NYSHPO.	3.4
EPA: 40 CFR 50 40 CFR 60-61 40 CFR 63 40 CFR 80 40 CFR 82 40 CFR 98 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). All applicable CAA and NYCRR regulations are incorporated into the BNL Title V permit. Radiological air emission sources are registered with the EPA.	3.5

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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 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 two excursions, these discharges met the SPDES permit limits in 2017.	3.6
EPA: 40 CFR 141–149 NYSDOH: 10 NYCRR 5	The Safe Drinking Water Act (SDWA) and New York State Department of Health (NYSDOH) standards for public water supplies establish minimum drinking water standards and monitoring requirements. SDWA requirements are enforced by the Suffolk County Department of Health Services (SCDHS).	BNL maintains a sitewide public water supply. This water supply met all primary drinking water standards in 2017. Corrective actions for all identified operation and maintenance deficiencies were established and communicated with SCDHS and are being addressed by the Laboratory's Energy and Utilities Division.	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 2017.	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 continues to conform 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, herbicides, biocides, rodenticides, fungicides, tickicides, as well as the pesticide containers and residuals.	BNL contracts and/or employs NYSDEC-certified pesticide applicators for specific pesticide categories to apply pesticides, herbicides, biocides, rodenticides, fungicides, and tickicides. Each applicator attends Continuing Education training, as needed, to maintain current category certifications and BNL (or the contractor that applies regulated materials) files an annual report to the NYSDEC Pesticide Bureau detailing the above applications including EPA Registration Nos., dates of applications, method of application, target organisms, types, locations, quantity and dosage rates 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. A small section of the Peconic River required additional clean-up which was conducted under a Wetlands Equivalency Permit in 2017.	3.12

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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
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 flora and fauna. Many species have been categorized by New York State as endangered, threatened, or of special concern; and one threatened species has been designated under the Endangered Species Act. The Laboratory's Natural Resource Management Plan outlines activities to protect these vulnerable species and their habitats (see Chapter 6 for details).	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 there are no impacts to nesting birds.	3.13
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 Safety and Health 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 414.1D 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/Rule, coupled with consensus standards, where appropriate, to ensure: 1) products and services meet or exceed customers' expectations; 2) management support for planning, organization, resources, direction, and control ; 3) performance and quality improvement thorough rigorous assessment and corrective action and; and 4) environmental, safety, and health risks and impacts associated with work processes are minimized while maximizing reliability and performance of work products.	BNL has a Quality Assurance (QA) Program in place to implement quality management methodology throughout its management systems and associated processes to: (1) achieve and maintain compliance with applicable environmental, safety, security, and health (ESSH) requirements; (2) continue improvement in ESSH performance; (3) provide a safe and healthy workplace; (4) protect the environment and conserve resources; (5) prevent pollution; (6) provide services and products of the highest quality consistent with the needs, expectations, and resources of our customers; and (7) continuously improve processes, systems, and capabilities to improve operations and increase the value of research products delivered to customers. 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

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
DOE: Order 435.1 Chg. 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 Chg. 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, 2010, 2013, and 2016. Continued system conformance was internally verified during 2017 with a full independent, external assessment scheduled to certify BNL's conformance to ISO14001:2015 revised standard during 2018.	Chapter 2
DOE: Order 458.1, Change 3	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, and 8

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

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	Tritium Evaporator	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 LINAC 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	1-52-009	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-21	NA	NA
NYSDEC - SPDES Equivalency	670	Sr-90 Treatment System	1-52-009	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	Closed out 2013	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	1-52-009	16-Dec-19	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System - BGRR/WCF	1-52-009	16-Dec-19	NA	NA
NYSDEC - SPDES Equivalency	TR 867	T-96 Remediation System	1-52-009	20-Mar-22	NA	NA
NYSDEC - SPDES Equivalency	644	Freon-11 Treatment System	1-52-009	20-Mar-22	NA	NA
NYSDEC - SPDES Equivalency	OS-2	Industrial Park Treatment System	1-52-009	30-Sep-19	NA	NA
NYSDEC - Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-19	NA	NA
NYSDEC - LI Well Permit	BNL	Domestic Potable/Process Wells	1-4722-00032/00151	17-Jul-26	NA	NA
NYSDEC - Air Quality	423	Metal Parts Cleaning Tank	1-4722-00032/00115	03-Feb-19	U-METAL	42308
NYSDEC - Air Quality	423	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	03-Feb-19	U-FUELS	42309-10
NYSDEC - Air Quality	423/630	Motor Vehicle A/C Servicing	1-4722-00032/00115	03-Feb-19	U-MVACS	MVAC1- 3
NYSDEC - Air Quality	244	Paint Spray Booth	1-4722-00032/00115	03-Feb-19	U-PAINT	24402
NYSDEC - Air Quality	244	Flammable Liquid Storage Cabinet	1-4722-00032/00115	03-Feb-19	U-PAINT	244AE
NYSDEC - Air Quality	479	Metal Parts Cleaning Tank	1-4722-00032/00115	03-Feb-19	U-METAL	47908
NYSDEC - Air Quality	510	Spin Coating Operation	1-4722-00032/00115	03-Feb-19	U-INSIG	510AK
NYSDEC - Air Quality	801	Target Processing Laboratory	1-4722-00032/00115	03-Feb-19	U-INSIG	80101
NYSDEC - Air Quality	Site	Aerosol Can Processing Units	1-4722-00032/00115	03-Feb-19	U-INSIG	AEROS
NYSDEC - Air Quality	498	Aqueous Cleaning Facility	1-4722-00032/00115	03-Feb-19	U-METAL	49801
NYSDEC - Air Quality	535B	Plating Tanks	1-4722-00032/00115	03-Feb-19	U-INSIG	53501
NYSDEC - Air Quality	535B	Etching Machine	1-4722-00032/00115	03-Feb-19	U-INSIG	53502
NYSDEC - Air Quality	535B	Printed Circuit Board Process	1-4722-00032/00115	03-Feb-19	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	03-Feb-19	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-61007	61007
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	03-Feb-19	U-METAL	61008
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-61005	6101A
NYSDEC - Air Quality	630	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	03-Feb-19	U-FUELS	63001-03
NYSDEC - Air Quality	902	Epoxy Coating/Curing Exhaust	1-4722-00032/00115	03-Feb-19	U-COILS	90206
NYSDEC - Air Quality	903	Metal Parts Cleaning Tank	1-4722-00032/00115	03-Feb-19	U-METAL	90304
NYSDEC - Air Quality	922	Electroplating Operation	1-4722-00032/00115	03-Feb-19	U-INSIG	92204
NYSDEC - Air Quality	923	Electronic Equipment Cleaning	1-4722-00032/00115	03-Feb-19	U-METAL	9231A
NYSDEC - Air Quality	923	Parts Drying Oven	1-4722-00032/00115	03-Feb-19	U-METAL	9231B
NYSDEC - Air Quality	Site	Halon 1211 Portable Extinguishers	1-4722-00032/00115	03-Feb-19	U-HALON	H1211
NYSDEC - Air Quality	Site	Halon 1301 Fire Suppression Systems	1-4722-00032/00115	03-Feb-19	U-HALON	H1301
NYSDEC - Air Quality	Site	Commercial Refrigeration Equipment	1-4722-00032/00115	03-Feb-19	U-RFRIG	COMRE
NYSDEC - Air Quality	Site	Packaged A/C Units	1-4722-00032/00115	03-Feb-19	U-RFRIG	PKG01-02
NYSDEC - Air Quality	Site	Reciprocating Chillers (45)	1-4722-00032/00115	03-Feb-19	U-RFRIG	REC01-53
NYSDEC - Air Quality	Site	Rotary Screw Chillers (15)	1-4722-00032/00115	03-Feb-19	U-RFRIG	ROTO1-15
NYSDEC - Air Quality	Site	Split A/C Units	1-4722-00032/00115	03-Feb-19	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal Chillers (19)	1-4722-00032/00115	03-Feb-19	U-RFRIG	CEN01-26
NYSDEC - Air Quality	463	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	46301
NYSDEC - Air Quality	490	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	49006
NYSDEC - Air Quality	515	Diesel Non-Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	51501
NYSDEC - Air Quality	555	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	55503
NYSDEC - Air Quality	635	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	63501
NYSDEC - Air Quality	734	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	73401
NYSDEC - Air Quality	735	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	73501
NYSDEC - Air Quality	740	Diesel Emergency Generators (2)	1-4722-00032/00115	03-Feb-19	U-GENER	74001-02
NYSDEC - Air Quality	801	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	80102
NYSDEC - Air Quality	912	Diesel Emergency Generators (3)	1-4722-00032/00115	03-Feb-19	U-GENER	912A1-A3
NYSDEC - Air Quality	30	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	030AB
NYSDEC - Air Quality	244	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	244AB
NYSDEC - Air Quality	422	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	422AF
NYSDEC - Air Quality	423	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	42304
NYSDEC - Hazardous Waste	WMF	Waste Management	1-4722-00032/00102	06-Sep-22	NA	NA
NYSDEC - Water Quality	CSF	Major Petroleum Facility	1-1700	31-Mar-22	NA	NA
NYSDEC - WQ- Equivalency	Site	Peconic River Cleanup	1-4722-00032/00153	24-Apr-22	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

- 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 (e.g., fuel oil)
- 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 13 emission units
- EPA Underground Injection Control (UIC) Area permit for the operation of 125 UIC wells (e.g., dry wells and cesspools)
- Permit for the operation of six domestic water supply wells and one irrigation well, issued by NYSDEC
- Twelve SPDES 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

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

The Laboratory had one wetland or Wild, Scenic, and Recreational Rivers Permit opened in 2017. The New York State Wild, Scenic, and Recreational Rivers Act was created by the state legislature in 1972 to protect and preserve certain rivers considered to have remarkable scenic, recreational, geologic, fish wildlife, historic, cultural, or other similar values. The permit is an equivalency permit for the cleanup of a small area of contamination within the Peconic River.

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 2017, environmental evaluations were completed for 146 proposed projects at BNL. Of those, 144 were considered minor actions requiring no additional documentation. Two projects were addressed by submitting notification forms to DOE, which determined that both projects were covered by existing "Categorical Exclusions" (per 10 CFR 1021) or fell within the scope of a previous environmental assessment.

3.4 PRESERVATION LEGISLATION

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

BNL has four 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, the 1960s Era Efficiency Apartments, 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 2013a), 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. Cultural resource activities 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 2017, 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 (NOx). The NOx RACT standard for the combustion of natural gas and No. 6 oil burned in the Laboratory's three large boilers (Nos. 5, 6, and 7) is 0.15 lbs/MMBtu for both fuels. The NOx RACT emission limit for the CSF's one mid-size boiler (No. 1A) is 0.20 lbs/MMBtu.

Boilers with a maximum operating heat input between 25 and 250 MMBtu/hr (7.3 and 73.2 MW) can demonstrate compliance with the NOx standard using periodic emission tests or by using continuous emission monitoring equipment; all four CSF boilers fall in this operating range. Boilers 6 and 7 use continuous emission monitoring systems (CEMS) to demonstrate compliance with NOx standards. Because past emissions testing and CEMS results when No. 6 oil was burned have shown that all four CSF boilers cannot meet the new lower NOx RACT standards effective as of July 2014, BNL is using an approved system averaging plan to demonstrate compliance in quarterly reports submitted to NYSDEC. 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 six-minute averages, except for one period not to exceed 27 percent in any one hour.

During 2017, there were no recorded exceedances of the NOx RACT limit by the Boiler 6 and 7 CEMS. Using the system averaging approach, actual weighted average NOx emission rates for operating boilers for the first through fourth quarters were 0.104, 0.102, 0.077, and 0.101 lbs/MMBtu, respectively, which were below the corresponding quarterly permissible weighted average emissions rates of 0.152, 0.150, 0.150, and 0.150 lbs/MMBtu.

In 2017, there were two recorded excess opacity measurements due to unknown causes, five due to a temporary failure of the transmissometer blower motor, and a single excess opacity reading that occurred during quarterly quality assurance tests of the Boiler 6 and 7 opacity monitors. All of the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to NYSDEC. Chapter 4 discusses CSF compliance with NOx RACT standards and opacity limits in greater detail.

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 2017, 144 pounds of R-22 and 2,100 pounds of R-123 were recovered and recycled from refrigeration equipment that was serviced. Meanwhile, two pounds of R-11, 426 pounds of R-22, 185 pounds of R-134A, and 54 pounds of R-410 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, Laboratory 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 2017, 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. In April 2017, the Laboratory transferred 318 pounds of Halon 1301from a decommissioned fire suppression system to the Department of Defense Ozone Depleting Substances Reserve in Richmond, Virginia. The transfer was made in accordance with the Class I Ozone Depleting Substances Disposition Guidelines prepared by the DOE Office of Environmental Policy and Guidance.

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 2017, 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 2017, the Laboratory notified the EPA Region II office regarding the removal of materials containing asbestos. During the year, 35,420 pounds of friable asbestos (e.g., pipe insulation, transite board, floor tiles, water main pipes) materials were removed and disposed of according to EPA requirements.

3.5.2.3 Radioactive Airborne Emissions

Minor and major sources of radiological airborne emissions from BNL's facilities and activities are evaluated 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 2017 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, 2017 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 2017 was 7.24 E-01 mrem (7.24 μSv).

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 nine of 12 outfalls, as described below. See Figure 5-3 in Chapter 5 for the locations of the following BNL outfalls:

- Outfall 001 is used to discharge treated effluent from the Sewage Treatment Plant (STP) to groundwater recharge basins.
- 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. Because 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., cesspools) 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 (DMRs) that describe monitoring results, evaluate compliance with permit limitations, and identify corrective measures taken to address permit excursions. These reports are submitted electronically to EPA, NYSDEC central and regional offices, and the SCDHS through a new Network DMR (NetDMR) system. 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 surface water. 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 groundwater recharge basins. The STP provides tertiary treatment of the wastewater and includes the following processes: settling/sedimentation, biological reduction of organic matter and nitrogen, and final filtration. 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, along with relevant SPDES permit limits. 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 2017.

There was one excursion of the SPDES permit limit for Biological Oxygen Demand (BOD_5) at Outfall 001. A composite sample collected on April 3, 2017 for routine compliance analysis exhibited a BOD_5 concentration of 5.8 mg/L. The permit limit for BOD_5 is 5 mg/L. The cause of this noncompliance event was not determined as there were no plant upsets during this time period. Fifteen years of analytical results for BOD_5 from the STP Outfall were reviewed and the limit was never exceeded; due to this past performance, this excursion was not expected to recur.

As a preventative (long term) corrective action, a permittee initiated SPDES Permit Modification request to NYSDEC to remove the permit limit for BOD_5 and other surface water based effluent limits at the STP was initiated and submitted for NYSDEC approval. The basis for this was that BNL's STP no longer discharges to surface water (Peconic River). Starting in October 2014, discharges to the river ceased after construction of a new final filtration system and groundwater recharge basins. The low BOD_5 effluent discharge limit was based on the fact that discharges prior to 2014 were to a stream where little or no streamflow was available for dilution and therefore subject to intermittent stream effluent limits. In October 2017, BNL received a new SPDES permit that included the removal of BOD_5 as a required permit limit.

Figures 3-1 through 3-7 plot the five-year trends for monthly concentrations of copper, iron,

lead, mercury, nickel, silver, and zinc in the STP discharge.

3.6.2 Recharge Basins and Stormwater

Water discharged to Outfalls 002 through 008 and Outfalls 010 through 012 recharges to groundwater, replenishing the underlying aquifer. Monitoring requirements for each of these discharges vary, depending on the type of wastewater received and the type of cooling water treatment reagents used. Table 3-4 summarizes the monitoring requirements and performance results.

In 2017, there was one non-compliance event reported for Outfall 002 (HN). A grab sample collected on January 4, 2017 for routine quarterly compliance analysis exhibited a 1-Hydroxyethylidene-1, 1-diphosphonic acid (HEDP) concentration of 1.09 mg/L. The permit

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*
pH (SU)	6.2	8.4	Continuous Recorder	Min 5.8, Max. 8.5	0	100
Max. 5-Day BOD (mg/L)	<2	5.8	Twice Monthly	5	1	96
% BOD Removal	> 89	> 98	Monthly	85	0	100
Max. TSS (mg/L)	<0.6	2.2	Twice Monthly	20	0	100
% TSS Removal	> 96	>99	Monthly	85	0	100
Settleable solids (ml/L)	0	0	Daily	0.1	0	100
Solids, Total Dissolved (mg/L)	303	503	Monthly	1000	0	100
Ammonia nitrogen (mg/L)	< 0.1	1.2	Twice Monthly	2	0	100
Total nitrogen (mg/L)	0.85	9.8	Twice Monthly	10	0	100
Total phosphorus (mg/L)	1.1	1.9	Twice Monthly	NA	0	100
Cyanide (mg/L)	< 0.002	0.003	Twice Monthly	0.1	0	100
Copper (mg/L)	0.006	0.027	Twice Monthly	0.15	0	100
Iron (mg/L)	0.22	0.47	Twice Monthly	0.6	0	100
Lead (mg/L)	0.001	0.005	Twice Monthly	0.025	0	100
Mercury (ng/L)	5	20	Twice Monthly	200	0	100
Methylene chloride (ug/L)	<2	< 2	Twice Monthly	5	0	100
Nickel (mg/L)	< 0.002	0.004	Twice Monthly	0.1	0	100
Silver (mg/L)	< 0.001	0.001	Twice Monthly	0.015	0	100
Toluene (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Zinc (mg/L)	0.03	0.23	Twice Monthly	2	0	100
1,1,1-trichloroethane (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Max. Flow (MGD)	0.3	1.0	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.16	0.3	Continuous Recorder	NA	0	100
HEDP (mg/L)	<0.05	0.28	Monthly	0.5	0	100
Tolytriazole (mg/L)	< 0.005	< 0.005	Monthly	0.05	0	100

Notes: Notes:
See Figure 5-3 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
NA = Not Applicable
SPDES = State Pollutant Discharge Elimination System
SU = standard unit
TSS = total suspended solids

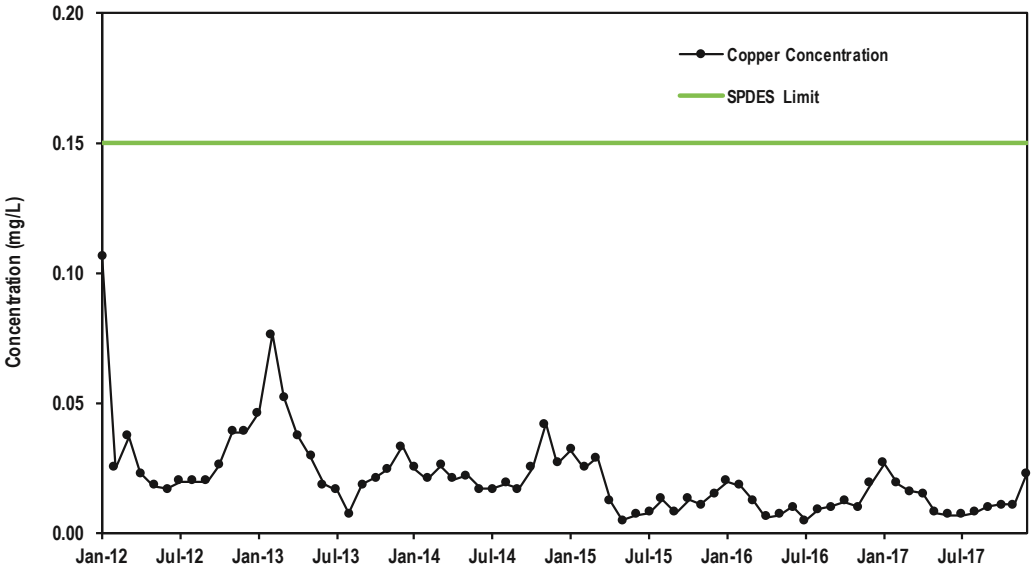

Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2012–2017.

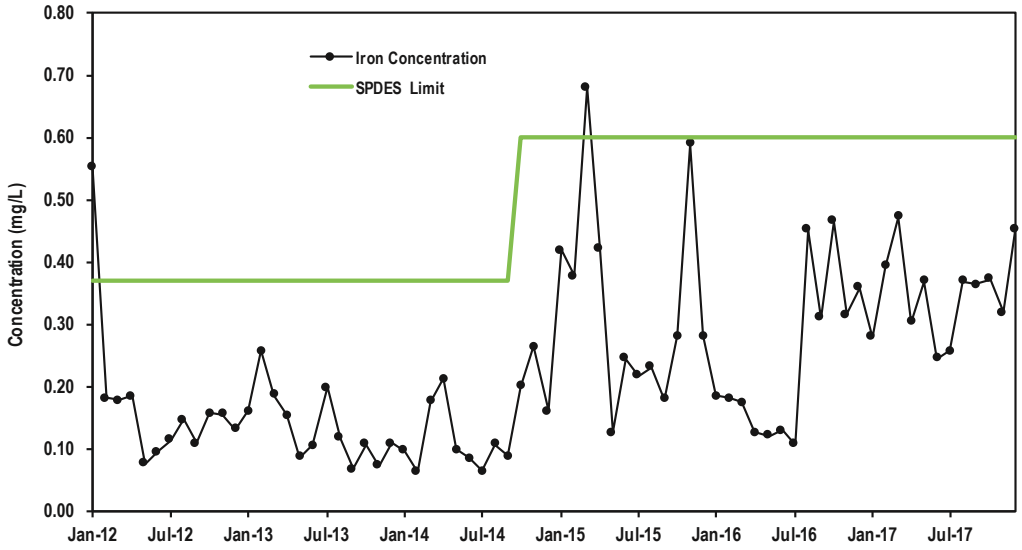

Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2012–2017.

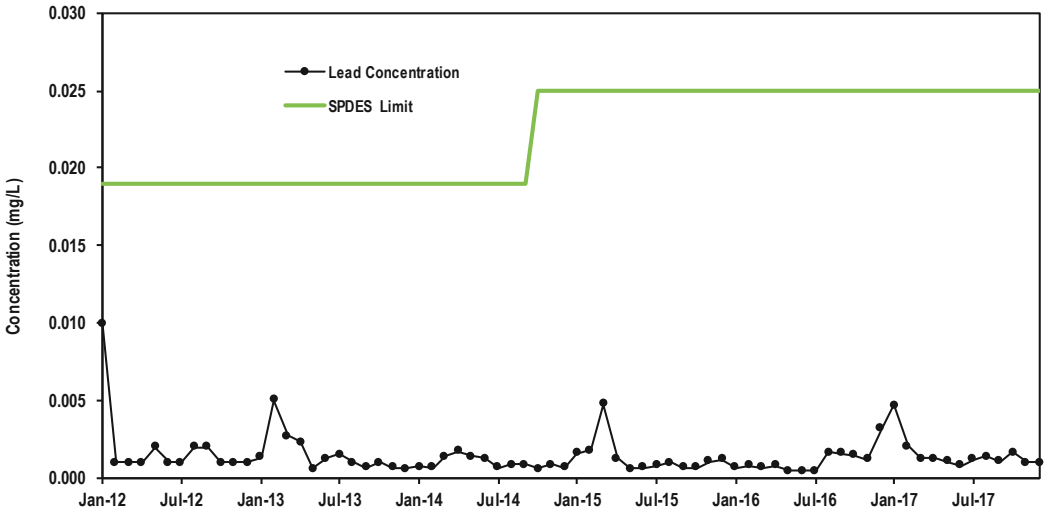

Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2012–2017.

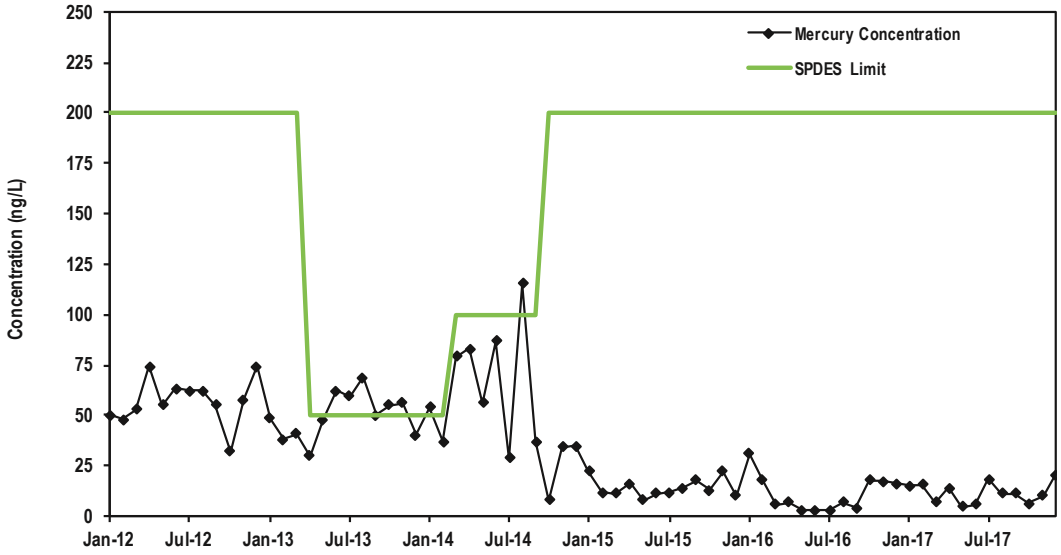

Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2012–2017.

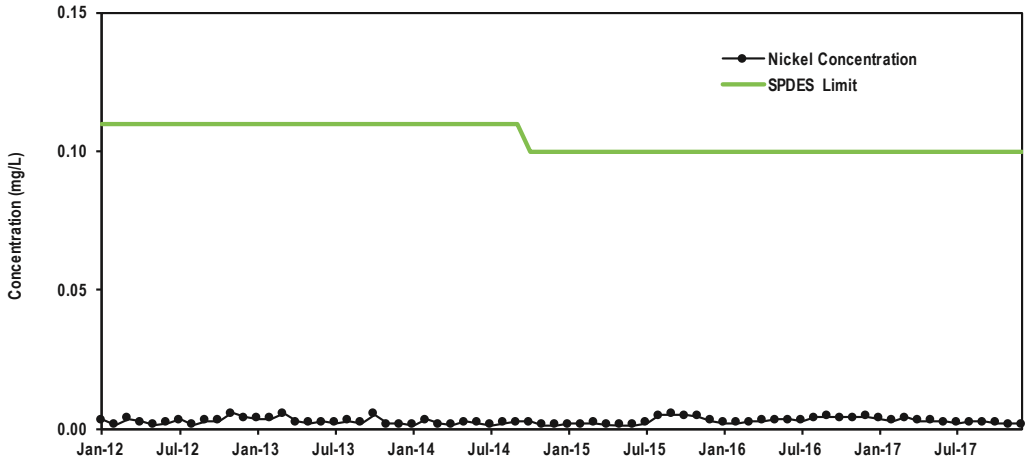

Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2012–2017.

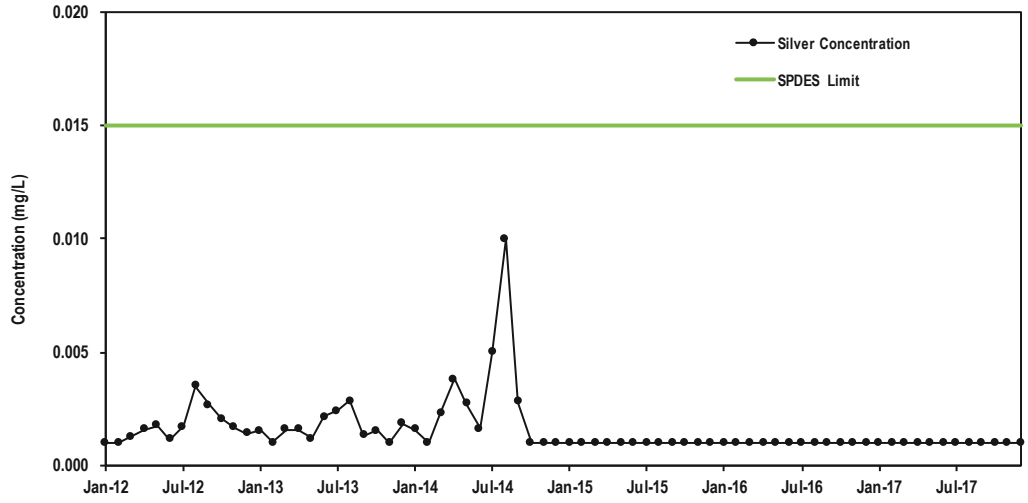

Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2012–2017.

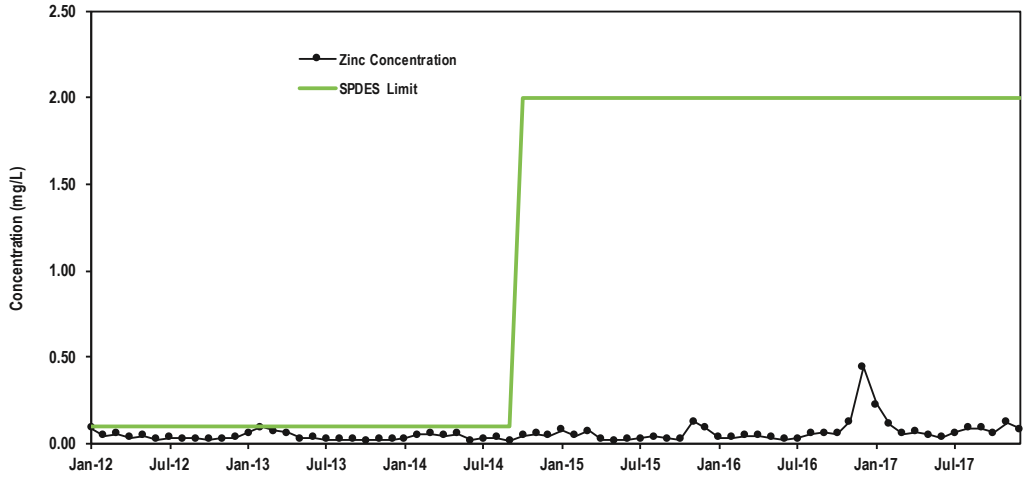

Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2012–2017.

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 Min. Max.	CR CR 0.41	CR 0.00009 0.04	CR 0.05 0.48	CR 0.04 0.13	CR 0.04 0.13	CR 0.08 0.2	11 0.004 2.2	11 0.002 1.8	 NA NA	NA	NA
‘pH (SU)	Min. Max.	6.5 8.4	7.6 8.5	6.5 8.1	6.3 8.3	6.4 8.3	6.5 8.9	6.8 8.1	7.2 8.3	NA 8.5, 9.0 (a)	0	100
Oil and Grease (mg/L)	N Min. Max.	12 < 1.1 1.3	12 < 1.1 9.4	12 < 1.1 3.7	12 < 1.1 1.5	12 < 1.1 1.4	NR NR NR	11 < 1.1 2.4	11 < 1.1 4.8	 NA 15	0	100
Copper (mg/L)	N Min. Max.	NR NR NR	NR NR NR	4 < 0.003 (T) 0.008 (T)	NR NR NR	NR NR NR	NR NR NR	NR NR NR	4 <0.003 (D) 0.004 (D)	 NA 1.0	0	100
Aluminum (mg/L)	N Min. Max.	5 < 0.07 (T) 0.56 (T)	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	4 < 0.07 (D) 0.07 (D)	4 < 0.07 (D) 0.2 (D)	 NA 2.0	0	100
Lead, Dissolved (mg/L)	N Min. Max.	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	4 <0.001 0.001	 NA 0.05	0	100
Vanadium, Dissolved (mg/L)	N Min. Max.	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	4 0.004 0.006	 NA NPL	NA	NA
Chloroform (µg/L)	N Min. Max.	4 0.3 1.0	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	 NA 7	0	100
Bromodichloromethane (µg/L)	N Min. Max.	4 <1.0 <1.0	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	 NA 50	0	100
1,1,1-trichloroethane (µg/L)	N Min. Max.	4 <1.0 <1.0	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	11 < 1.0 < 1.0	NR NR NR	 NA 5	0	100
1,1-dicloroethane (µg/L)	N Min. Max.	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	11 < 1.0 < 1.0	NR NR NR	 NA 5	0	100
Hydroxyethylidene-diphosphonic acid (mg/L)	N Min. Max.	4 <0.05 1.1	NR NR NR	4 <0.05 <0.05	4 <0.05 <0.05	4 <0.05 <0.05	NR NR NR	NR NR NR	NR NR NR	 NA 0.5	1	75
Tolyltriazole (mg/L)	N Min. Max.	4 <0.005 <0.005	NR NR NR	4 <0.005 <0.005	4 <0.005 <0.005	4 <0.005 <0.005	NR NR NR	NR NR NR	NR NR NR	 NA 0.2	0	100

Notes:
See Figure 5-3 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
(a) pH limit is 8.5 for Outfalls 005, 008, and 010; pH limit is 9.0 for Outfalls 002, 002B, 006A, 006B, and 007
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

limit for HEDP is 0.5 mg/L. A determination was made that this exceedance was most likely due to compliance with a NY State mandate for disinfection of cooling towers for the prevention of Legionella bacteria and practice of manually dosing towers, which could create an abnormal spike in the tower treatment levels for a day or so following manual additions. Compliance with this mandate has resulted in the need to treat several additional cooling towers manually. Arrangements were made to collect an additional sample from Outfall 002 to ensure that HEDP concentrations were below permit limits. A grab sample was collected on February 1, 2017 and the results indicated that the HEDP concentration was < 0.25 mg/L, which is below the permit limit.

Facilities & Operations (F&O) and Environmental Protection Division (EPD) staff met on February 13, 2017 to discuss this issue and agreed that the following long-term corrective actions be further evaluated/implemented to prevent this exceedance from occurring in the future: 1) Improve automation at cooling towers to prevent overfeed of product; and 2) stagger the draining of the cooling towers to allow a more steady discharge of treated water to the outfall. To date, new feed stations have been installed in Building 912 and 957 towers. Additional feed stations are planned for Buildings 1000P, 1002, 1004, and 1010.

3.7 SAFE DRINKING WATER ACT

The extraction and distribution of drinking water are 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 (Bruno 2017) is prepared by the Laboratory to comply with these requirements.

3.7.1 Potable Water

The Laboratory has six water supply wells for on-site distribution of potable water; five of which were active during 2017. 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 2017, BNL's drinking water and the supply and distribution system were 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 Laboratory's environmental surveillance program. Data collected under this program are consistent with the data reported in Tables 3-5 and 3-6. This additional testing goes beyond the minimum SDWA testing requirements.

To ensure that consumers are informed about the quality of Laboratory-supplied potable water, BNL publishes a Consumer Confidence Report (CCR) in May of each year, a deadline stipulated by the SDWA. This report provides information regarding source water supply system, and 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/water/*.

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. 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

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 (µg/L)	< 0.1	< 0.1	< 0.1	0.66	3.1	< 0.1	SNS
Chlorides (µg/L)	39.7	44.8	37.1	71	62.5	64.9	250
Color (units)	10*	30*	30*	< 5	< 5	5	15
Conductivity (µmhos/cm)	194	199	197	339	297	351	SNS
Cyanide (mg/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)	0.25	0.58	0.35	0.75	0.61	0.63	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)	5.5	5	5.5	6	5.5	7.2	SNS
Sulfates (mg/L)	8.1	9.8	9.7	10.8	12.6	11.5	250
Total coliform	ND	ND	ND	ND	ND	ND	Negative
Metals							
Antimony (µg/L)	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	6
Arsenic (µg/L)	< 1.0	1	< 1.0	< 1.0	< 1.0	< 1.0	50
Barium (mg/L)	0.035	0.034	0.025	0.055	0.053	0.052	2
Beryllium (µg/L)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	4
Cadmium (µg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5
Chromium (mg/L)	< 0.007	0.001	< 0.007	< 0.007	< 0.007	< 0.007	0.1
Fluoride (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2.2
Iron (mg/L)	0.46*	4.99*	2.7*	< 0.20	< 0.20	0.2	0.3
Lead (µg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
Manganese (mg/L)	0.122	0.086	0.074	< 0.010	< 0.010	< 0.010	0.3
Mercury (µg/L)	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.28	2
Nickel (mg/L)	<0.0005	0.006	0.003	0.001	0.002	0.003	SNS
Selenium (µg/L)	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	2.3	50
Sodium (mg/L)	25	28.7	24.9	48.5	39.7	48.4	SNS
Silver (µg/L)	< 1	< 1	< 1	< 1	< 1	< 1	100
Thallium (µg/L)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	2
Zinc (mg/L)	0.031	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	5
Radioactivity							
Gross alpha activity (pCi/L)	< 1.99	< 1.93	< 1.77	< 2.06	< 1.4	NR	15
Gross beta activity (pCi/L)	< 2.2	1.84 ± 0.63	2.01 ± 0.58	3.51 ± 0.69	4.99 ± 0.71	NR	(a)
Radium-228 (pCi/L)	NS	NS	NS	NS	NS	NR	5
Strontium-90 (pCi/L)	< 0.77	< 0.47	< 0.65	< 0.60	< 0.65	NR	8
Tritium (pCi/L)	< 510	< 500	< 504	< 503	< 503	NR	20,000

(continued on next page)

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

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Potable Distribution Sample	NYS DWS
Other							
Alkalinity (mg/L)	9.1	8.9	14.7	30	25.5	60.8	SNS
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	< 0.20	7
Calcium (mg/L)	5.3	5.6	6.5	13	11.1	17	SNS
HAA5 (mg/L)	NR	NR	NR	NR	NR	0.007	0.06**
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	1.3	4
TTHM (mg/L)	NR	NR	NR	NR	NR	0.024	0.08**

Notes:
See Figure 7-1 for well locations.
Well 12 was not operational for 2017; 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) 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.

control devices are required at all facilities where hazardous materials are used in a manner that could result in their accidental 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.

During 2017, the Laboratory inspected 275 cross-connection control devices, including primary devices installed at interfaces to the potable water main, and secondary control devices at the point of use. 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

Underground Injection Control (UIC) wells are regulated under the SDWA. At the Laboratory, UICs include dry-wells, 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 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,

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	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
1,3,5-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chlorodifluoromethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
				µg/L			
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	2.3	2.4	40.8	0.7	0.6	2.0	50
Bromodichloromethane	2.8	0.5	2.5	12.3	1.1	3.5	50
Dibromochloromethane	2.9	< 0.5	0.55	3.3	< 0.5	0.6	50
Bromoform	1.1	0.9	< 0.5	1.6	< 0.5	< 0.5	50
Methyl tert-butyl ether	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Toxaphene	< 1	< 1	< 1	< 1	< 1	< 1	3
Total PCB's	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	<0.4	0.5
2,4,5,-TP (Silvex)	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	10
Dinoseb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	50
Dalapon	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	50
Pichloram	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Dicamba	<1	<1	<1	<1	<1	<1	50
Pentachlorophenol	<0.04	<0.04	< 0.04	< 0.04	< 0.04	< 0.04	1
Hexachlorocyclopentadiene	<0.1	0.018	< 0.1	< 0.1	< 0.1	< 0.1	5
Bis(2-ethylhexyl)Phthalate	<0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Bis(2-ethylhexyl)Adipate	<0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Hexachlorobenzene	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5
Benzo(A)Pyrene	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	50
Aldicarb Sulfone	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	SNS
Aldicarb Sulfoxide	<0.5	<0.5	<0.5	<0.5	1.1	1.1	SNS
Aldicarb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	SNS
Oxamyl	<1	< 1	< 1	< 1	< 1	< 1	50
3-Hydroxycarbofuran	<1	< 1	< 1	< 1	< 1	< 1	50
Carbofuran	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	40
Carbaryl	<1	< 1	< 1	< 1	< 1	< 1	50
Methomyl	<1	< 1	< 1	< 1	< 1	< 1	50
Glyphosate	<6	< 6	< 6	< 6	< 6	< 6	50
Diquat	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	50
1,2-dibromoethane (EDB)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05
1,2-dibromo-3-chloropropane	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.2
Lindane	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Heptachlor	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.4
Aldrin	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	5
Heptachlor Epoxide	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Dieldrin	<0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5
Endrin	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.2
Methoxychlor	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	40
Chlordane	<0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
2,4,-D	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Alachlor	<0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Simazine	<0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	50
Atrazine	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
				µg/L			
Metolachlor	<1	<1	<1	<1	<1	<1	50
Metribuzin	<0.5	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	50
Butachlor	<1	<1	<1	<1	<1	<1	50
Endothall	<9	< 9	< 9	< 9	< 9	< 9	100
Propachlor	<1	<1	<1	<1	<1	<1	50

Notes:
See Figure 7-1 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 Pace Labs, 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 2017.
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

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 [ ]

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. There were no changes to BNL's total UIC inventory (125) in 2017.

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 is filed with NYSDEC, EPA, and DOE and must be updated every 5 years. BNL remained in full compliance with SPCC requirements in 2017.

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 require that facilities report inventories and releases 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 Tier II and Tier III Reports required under EPCRA Sections 302, 303, 311, 312, and 313. In fulfillment of the Tier II requirements, BNL submitted an inventory of 44 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. The chemicals ranged from road salt (~ 1,200 tons) to chromic chloride (1 pound). To satisfy the requirements of the Tier III submittal, the Laboratory submitted its data via the EPA approved TRI-ME computer-based submittal program. BNL reported releases of lead (~ 75,065 pounds), mercury (~6.5 pounds), polychlorinated biphenyls (PCBs) (~2 pounds), benzo(g,h,i)perylene (<1 pound), and polycyclic aromatic compounds (<1 pound) in 2017. 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 2017, 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 five 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 spills is conducted, as necessary, to prevent impacts to the environment, minimize human health exposures, and restore the site.

There were 21 spills in 2017 and 11 of those spills met regulatory agency reporting criteria. The remaining 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 11 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. In all instances, 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 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 fuel oil used at the CSF to produce high-pressure steam to heat and cool BNL facilities is stored in six tanks with capacities ranging from 300,000 to 600,000 gallons. The remaining storage facilities at BNL have capacities that 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). There were no changes to BNL's MPF License in 2017.

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

Spill No. and Date	Material/ Quantity	ORPS Report	Source/Cause and Corrective Actions
17-01 01/5/17	Transformer Oil/ 1 gallon	No	While conducting a routine PM inspection, Tower Line personnel noticed oil on the concrete pad for a transformer serving Bldg. 832. The leak was apparently coming from three fuse holders located at the top of the transformer basin and the oil traveled down the transformer body onto the concrete pad and then onto the gravel surrounding the pad. Tower Line personnel placed adsorbent material on the concrete pad and the Grounds Dept. removed stained gravel and some soil that was impacted. A single 55-gallon drum was used for the disposal of the stained gravel, soil, adsorbent pads, PPE and debris. Liquid transformer oil was consolidated with similar wastes to be disposed offsite along with the 55-gallon drum as non-hazardous industrial waste by Waste Management.
17-04 01/24/17	Hydraulic Fluid/ 10 gallons	No	During routine shift surveillance of the AGS Siemens Motor-Generator Set in the basement of Building 928, an electrical technician noted oil leaking from a pipe fitting above the tank and a thin film of oil on the adjacent floor. Approximately 10 gallons of oil was estimated to have spilled when the condition was discovered. Operation of the Motor Generator set was immediately shut down. Speedy dry and absorbent pads were used to clean the spilled oil from the basement floor. The trap of a floor drain in the impacted area was also cleaned using oil-absorbent pads. Waste generated from the spill clean-up was placed into a 55 gallon drum to be disposed as non-hazardous industrial waste by Waste Management.
17-05 04/11/17	Hydraulic Fluid/ 1 gallon	No	While dumping leaves and tree branches at the Compost Area, Grounds personnel discovered a leak from the hydraulic mechanism of a Kubota utility vehicle. Contaminated soil beneath the vehicle was recovered and placed into a 55-gallon drum. The drum was transferred to the Waste Management Facility for eventual offsite disposal as non-hazardous industrial waste.
17-08 05/18/17	Hydraulic Fluid/ 30 gallons	No	While performing service work on the freight elevator in Bldg. 555, elevator technicians noted hydraulic system operational issues with the elevator as they lowered it from the 3rd floor to the lobby. Inspecting the elevator pit, they found traces of hydraulic oil on the framework around the piston. They also noted that oil levels were low in the elevator tank. Suspecting a leak, they immediately took the elevator out of service. Upon further investigation, they found oil present in the annular space between the piston steel casing and the piston's PVC secondary containment liner 46 feet below the pit floor. They estimated that 30 gallons leaked on the basis of oil added to the elevator hydraulic tank, its capacity, and measurements of the elevator position. Through additional inspection, they traced the leak to an open bleeder valve on the elevator jack head. Following elevator manufacturer instructions, technicians were able to confirm via tests that no hydraulic oil had leaked into the PVC secondary containment liner. Over multiple days, with assistance from Environmental Protection personnel, elevator technicians recovered 22.75 gallons of oil from the casing. After confirming all oil was removed from the casing, F&O contacted the elevator manufacturer and asked them to replace the piston shaft packing. Subsequent biweekly inspections conducted after the jack casing was replaced in September confirmed that hydraulic oil was no longer leaking into the annular space.
17-09 07/11/17	Hydraulic Fluid/ 4 gallons	No	While attempting to empty a dumpster by Bldg. 1002, the contractor driver found the hydraulic lift was not working as fluid had leaked from a hose and pooled on pavement and soil near the dumpster. The driver immediately alerted C-AD personnel in the building of the spill and then applied granular absorbent to the spill area. Roughly four (4) gallons of hydraulic fluid leaked to pavement and soil. He also contacted management at their facility. Additional contractor personnel arrived with a roll-off container and they dug down roughly 3 inches to clean soil removing roughly 10 cubic feet of contaminated soil into the roll-off. Grounds personnel arrived with the street sweeper and used brooms to work sand into the pavement of 1 yard wide 0.3 mile path of contaminated pavement between Bldg. 1002 and an earlier waste stop at Bldg. 1012. The sweeper picked up the sand and took it back to Bldg 326. The contractor took contaminated absorbent and recovered soil to a transfer facility in Yaphank where it was later taken to a licensed industrial waste facility in Waverly Virginia for final disposition.
17-10 08/2/17	Radiator Fluid/ 1 pint	No	As it was being used in the vicinity of South Boundary Path, a radiator hose on a contractor's pick-up failed releasing roughly a pint of antifreeze onto the soil. The vehicle was taken to the on-site service station for repairs. The contractor dug up and containerized contaminated soil for disposal as industrial waste.

(continued on next page)

Table 3-8. Summary of Chemical and Oil Spill Reports. *(concluded).*

Spill No. and Date	Material/ Quantity	ORPS Report	Source/Cause and Corrective Actions
17-12 08/24/17	Mineral Oil/ 3 quarts	No	While removing a barricade around a dumpster at the rear of Bldg. 930, Collider-Accelerator Department personnel discovered mineral oil leaking from a corner of the dumpster onto soil. The oil had leaked from a vacuum pump within the dumpster. Speedy dry was applied to soil and pans were set by the corner of the dumpster to capture dripping oil. After the dumpster was moved to permit clean-up, Grounds personnel recovered contaminated speedy dry and soil and placed it into a 55-gallon drum that was transferred to 90-day waste storage area at Bldg. 452 to await off-site disposal as industrial waste via Waste Management.
17-14 09/21/17	Transmission Fluid/3 quarts	No	As riggers lifted a tensile tester machine to be excessed for scrap metal, it fell from the forklift spilling some residual transmission fluid in the equipment onto pavement and soil behind Bldg. 494. Green Stuff® absorbent was used to absorb spilled fluid. Contaminated soil and Green Stuff® were scraped up by Grounds personnel using a shovel and placed into a 5-gallon bucket that was transferred to 90-day waste accumulation area at Bldg. 452. Residual fluid within the machine was recovered and the machine was deposited into a scrap metal dumpster.
17-16 10/3/17	Hydraulic Fluid/ 0.75 gallons	No	While transferring soil to the center median in front of Bldg. 30, the operator of a Kubota utility vehicle noticed hydraulic fluid leaking beneath the vehicle after dumping soil from vehicle. Speedy dry and absorbent pads were used to clean-up hydraulic fluid leaking from the vehicle after the driver moved it onto pavement. Contaminated soil at the median was dug up by Grounds personnel and placed into two 55-gallon drums along with contaminated speedy dry and absorbent pads. The drums were taken to the 90-day waste storage area at Bldg. 452.
17-17 10/13/17	#6 Fuel Oil/ ≈1 quart	No	While Central Steam Facility (CSF) stationary engineers were bringing the #6 fuel oil shell & tube heat exchanger (#2 Station/bundle#1) online, an oil tube failed causing fuel oil to mix with condensate. The mixture discharged from the open condensate drain valve onto the concrete pad and into the building sanitary drain system. Oil adsorbent pads were used to clean oil from the pad. Water Systems staff opened sanitary drain manhole covers and placed retrievable oil absorbent booms by the sanitary drain inlet pipes to capture oil passing through the system. As a precautionary measure to prevent any oil from reaching the sewage treatment plant, oil absorbent booms were placed in two down gradient sanitary system manholes in the field east of North Sixth Street and before the influent to the sewage treatment plant. The first two sanitary manholes outside the CSF were the only manholes with observable oil and oil sheen present. After Water Systems and EPD personnel determined that no additional oil or oil sheen was visible in water flowing through the sanitary system, oil adsorbent pads were used to capture residual floating oil in the second sanitary manhole that hadn't been adsorbed by the first boom. The oil contaminated adsorbent pads and adsorbent booms were then removed and placed into a 55 gallon drum. The drum was transferred to the 90-day waste storage area at Bldg. 452.
17-18 10/16/17	Hydraulic Fluid/ 1 quart	No	While the 150 Grove Lattice Boom Crane was being used near Bldg, 1004, a hydraulic line ruptured causing hydraulic fluid to spray onto the side of the crane and onto the ground. After seeing fluid spraying from the ruptured line, the operator immediately shut down the crane and contacted Fire Rescue for assistance with the clean-up. Absorbent pads that were used to wipe down oil from the side of the crane and contaminated soil collected near its base were placed into two 5-gallon buckets for disposal by Waste Management.

Notes: ORPS = Occurrence Reporting and Procesing System

There are currently 66 petroleum storage facilities listed on the License, which expires on March 31, 2022. During 2017, BNL remained in full compliance with MPF license requirements, which include monitoring groundwater in the vicinity of the six above-ground storage tanks located at the MPF. 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 2017, 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.

A major upgrade was performed at the MPF on the secondary containment berm for Tank No. 611-10, and Tank Nos. 611-04 and 611-09 were taken out-of-service, drained of all fuel, thoroughly cleaned, and inspected by a NACE-certified inspector. Repairs and more berm rehabilitation projects are scheduled for 2018.

On August 15, 2017, a representative from the U.S. EPA Office of Oil Pollution Prevention conducted an inspection of the storage tanks-facilities included on the MPF license. This inspection included a review of the Spill Prevention Control and Countermeasure (SPCC) Plan, facility blueprints-maps, training records, inspection records, the Spill Management Tabletop Exercise (SMTTX) Drill records, and other documents. There were no findings.

Due to favorable past performances on past petroleum bulk storage compliance audits and strong overall program, the NYSDEC exempted the Laboratory from its annual inspection in 2017.

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 2017, BNL renewed its Chemical Bulk Storage (CBS) Registration in accordance with NYSDEC directives and received a Hazardous Substance Bulk Storage Registration Certificate. This certificate will expire on July 27, 2019.

Due to favorable past performances on past chemical bulk storage compliance audits and strong overall program, the NYSDEC exempted the Laboratory from its annual inspection in 2017.

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, SCDHS notified BNL that they will cease permitting activities (e.g., 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 120 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 continues 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. Although 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, it 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 one year before shipping the wastes off site to licensed treatment and disposal facilities. As noted in Chapter 2, BNL also has a number of satellite accumulation and 90-Day Hazardous Waste Accumulation 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.

In 2017, BNL received approval from the NYSDEC for its 6NYCRR Part 373 RCRA Permit renewal which regulates the storage of hazardous waste. Approval was also granted for the closure of two 90-Day Hazardous Waste Accumulation Areas which were no longer needed.

In March and September 2017, the NYSDEC and the EPA respectively performed an unannounced inspection of hazardous waste activities at BNL. Both agencies were satisfied with hazardous waste operations observed and identified no violations or concerns.

3.10 POLYCHLORINATED BIPHENYLS

The storage, handling, and use of Polychlorinated Biphenyls (PCBs) are regulated under the Toxic Substance and Control Act. Capacitors manufactured before 1979 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 three 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 2017 and disposed of 614.5 pounds of PCB contaminated equipment comprised predominantly of lighting ballasts and small capacitors. 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 (e.g., insecticides, rodenticides, herbicides, and algicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act. BNL uses an Integrated Pest Management plan that was developed over a decade ago and subsequently audited by a third party in 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 and the Biology Field. 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.

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 New York 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 2016 and BNL 2013a) 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.

3.13 PROTECTION OF WILDLIFE

3.13.1 Endangered Species Act

BNL updates its list of species that are endangered, threatened, and/or of special concern (see Table 6-1 in Chapter 6) as data from state and federal sources are provided. The northern long-eared bat *(Myotis septentrionalis)* was determined to be a federally threatened species on April 2, 2015 and is the first federally listed species known to be present at the Laboratory. This species is known to utilize the site at least during the summer months, and management options have been established for the protection of this species on site. The rusty-patched bumble bee *(Bombus affinis)* was determined to be federally endangered on January 11, 2017. This bee was historically found on Long Island. There is a remote chance the bee may still exist on Long Island; therefore, care is taken during pollinator surveys to limit impacts to bumble bees.

State-recognized endangered (E) or threatened (T) species at BNL include: eastern tiger salamander (E), persius duskywing (E), bracken fern (E), crested fringed orchid (E), engelman spikerush (E), dwarf huckleberry (E), whorled loosestrife (E), fireweed (E), prostrate knotweed (E), possum haw (E), Ipecac spurge (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), eastern showy aster (T), and stiff-leaved goldenrod (T).

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 BNL Natural Resource Management Plan (NRMP) (BNL 2016) 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 Long Island Solar Farm (LISF), a small tiger salamander habitat was modified to ensure improved water retention for longer periods of time.

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 to the Peconic River; monitoring populations and water quality to ensure that habitat remains viable; and minimizing disturbances to the river and adjacent banks.

Long Island experienced an extended drought from 2015 through early 2017 which resulted in virtually all water-bodies on the BNL site drying, including the one remaining coastal plain pond supporting banded sunfish and swamp darter. The NYSDEC reported that all but a few banded sunfish habitats experienced the same drying, and that plans must be developed for the restoration of these two species once drought conditions lift.

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.

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. The Laboratory continues to evaluate bird populations as part of the management strategy outlined in the NRMP.

The Laboratory has 33 plant species that are protected under state law: eight are endangered; three are threatened (as listed above); 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. Five species on the BNL list are considered to be likely present or possible due to presence of correct habitat. 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, the Laboratory 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 84 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 birds' 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 ongoing or planned construction activities. 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. 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. Since that time, seven additional nesting pairs have been documented on Long Island. Bald eagles have

been documented on the BNL site and were routinely seen in the vicinity of the Sewage Treatment Plant through much of 2017. Further information on bald eagles is presented in Chapter 6.

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 from these areas 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 BNL Site Radiological Control Manual (BNL 2013b) and are consistent with the pre-approved authorized release limits set by DOE Order 458.1.

In 2017, excess materials not identified as radioactive, such as scrap metal electronics equipment as a result of normal operations 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 2017.

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 2017, BNL was inspected by federal, state, or local regulators on 10 occasions. These inspections included:

- *Air Compliance.* In August, a NYSDEC inspector conducted a full compliance evaluation of regulatory emission sources including review of records. There were no findings.
- *Potable Water.* In August, 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 & Utilities Division.
- *SPCC.* In August, EPA performed a Field Inspection to evaluate BNL's SPCC Plan and its implementation and there were no deficiencies identified.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the Laboratory's STP to evaluate operations and sample the effluent. No performance or operational issues were identified. NYSDEC performed a surveillance inspection in November; there were no issues identified.
- *RCRA.* In March, three inspectors from NYSDEC performed a two-day RCRA inspection and did not identify any concerns or violations. In September, EPA performed an unannounced RCRA Compliance inspection and did not identify any concerns or findings.

3.15.2 DOE Assessments/Inspections

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs during 2017 and participated as an observer of the Brookhaven Sciences Associates (BSA) Multi-Topic Assessment of Brookhaven National Laboratory's of BNL's environmental protection programs described below. BHSO participation comprised of observing BSA's scoping, assessment conduct, and reporting. BHSO also performed a surveillance of Groundwater Treatment System Carbon Replacement at the Operable Unit IV Ethylene Dibromide treatment system. No findings were identified, and all operations were observed to be conducted in a safe and environmentally sound manner.

3.15.3 Environmental Multi-Topic Assessment

The BNL EPD conducts routine programmatic assessments. The determination of topics for these assessments is based upon past regulatory findings, results of Tier I inspections and/or other routine self-assessments, and frequency of past assessments. In 2017, EPD conducted a programmatic

self-assessment on BNL's Storage and Transfer of Hazardous and Nonhazardous Materials, Radioactive and Non-Radioactive Airborne Emissions, and Liquid Effluent programs. The specific objectives and scope of these assessments were described in assessment plans and implemented in accordance with the EPD's procedure for *"Preparing for and Conducting Regulatory Environmental Compliance Assessments"*. During the course of these assessments, 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 of these programs.

The assessment of these programs identified eight Noteworthy Practices, 16 Observations, 15 Opportunities for Improvement, and eight minor Nonconformances. Except for the noted minor Nonconformances, the assessed programs as a whole were found to be in conformance with applicable BNL Standards Based Management System and external regulatory requirements. A causal analysis was performed and a corrective action plans were prepared for the identified minor nonconformances and observations to address the issues. Progress on the actions are tracked to closure in BNL's Institutional Assessment Tracking System.

3.15.4 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.

The NNSS performed surveillance on the BNL Radioactive Waste program on April 4 and 5, 2017. The team consisted of two members of the Rad-Waste Assistance Program (RWAP), one DOE Nevada staff, and one State of Nevada regulator. The team concentrated on Quality Assurance and Chemical Characterization. The Quality Assurance elements assessed pertained to Training and Qualifications, Document and Records Management, Procurement/Supplier Evaluations and Inspection and Acceptance Testing of materials/supplies. Chemical Characterization was assessed for each waste stream's characterization process to ensure that the methods and records comply with the waste acceptance criteria.

The assessment resulted in two findings and one observation for which a Corrective Action Plan, identifying actions taken to resolve the findings and their associated schedule for completion, was requested. The findings identified pertained to the review and submission of required documents that support BNL's waste certification program. The observation was that BNL's chemical characterization data was not clearly documented in its waste profiles and was difficult for the auditor to follow. The findings and observation were addressed in June 2017.

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 2017 (see Table 3-9). There were no Notices of Violation accessed in 2017; however, there was one environmental event that was reported in accordance with BNL's Event/Issue Management Subject Area and documented in the Integrated Operational Performance System. The event is summarized in Table 3-10.

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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	BNL, DOE, SCDHS	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)	DOE, EPA, 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, RCRA, and 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 2072, respectively. All groundwater treatment systems operated as required in 2017.
No Notices of Violation/Enforcement Actions for 2017.				

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

Table 3-10. Summary of Other Environmental Occurrence Reports, 2017.

IOPS* Event #: E-00186	Date: 01/16/17
Startup testing in preparation for the 2017 RHIC Run identified a small leak in a 35 foot underground section of a water system used to cool about 60 beam line magnets. The loss rate was determined to be approximately 4 gallons/day and it was estimated that approximately 375 gallons leaked during system testing and the search for the leak. Based upon cooling water surveillance data, the cooling water typically has an average tritium concentration of 1,299 pCi/L or less. For comparison, the drinking water standard for tritium is 20,000 pCi/L. Even though concentrations of the cooling water were ~5% of the drinking water standard a committment was made to repair the pipe prior to starting the RHIC experiment run. Environmental impacts were investigated and tritium was not detected in groundwater.	Status: New piping was installed and tested and cooling water system was placed back in service for commissioning. Monitoring of tritium concentrations in cooling water system and in nearby groundwater monitoring well will continue.

Notes:
* Reported in accordance with BNL's Event/Issue Management Subject Area and documented in the Integrated Operational Performance System (IOPS).

4 Air Quality

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

During 2017, BNL facilities released a total of 10,660 curies of short-lived radioactive gases. Oxygen-15 and Carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.99 percent of the site's radiological air emissions.

Because natural gas prices were comparatively lower than residual fuel oil prices throughout the year, BNL's Central Steam Facility used natural gas to meet 98.3 percent of the heating and cooling needs of the Laboratory's major facilities in 2017. As a result, emissions of particulates, oxides of nitrogen, sulfur dioxide, and volatile organic compounds were well below the respective regulatory permit criteria pollutant limits.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and U.S. Department of Energy (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 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 two active facilities, the Brookhaven Linac Isotope Producer (BLIP) which is continuously monitored with an inline detection system, and the Target Processing Laboratory (TPL) that has a particulate filter sampling system to continuously collect gross alpha and gross beta samples, and one inactive facility, the High Flux Beam Reactor (HFBR), where periodic monitoring is conducted. Figure 4-1 provides the locations of these monitored facilities, and Table 4-1 presents airborne release data from 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 8-5.

4.2 FACILITY MONITORING

Radioactive emissions are monitored at the HFBR, BLIP, and TPL. The samplers in the exhaust stack for BLIP and the TPL exhaust duct are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-1 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 2017 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 0.0073 pCi/m^3, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0008 and 0.0113 pCi/m^3, respectively.

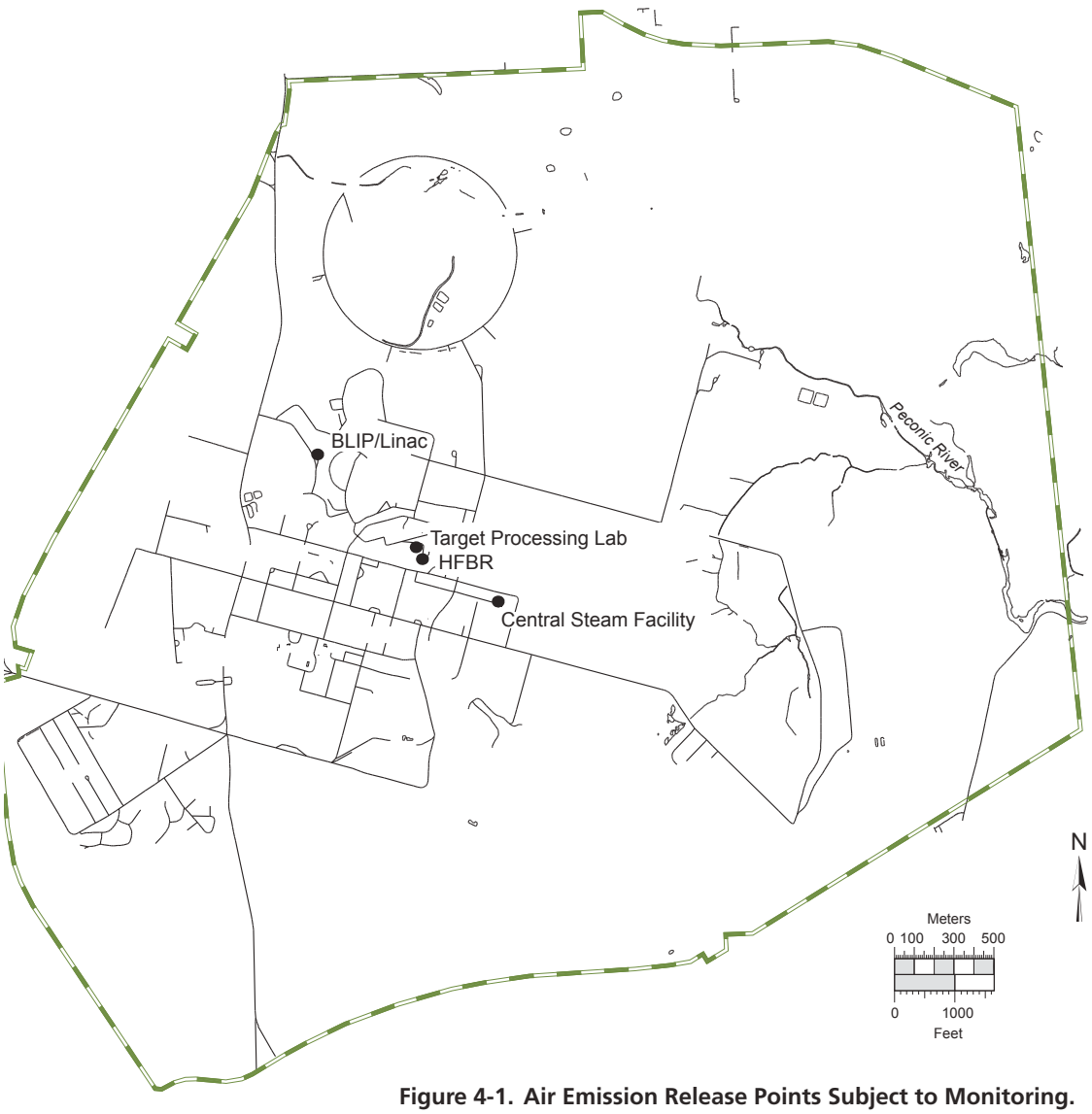


Figure 4-1. Air Emission Release Points Subject to Monitoring.

4.2.1 High Flux Beam Reactor

In 1997, a plume 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. As part of the HFBR Long-Term Surveillance Program (BNL 2013), air samples are collected from outside the HFBR confinement structure using a permanently installed sample port. Samples are analyzed for tritium to evaluate facility emissions and to ensure that air quality within the building is acceptable to permit staff entry. Samples are collected for three or four weeks per month using a standard desiccant sampling system for tritium analysis. Desiccant samples are analyzed by an off-site contract laboratory.

4.2.2 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 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 2017, BLIP operated over a period of 26 weeks, during which 3,553 Ci of C-11 and 7,107 Ci of O-15 were released (see Table 4-1). Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity, 1.34 E-2 Ci. Combined emissions of C-11 and O-15 were 10,660 Ci, about two percent higher than the combined emissions of 10,425 Ci in 2016. This increase is primarily due to operation at higher average current levels for short periods, and occasional increased water gaps for Thorium targets in 2017. The Thorium target irradiations are in support of future actinium-225 production programs.

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

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	3.91E-01
BLIP	Carbon-11	20.4 minutes	3.55E+03
	Oxygen-15	122 seconds	7.11E+03
	Tritium	12.3 years	1.34E-02
Total			**1.07E+04**

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

4.2.3 Target Processing Laboratory

As mentioned in Section 4.2.2, 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 the filtered air is then vented to the atmosphere. The types of radionuclides that are processed 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 based on historical analytical results of TPL particulate filters that 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 resumed.

4.2.4 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. 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 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, 348, 463, 480, 490, 490A, 510A, 535, 555, 725, 734, 735, 801, 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 8-5 in Chapter 8 for the calculated dose from these facility emissions.

4.2.5 Nonpoint Radiological Emission Sources

Nonpoint radiological emissions from a variety of diffuse sources may be evaluated for compliance with NESHAPs Subpart H. Diffuse sources evaluated often include planned research, planned waste management activities, and planned decontamination and decommissioning (D&D) activities. Evaluations determine whether NESHAPs permitting and continuous monitoring requirements are applicable, or whether periodic confirmatory sampling is needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of diffuse sources in 2017, if any.

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 four blockhouse stations 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 adsorbent material for processing by liquid scintillation analysis. In 2017, silica-gel samples were collected every two weeks.

4.3.1 Gross Alpha and Beta Airborne Activity

Particulate filter analytical results for gross alpha and beta airborne activity are reported in Table 4-3. Ambient air samples are collected weekly from site perimeter monitoring stations P2, P4, P7, and P9. 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 0.0013 and 0.0137 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

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

Monitored Facility		Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)
BLIP	N	52	52
	Max.	0.0023 ± 0.0008	0.0200 ± 0.0015
	Avg.	0.0005 ± 0.0004	0.0073 ± 0.0010
	MDL	0.0006*	0.0008*
TPL - Bldg. 801	N	52	52
	Max.	0.0028 ± 0.0008	0.0316 ± 0.0017
	Avg.	0.0008 ± 0.0005	0.0113 ± 0.0012
	MDL	0.0006*	0.0008*

Notes:
See Figure 4-1 for monitored facility 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/m^3)	Gross Beta (pCi/m^3)
P2	N	51	51
	Max	0.0030 ± 0.0009	0.0223 ± 0.0016
	Avg.	0.0014 ± 0.0006	0.0135 ± 0.0012
	MDL	0.0006*	0.0007*
P4	N	52	52
	Max	0.0047 ± 0.0025	0.0398 ± 0.0053
	Avg.	0.0011 ± 0.0005	0.0129 ± 0.0011
	MDL	0.0006*	0.0007*
P7	N	51	51
	Max	0.0034 ± 0.0008	0.0182 ± 0.0013
	Avg.	0.0011 ± 0.0005	0.0128 ± 0.0011
	MDL	0.0005*	0.0007*
P9	N	41	41
	Max	0.0030 ± 0.0008	0.0200 ± 0.0016
	Avg.	0.0015 ± 0.0007	0.0162 ± 0.0015
	MDL	0.0007*	0.0009*
Grand Average		**0.0013 ± 0.0006**	**0.0137 ± 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

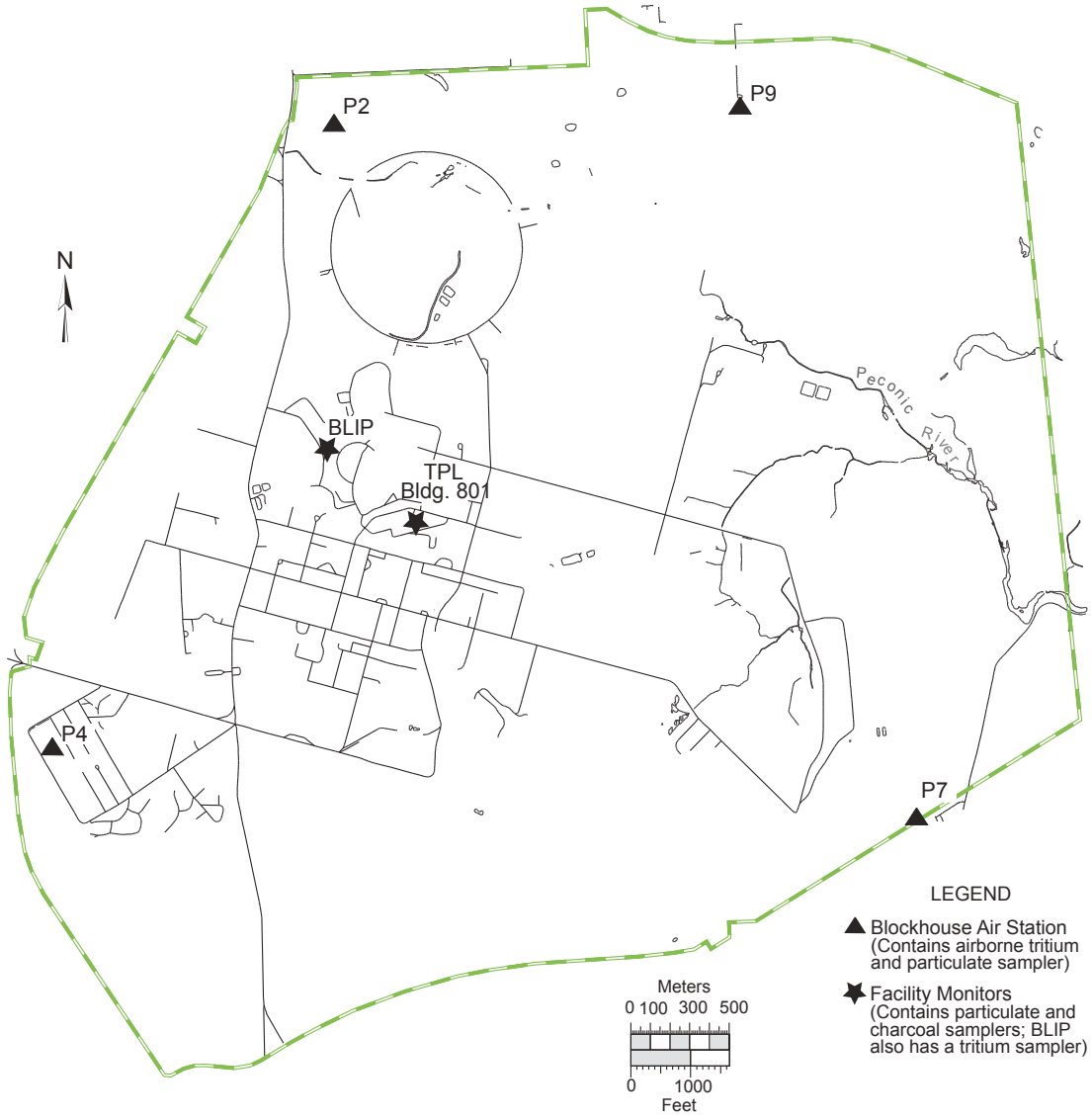


Figure 4-2. BNL On-Site Ambient Air Monitoring Stations.

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 provided by NYSDOH. 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 0.0009 and 0.0148 pCi/m^3, with an average concentration of 0.0081 pCi/m^3. BNL results ranged from 0.0057 to 0.0182 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 2017, NYSDOH reported that airborne gross beta activity at that location varied between 0.0026 and 0.0273 pCi/m^3 and had an average concentration of 0.0113 pCi/m^3. All 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 2017, tritium samples were collected from Stations P2, P4, P7, and P9 to assess the potential impacts from the Laboratory's two tritium sources. 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 2017; however, two samples could not be analyzed because the amount of moisture captured on the silica gel was insufficient for analysis. The average tritium concentrations at all the sampling locations were less than the typical minimum detection limits, which ranged from 4.0 to 12.6 pCi/m^3.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

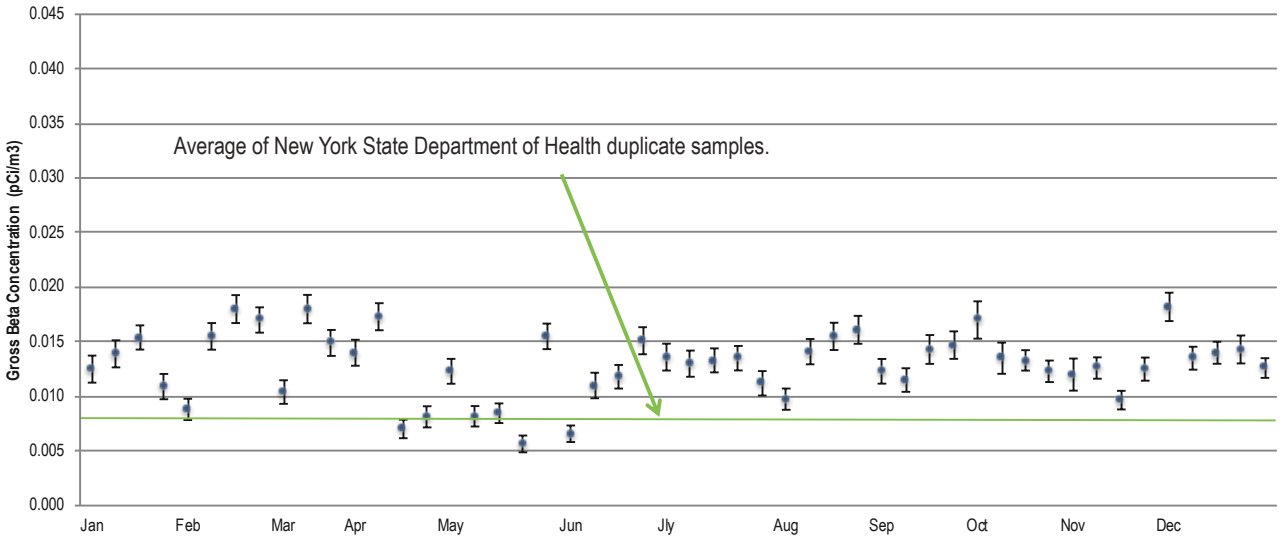
Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emission monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that requires monitoring for nonradiological emissions. 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 the CSF boilers have the potential to emit more than 100 tons per year of oxides of nitrogen (NOx), the CSF is considered a major facility, and all four of its boilers are subject to the Reasonably Available Control Technology (RACT) requirements of Title 6 of the New York Code, Rules, and Regulations (NYCRR) Subpart 227-2. Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are also subject to the Federal New Source Performance Standard (40 CFR 60 Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Boilers). Both boilers are equipped with continuous emission monitoring systems (CEMS) to show compliance with NOx standards of Subpart 227-2 and Subpart Db, 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 monoxide (CO). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation (NYSDEC).

On July 1, 2014, new Subpart 227-2 lower RACT for NOx emissions became effective. The respective NOx RACT emission limits of 0.20 lbs/MMBtu for the combustion of natural gas and 0.30 lbs/MMBtu for the combustion of No. 6 oil burned in the CSF three large boilers dropped to 0.15 lbs/MMBtu for both fuels. The NOx RACT emission limit for the CSF's one mid-size boiler (Boiler 1A) dropped from 0.30 lbs/MMBtu to 0.20 lbs/MMBtu.

From May 1 to September 15 of each year, the peak ozone period, owners and operators of



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

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

boilers equipped with CEMS must demonstrate compliance with Subpart 227-2 NOx RACT limits by calculating the 24-hour average emission rate from CEMS readings and comparing the value to the emission limit. During the remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Owners and operators of boilers not equipped with CEMS must demonstrate compliance with NOx RACT limits via periodic emissions testing. Following the end of each calendar quarter, facilities with boilers equipped with CEMS must tabulate and summarize applicable emissions, monitoring, and operating parameter measurements recorded during the preceding three months. Measured opacity levels can not exceed 20 percent opacity, except for one six-minute period per hour of not more than 27 percent opacity.

Because past emissions testing and CEMS results when No. 6 oil was burned have shown that all four CSF boilers cannot meet the new lower NOx RACT standards, BNL is using an approved system averaging plan to demonstrate compliance in quarterly reports submitted to NYSDEC. This is accomplished with a NOx ledger, where NOx rate credits accumulated during quarterly periods when natural gas is burned at levels below the NOx RACT limits offset ledger debits that occur when any of the four boilers burn oil. The ledger must show that the actual NOx weighted average emission rate of operating boilers is less than the Subpart 227-2 permissible NOx weighted average rate for the quarter. The actual weighted average emission rates for operating boilers in the first, second, third, and fourth quarters, respectively, were 0.104, 0.102, 0.077, and 0.101 lbs/MMBtu, while the corresponding permissible weighted average emissions rates each quarter were 0.152, 0.150, 0.150, and 0.150 lbs/MMBtu.

In 2017, there were two Boiler 7 excess opacity measurements from unknown causes, five excess opacity readings due to a temporary failure of the Boiler 7 transmissometer blower, and a single excess opacity reading that occurred during scheduled quality assurance calibration error tests of the Boiler 7 opacity monitor. 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 on days when the boilers were operated.

To satisfy quality assurance requirements for the continuous emissions monitoring system

Table 4-4. Ambient Airborne Tritium Measurements in 2017.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m^3)	Average (pCi/m^3)
P2	NNW	26	3.7 ± 3.3	0.3 ± 4.4
P4	WSW	26	6.9 ± 3.8	0.9 ± 3.8
P7	ESE	26	7.2 ± 7.2	0.2 ± 4.0
P9	NE	22	9.2 ± 14.7	0.2 ± 5.4
Grand Average				**0.4 ± 4.4**

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 4.0 and 12.6 pCi/m^3.

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 NOx and CO_2 was conducted in December 2017. The results of the RATA demonstrated that the Boiler 6 and 7 NOx 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 2017, residual fuel prices exceeded those of natural gas for most of the year. As a result, natural gas was used to supply 98.3 percent of the heating and cooling needs of BNL's major facilities. By comparison, in 2009, residual fuel satisfied 42.6 percent of the major facility heating and cooling needs. Consequently, 2017 emissions of particulates, NOx, and sulfur dioxide (SO_2) were 6.7, 25.2, and 43.2 tons less than the respective totals for 2009, when No. 6 oil was used to supply a much higher percent of site heating and cooling needs. Table 4-5 shows fuel use and emissions since 2008.

4.5 GREENHOUSE GAS EMISSIONS

One of the overarching goals of Executive Order (EO) 13693, *Planning for Federal Sustainability in the Next Decade*, 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 (FY) 2025: reduce Scope 1 and 2 GHG emissions by 50 percent relative to their FY 2008 baseline and reduce Scope 3 GHG emissions by 25 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 (BNL 2017). BNL's SSP identifies several actions that have or will be taken to help the Laboratory progress towards meeting the Scope 1 and 2 GHG emissions reduction goal.

In November 2011, the Long Island Solar Farm (LISF), a large array of more than 164,000 solar photovoltaic panels constructed on the BNL site began producing solar power. The LISF is expected to deliver an annual average of 44 million kilowatt-hours (kWh) per year of solar energy into the local utility grid over a 20-year period. In 2017, the LISF provided 49.6 million kilowatt-hours of solar energy to Long Island. This equates to a 32,109 metric tons CO_2 equivalents ($MtCO_2e$) GHG offset or reduction. Even though the power from the LISF is purchased by the local utility, the Laboratory receives GHG reduction credits by purchasing an equivalent amount of Renewable Energy Credits (RECs) each year. In March 2011, BNL began receiving 15 megawatts per hour of hydropower from the New York Power Authority. In 2017, BNL consumed 119,486 megawatts of hydropower, providing a net combined GHG reduction of 94,918 $MtCO_2e$ from the LISF and hydropower. Furthermore, in 2016 BNL completed an expansion of the Northeast Solar Energy Research Center (NSERC). The NSERC is a solar photovoltaic facility that now has a capacity of 816 kW. In 2017, it provided 968,485 kWh and offset 544 $MtCO_2e$.

In October 2013, DOE awarded BNL a Utility Energy Service Contract (UESC). This project called for the implementation of energy savings measures to reduce Scope 1 and 2 GHG levels by approximately 7,000 $MtCO_2e$. In May of 2015, the Laboratory completed Phase I energy conservation measures that included:

- The installation of a 1,250-ton high-efficiency chiller to increase the efficiency of supplied chilled water;
- Upgraded lighting systems in 18 buildings;
- Enhanced building control upgrades, and additions to provide for heating, ventilation,

Table 4-5. Central Steam Facility Fuel Use and Emissions (2008–2017).

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)
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
2014	34.03	5,107	0.00	0	673.80	690,584	2.6	30.9	1.0	1.9
2015	9.66	1,449	0.00	0	619.98	638,209	2.4	30.3	0.4	1.7
2016	804.38	120,712	0.00	0	441.98	453,348	3.7	33.6	19.0	1.7
2017	65.07	9,765	0.00	0	564.96	579,559	2.3	28.2	1.7	1.6
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

and air conditioning temperature setbacks in nine buildings.

The UESC project has been a success, with annual energy savings within 3% of the original estimates for each of the three full years since completion. Other planned energy savings initiatives from Phase II UESC projects set to begin in FY 2018 will include additional lighting and building control upgrades, and chilled water storage improvements. BNL will periodically evaluate the potential to install a combined heat and power plant and will recommend going forward if a business case develops to make installation a viable alternative.

To meet the 2025 Scope 3 GHG emissions reduction goal, Scope 3 emissions must be lowered by 5,034 $MtCO_2e$ from the FY 2008 baseline of 20,136 $MtCO_2e$. Overall, Scope 3 GHG emissions dropped by 6,323 $MtCO_2e$, down 27 percent from FY 2016, and 15.2 percent less than the FY 2008 baseline value of 20,136 $MtCO_2e$. GHG emissions from electrical transmission and distribution losses decreased 6,696 $MtCO_2e$, accounting for most of the drop. The reduction in GHG emissions from transmission and distribution losses was primarily due to a 42.7% drop in the e-Grid Distribution Loss Adjustment Factor, which declined from 9.09% in FY 2016 to 5.21% in FY 2017.

Unless projected drops in purchased electricity and transmission and distribution loss GHG emissions from the implementation of planned UESC Phase II energy conservation measures and construction of a combined heat and power plant are significant, BNL will need to focus its efforts on reducing GHG emissions from employee business air travel and employee commuting. Actions taken in 2017 that will help BNL to reduce GHG emissions from air travel and employee commuting and move forward in achieving the Scope 3 GHG reduction goal included:

- Efforts taken by the Information Technology Division to emphasize how video conferencing utilizing the Blue Jeans cloud base tool can be used for internal meetings and to collaborate with external associates; enabling employees to boost their productivity while also helping to reduce their travel time and costs to attend meetings and conferences.
- BNL's submission of a proposed alternative methodology to the DOE Sustainability Performance Office for estimating our commuting GHG emissions for their consideration and approval. The key to the alternative methodology is the use of a combination of emission factors to more accurately estimate GHG emissions from passenger cars and

light duty trucks that our employees are actually driving.

CH_4 and N_20 emission factors to be used are those established by ICF International on the basis of vehicle emissions tests to certify 2009 model year and later passenger cars and light duty trucks to meet EPA Tier 2 emission standards. The CO_2 emission factors to be used are based on fleet-wide emission targets for Model Years 2012-2016 and for Model Years 2017-2025 cars and light duty trucks established in joint rules to improve fuel economy and reduce greenhouse gas emissions passed by EPA and the National Highway Traffic Safety Administration on May 7, 2010 and October 15, 2012.

- BNL's participation in the Annual Car Free Day Long Island (LI) on September 22, 2017. In an effort to increase employee awareness and appreciation of the environmental, health, and economic benefits of sustainable means of transportation, employees were encouraged to make a pledge on the Car Free Day LI website to be car-free or car-lite on September 22 and commit to drive less by carpooling, biking, walking, or telecommuting. Sixty-three employees participated by making pledges to carpool, bike, walk, and telecommute to reduce their driving for one day.

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5 Water Quality

Wastewater generated from operations at Brookhaven National Laboratory (BNL) is treated at the Sewage Treatment Plant (STP) before it is discharged to nearby groundwater 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 2017 shows that the average gross alpha and beta activity levels in the STP discharge (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. Non-radiological 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 stormwater and cooling water discharged to recharge basins were within typical ranges and no gamma-emitting radionuclides were detected. Disinfection byproducts continue to be detected at low concentrations, 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 runoff in stormwater discharges.

With the exception of the most upstream sampling location (Station HY), the on-site portions of the Peconic River were dry throughout 2017 due to drought conditions. Radiological data from Peconic River surface water sampling show that the average concentrations of gross alpha and gross beta activity from on-site locations were indistinguishable from off-site locations and control locations, and 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 area, and tritium was not detected above method detection limits in any of the surface water samples.

5.1 SURFACE WATER MONITORING PROGRAM

In addition to monitoring discharges to surface waters under the SPDES program described in Chapter 3, BNL routinely monitors surface water quality (including radionuclides) as part of the site Surveillance Program. Although discharges of treated wastewater from the Laboratory's STP into the headwaters of the Peconic River ceased in October 2014, the Laboratory continues to monitor surface water at several locations along the Peconic River to assess the impact that site operations may have on surface water quality. On-site monitoring station HY is located upstream of all Laboratory operations, and provides information on the background water quality of the Peconic River (see Figure 5-1). The Carmans River is monitored as a geographic control location for

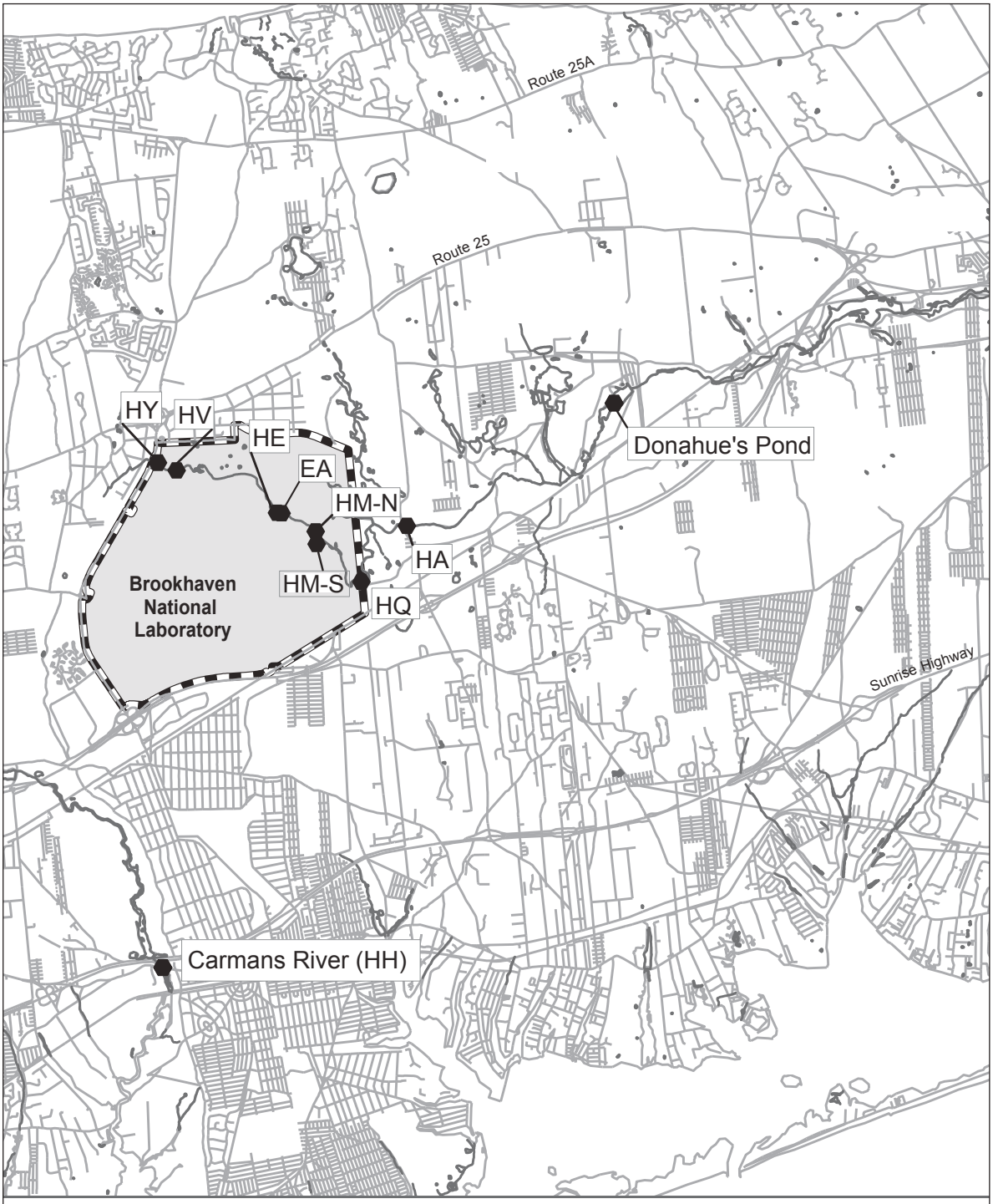

Figure 5-1. Sampling Stations for Surface Water and Fish.

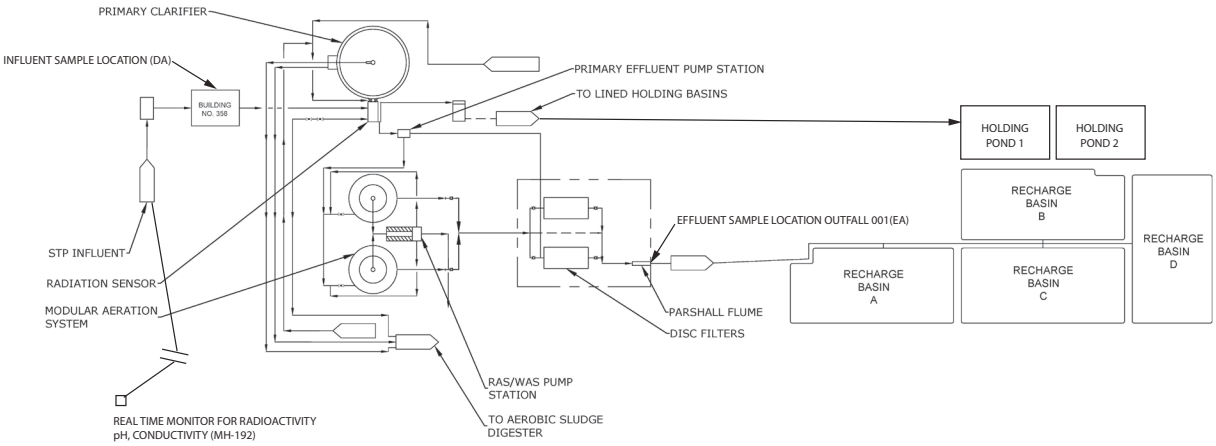

Figure 5-2. Schematic of BNL's Sewage Treatment Plant (Recharge Basin Discharge)

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, groundwater fed stream. Off-site flow occurs only following periods of sustained precipitation and a concurrent rise in the water table, typically in the spring. There was no off-site flow in 2017. The on-site portions of the Peconic River remained dry throughout the year due to drought conditions.

Historical monitoring data indicates no significant variations in water quality throughout the Peconic River system, and pollution prevention efforts at the Laboratory have significantly reduced the risk of accidental releases. 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 that is issued by the NYSDEC (Section 3.6.1). Figure 5-2 shows a schematic for discharge of treated STP effluent to nearby groundwater recharge basins. The Laboratory's STP treatment process includes three principal steps: 1) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 2) secondary clarification, and 3) filtration for final solids removal. 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.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity occurs at two locations. The first site, MH-192, is approximately 1.1 miles upstream of the STP, and provides a minimum of 30 minutes to warn the STP operators that wastewater exceeding SPDES limits or BNL administrative effluent release criteria is en route. 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 can be diverted to two double-lined holding ponds. The total combined capacity of the two holding ponds exceeds six million gallons, or approximately 18 days of flow. Diversion would continue until the influent water quality would allow for the permit limits and release criteria to be met. Wastewater diverted to the holding ponds is tested and evaluated against the requirements for release.

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

		Flow (Liters)	Tritium (pCi/L)		Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
			max.	avg.	max.	avg.	max.	avg.
January	*influent*	2.89E+07	< 376	< MDL	< 14.1	2.1 ± 1.8	12.5 ± 2.6	7.7 ± 2.5
	effluent	2.24E+07	< 354	< MDL	< 4.5	0.3 ± 0.9	8.7 ± 1.7	7.3 ± 0.9
February	*influent*	2.43E+07	< 346	< MDL	52.9 ± 30.5	24.2 ± 23.6	36.2 ± 15.0	19.3 ± 14.4
	effluent	1.64E+07	< 346	< MDL	< 3.1	0.5 ± 0.9	7.2 ± 1.4	6.3 ± 1.0
March	*influent*	3.06E+07	< 342	< MDL	39.5 ± 19.7	12.5 ± 18.6	34.5 ± 11.8	17.9 ± 11.8
	effluent	1.87E+07	< 353	< MDL	2.2 ± 1.3	0.8 ± 1.4	7.1 ± 1.3	5.9 ± 1.1
April	*influent*	2.81E+07	< 260	< MDL	< 8.5	2.7 ± 3.4	4.8 ± 1.2	3.6 ± 1.1
	effluent	2.38E+07	< 352	< MDL	< 2.3	-0.4 ± 0.7	5.1 ± 1.1	4.4 ± 0.6
May	*influent*	5.01E+07	< 261	< MDL	3.4 ± 2.4	1.4 ± 0.9	8.8 ± 1.8	6.4 ± 1.5
	effluent	2.98E+07	< 259	< MDL	< 2.0	0.6 ± 1.1	8.7 ± 1.6	6.7 ± 1.4
June	*influent*	3.54E+07	< 356	< MDL	2.5 ± 2.1	1.4 ± 1.3	7.3 ± 1.8	5.4 ± 1.5
	effluent	2.44E+07	< 354	< MDL	< 2.6	0.3 ± 0.4	6.2 ± 1.2	4.9 ± 0.8
July	*influent*	3.55E+07	< 312	< MDL	< 6.4	3.2 ± 1.5	13.0 ± 4.3	11.7 ± 1.3
	effluent	2.70E+07	< 309	< MDL	< 3.5	0.4 ± 1.1	9.4 ± 1.9	6.4 ± 1.6
August	*influent*	3.25E+07	< 327	< MDL	< 6.1	-1.2 ± 2.6	12.5 ± 6.2	7.8 ± 3.1
	effluent	3.00E+07	< 383	< MDL	< 1.7	0.0 ± 0.4	6.4 ± 1.2	4.8 ± 1.1
September	*influent*	3.22E+07	< 320	< MDL	< 5.3	0.3 ± 1.1	7.1 ± 1.5	5.4 ± 1.2
	effluent	2.53E+07	< 300	< MDL	3.2 ± 2.2	1.4 ± 1.4	6.6 ± 1.4	5.2 ± 1.1
October	*influent*	3.90E+07	< 347	< MDL	< 2.4	-0.2 ± 1.0	6.6 ± 1.7	5.7 ± 0.6
	effluent	2.97E+07	< 356	< MDL	2.4 ± 1.4	1.1 ± 0.8	6.9 ± 1.4	5.3 ± 0.9
November	*influent*	2.33E+07	< 343	< MDL	< 1.2	-0.1 ± 0.4	6.3 ± 1.0	3.9 ± 1.2
	effluent	1.99E+07	< 343	< MDL	< 2.2	-0.1 ± 0.3	5.6 ± 1.5	4.2 ± 1.0
December	*influent*	1.96E+07	< 296	< MDL	< 1.3	0.5 ± 0.5	5.9 ± 1.1	5.2 ± 0.5
	effluent	2.20E+07	< 274	< MDL	< 1.3	-0.3 ± 0.3	5.2 ± 0.8	4.4 ± 0.7
Annual Avg.	*influent*			< MDL		4.0 ± 3.0		8.4 ± 2.0
	effluent			< MDL		0.4 ± 0.3		5.6 ± 0.4
Total Release		**2.89E+08**		**10.5 mCi (a)**		**0.1 mCi**		**1.6 mCi**
Average MDL (pCi/L)				**353**		**2.6**		**1.3**
SDWA Limit (pCi/L)				**20,000**		**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) The total released value for tritium is a conservative calculation that is based on an average of the 95% confidence interval maximums as estimates of monthly average release concentrations. The majority of the effluent samples showed average concentrations less than zero and all results were less than the MDL.
(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 activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

If necessary, the wastewater is treated and then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits for non-radiological parameters or BNL effluent release criteria for radiological parameters. In 2017, there were no instances where influent water quality required diversion of wastewater to the hold-up ponds.

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 six 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, and at the STP outfall, Station EA, as shown in Figure 5-2. At each location, samples are collected on a flow-proportional basis; that is, for every 1,000 gallons of water treated, approximately four fluid ounces of sample are collected and composited into a five-gallon collection container. These samples are analyzed weekly for gross alpha and gross beta activity and for tritium. 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 STP discharge 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

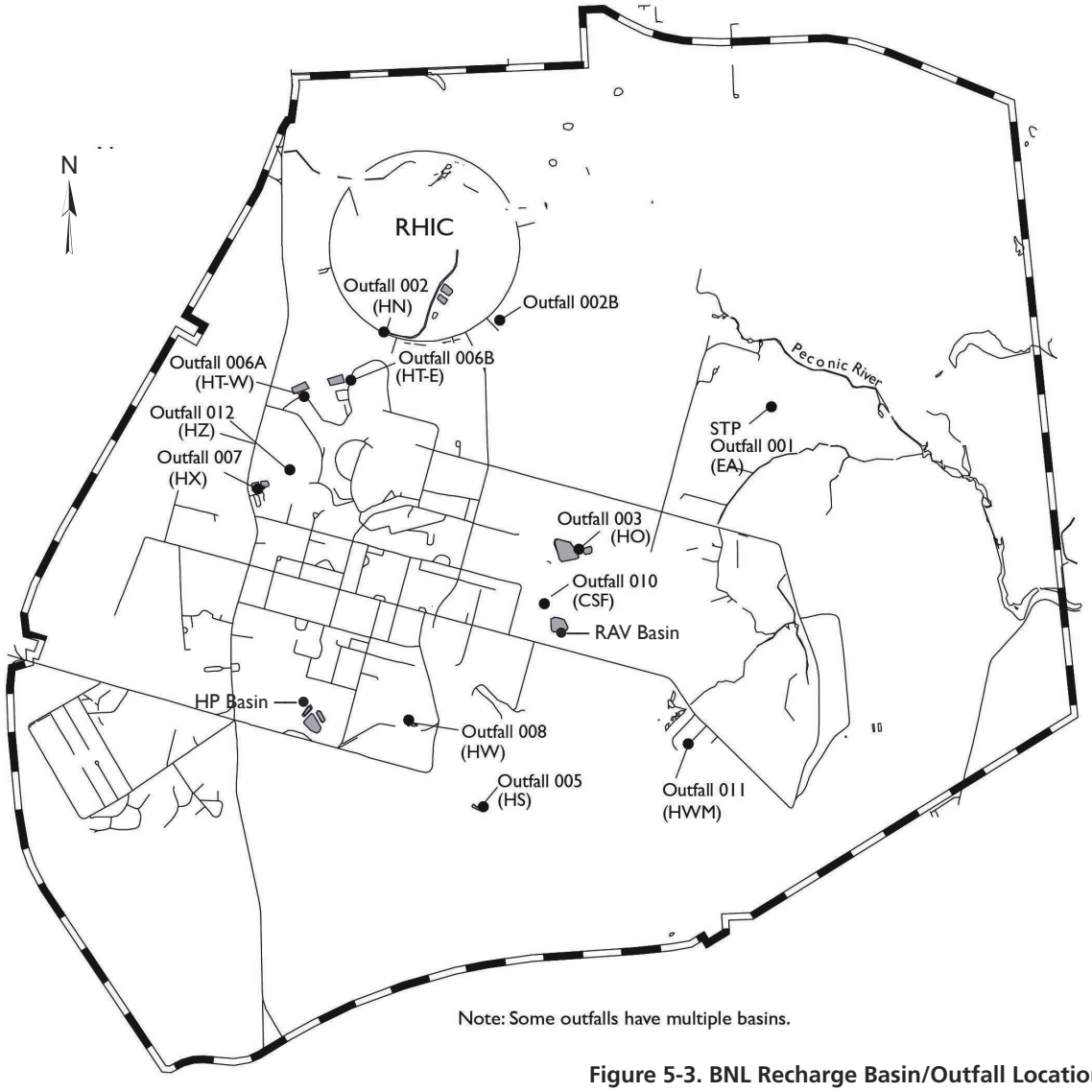

Figure 5-3. BNL Recharge Basin/Outfall Locations.

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 2017. Annual average gross alpha and beta activity levels in the STP effluent were 0.4 ± 0.3 pCi/L and 5.6 ± 0.4 pCi/L, respectively. These average concentrations are higher than control location data (Carman's River Station HH) reported in Table 5-5; however, they are well below the SDWA standards that are used for comparison purposes. Tritium was not detected above minimum detection limits in the discharge of the STP (EA, Outfall 001) for the entire year. In 2017, there were no gamma-emitting nuclides detected in the STP effluent.

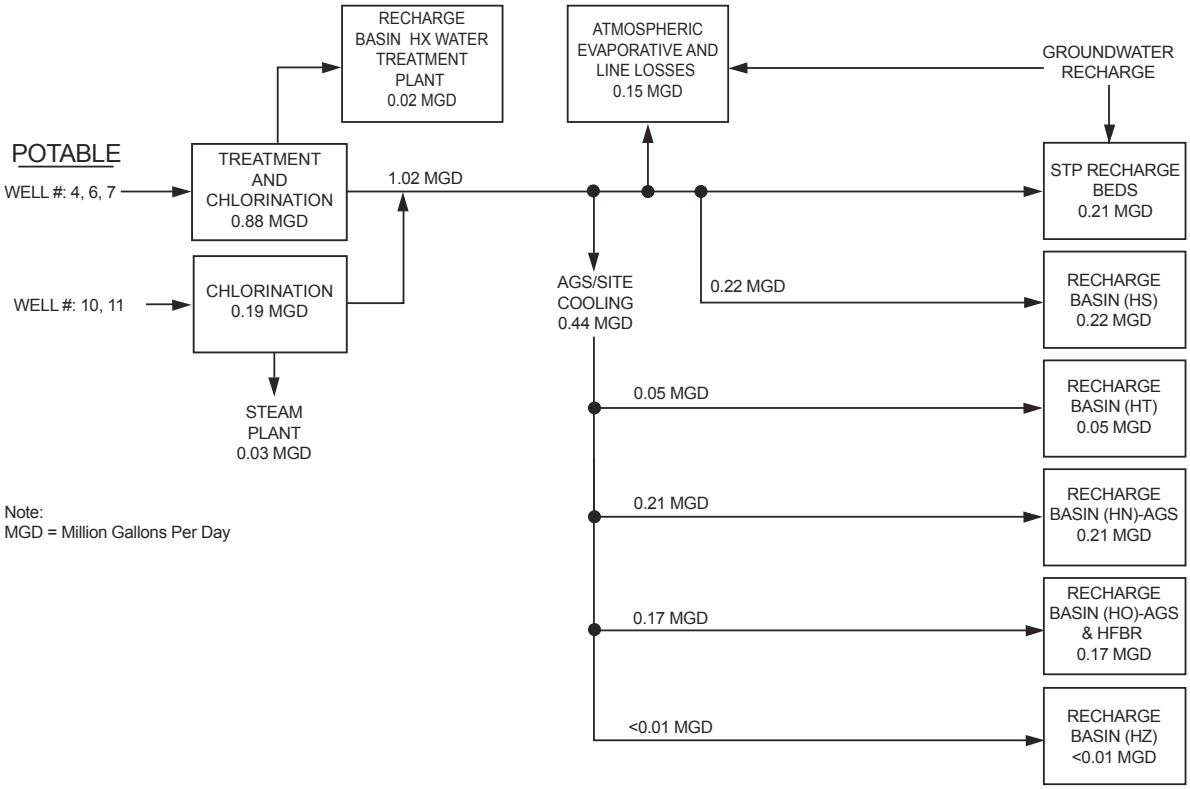

Figure 5-4. Schematic of Potable Water Use and Flow at BNL.

5.2.2 Sanitary System Effluent – Nonradiological Analyses

Monitoring of the STP effluent for volatile organic compounds (VOCs), inorganics, and anions is conducted as part of the SPDES 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 only 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, potentially impact groundwater quality (BNL 2014).

The Laboratory's SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from metal cleaning operations in Building 498 and cooling tower discharges from Building 902. These operations are monitored for contaminants such as metals, cyanide, VOCs, and semivolatile organic compounds. In 2017, 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 are not expected to be of consistent quality and are not routinely generated are held for characterization before release to the sanitary system. The process wastewaters typically include 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 are analyzed for contaminants specific to the process, and the concentrations are compared to the SPDES effluent limits and BNL's effluent release criteria (BNL 2014). If the concentrations are within limits, authorization for sewer system discharge is granted; if not, alternate means of disposal are used. Any waste that contains elevated levels of hazardous or radiological contaminants in concentrations that exceeded Laboratory effluent release criteria are sent to the BNL Waste Management Facility for proper management and off-site disposal.

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.*	< 1.12	1.61 ± 0.82	< 340
	avg.	0.75 ± 0.19	1.31 ± 0.6	< MDL
HO	*max.*	< 1.39	<0.92	362 ± 227
	avg.	0.27 ± 1.2	0.69 ± 0.22	154.4 ± 406.9
HS	*max.*	< 0.96	2.54 ± 0.79	< 330
	avg.	0.59 ± 0.17	1.75 ± 1.54	80.4 ± 108.98
HT-E	*max.*	< 3.2	2.16 ± 1	< 341
	avg.	0.51 ± 0.67	1.42 ± 1.45	4.3 ± 197.37
HT-W	*max.*	< 1.3	1.04 ± 0.56	< 352
	avg.	0.88 ± 0.37	0.83 ± 0.41	52.75 ± 94.57
HW	*max.*	1.44 ± 1.13	3.79 ± 0.91	< 388
	avg.	1.32 ± 0.24	3.24 ± 1.09	6.05 ± 67.52
HZ	*max.*	< 1.48	< 0.9	< 344
	avg.	0.11 ± 0.36	0.24 ± 0.37	82.25 ± 54.39
SDWA Limit		**15**	**(a)**	**20,000**

Notes:
See Figure 5-2 for recharge basin/outfall locations.
All values reported with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
To convert values from pCi to Bq, divide by 27.03.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent of this value cannot be calculated.
MDL = minimum detection limit
SDWA = Safe Drinking Water Act

5.4 RECHARGE BASINS

Recharge basins are used for the discharge of "clean" wastewater, including once-through cooling water, stormwater runoff, and cooling tower blowdown. These wastewaters are suitable for direct replenishment of the groundwater aquifer. Figure 5-3 shows the locations of the Laboratory's discharges to recharge basins (also called "outfalls" under BNL's SPDES permit). Figure 5-4 presents an overall schematic of potable water use at the Laboratory, and how much of this water is discharged to the 11 on-site recharge basins:

- Basins HN, HT-W, and HT-E receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron

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.*	6.7	7.2	7	7.5	7.6	7.2	7.3	7.1	6.5 - 8.5	NA
	max.	7.5	7.7	7.7	7.8	8	7.8	7.7	8.3		
Conductivity (µS/cm)	*min.*	166	230	67	237	263	38	131	255	SNS	NA
	max.	527	281	455	251	295	260	1763	277		
	avg.	347	256	261	244	279	149	947	266		
Temperature (°C)	*min.*	8.3	11.7	8.8	14	8.4	10.1	9.9	10.2	SNS	NA
	max.	22.3	19	22.5	23.2	23.7	22.4	21.5	23		
	avg.	15.3	15.3	15.6	18.6	16	16.3	15.7	16.6		
Dissolved oxygen (mg/L)	*min.*	8.5	7.8	8.5	8	8.7	8.6	9	7.7	SNS	NA
	max.	10.6	10.8	11.7	9.6	11.6	10.1	10.1	11.1		
	avg.	9.6	9.3	10.1	8.8	10.2	9.3	9.5	9.4		
Chlorides (mg/L)	*min.*	21	48	5	40	41	6	14	45	500	2.5
	max.	120	50	110	47	150	58	540	55		
	avg.	71	49	58	44	96	32	277	50		
Sulfates (mg/L)	*min.*	4.6	9.5	1.5	9	8.4	2.1	3.2	8	500	1.3
	max.	12	9.5	10	9.6	9	4.8	7.4	9.6		
	avg.	8.3	9.5	5.75	9.3	8.7	3.45	5.3	8.8		
Nitrate as nitrogen (mg/L)	*min.*	0.13	0.28	0.06	0.13	0.12	0.39	0.74	0.23	10	0.04
	max.	0.32	0.36	0.42	0.27	0.22	0.59	0.75	0.28		
	avg.	0.22	0.32	0.24	0.2	0.17	0.49	0.74	0.26		

Notes:
See Figure 5-2 for the locations of recharge basins/outfalls.
(s) = stormwater
AGS = Alternating Gradient Synchrotron
Linac = Linear Accelerator
NA = Not Applicable
NYSDEC = New York State Department of Environmental Conservation
RHIC = Relativistic Heavy Ion Collider
SNS = Effluent Standard Not Specified

(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 Building 725 Computational Science Initiative (CSI) facility.
- 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 (FHWMF), 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 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) equivalency permits.

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
	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	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	2000	50
	max.	< 50.0	< 50.0	< 50.0	< 50.0	58	< 50.0	60	< 50.0		
	avg.	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	55	< 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
	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	20	<20	<20	<20	<20	<20	<20	2000	20
	max.	28	28	33	30	30	31	27	24		
	avg.	24	24	24.5	23	23	23	22.5	21		
Be Beryllium (µg/L)	*min.*	<2.0	< 2.0	< 2.0	< 2.0	<2.0	< 2.0	<2.0	< 2.0	SNS	2
	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	< 2.0	< 2.0	<2.0	< 2.0	< 2.0	< 2.0	10	2
	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.*	< 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		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Cr Chromium (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	100	10
	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	< 10.0	<10.0	<10.0	<10.0	<10.0	< 10.0	1000	10
	max.	< 10.0	<10.0	12	<10.0	11	<10.0	52	35		
	avg.	< 10.0	<10.0	6.9	<10.0	<10.0	<10.0	30.9	20.6		
Fe Iron (mg/L)	*min.*	0.05	< 0.05	0.09	<0.05	0.08	< 0.05	0.07	<0.05	0.6	0.05
	max.	0.05	< 0.05	0.2	0.05	0.17	< 0.05	0.13	<0.05		
	avg.	< 0.05	< 0.05	0.14	<0.05	0.12	< 0.05	0.1	<0.05		
Hg Mercury (µg/L)	*min.*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	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.*	4.6	< 2.0	4.4	<2.0	15	9.6	8.1	5	600	2
	max.	25	6.3	26	15	26	9.6	12	6.7		
	avg.	14.8	4.1	15.2	8.5	20.5	9.6	10	5.9		

(continued on next page)

Table 5-4. Metals Analysis of Water Samples from BNL On-Site Recharge Basins. *(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.*	31	32	26	26	26	26	29	29	SNS	0.25
	max.	33	32	91	94	28	29	35	31		
	avg.	32.33	32	58.5	60	27	27.5	32	30		
Ni Nickel (µg/L)	*min.*	<10.0	< 10.0	< 10.0	< 10.0	<10.0	<10.0	<10.0	<10.0	200	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	<10.0	< 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	<3.0	<3.0	50	3
	max.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	16	8.5		
	avg.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	8.7	5.75		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	6	5
	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
	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
	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	< 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		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Zn Zinc (µg/L)	*min.*	< 20.0	< 20.0	< 20.0	<20.0	< 20.0	< 20.0	29	< 20.0	5000	20
	max.	< 20.0	< 20.0	23	20	30	22	130	22		
	avg.	< 20.0	< 20.0	21.5	19.5	21.5	<20	79.5	20		

Notes:
See Figure 5-2 for the locations of recharge basins/outfalls.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards
Linac = Linear Accelerator
MDL = minimum detection limit

Each of the recharge basins is a permitted point-source discharge under the Laboratory's SPDES permit and equivalency permits under the CERCLA program. Where required by the permit, the basins are equipped with a flow monitoring station; allowing for weekly recordings of flow rates. 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 2017, water samples were collected from all the basins listed above semi-annually except for recharge Basin HX at the Water Treatment Plant (due to previously documented non-impact to groundwater from plant operations) and recharge basin at the FHWMF (there are no longer any operations at the FHWMF that could lead to the contamination of runoff).

Table 5-5. Radiological Results for Surface Water Samples Collected along the Peconic and Carmans Rivers for: 2017

Sampling Station		Gross Alpha	Gross Beta	Tritium	Sr-90
		(pCi/L)			
HY (headwaters) on site, west of the RHIC ring	*N*	2	2	2	2
	max	1.7 ± 0.86	3.29 ± 0.87	< 295	< 0.49
	avg	1.39 ± 0.61	2.64 ± 1.27	<MDL	0.09 ± 0.56
HV (headwaters) on site, inside the RHIC ring	*N*	1	1	1	NA
	max	< 1.46	< 0.97	< 385	NA
	avg	NA	NA	NA	NA
Donahue's Pond off site	*N*	1	1	1	1
	max	< 1.07	< 0.81	< 325	< 0.26
	avg	NA	NA	NA	NA
Carmans River HH control location, off site	*N*	2	2	2	2
	max	< 1.29	1.63 ± 0.68	< 389	< 0.22
	avg	0.24 ± 1.11	1.5 ± 0.24	<MDL	0.09 ± 0.25
SDWA Limit (pCi/L)		**15**	**(a)**	**20,000**	**8**

Notes:
See Figure 5-4 sampling station locations.
All values reported with a 95% confidence interval.
To convert values from pCi to Bq, divide by 27.03.
MDL = minimum detection limit
N = number of samples analyzed
NA = not applicable
NS = not sampled due to dry conditions
RHIC = Relativistic Heavy Ion Collider
SDWA = Safe Drinking Water Act
STP = Sewage Treatment Plant
(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

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. Gross alpha activity ranged from non-detect to 1.44 pCi/L and gross beta activity ranged from non-detectable to 3.79 ± 0.91 pCi/L. Low-level detections of beta activity are attributable to naturally occurring radionuclides, such as potassium-40 (K-40: half-life, 1.3E+09 years). No gamma-emitting nuclides attributable to BNL operations or tritium were detected in any discharges to recharge basins.

5.4.2 Recharge Basins – Nonradiological Analyses

During 2017, discharge 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, respectively. The nonradiological analytical results are compared to groundwater discharge standards promulgated under Title 6 of the New York Codes, Rules, and Regulations (NYCRR), Part 703.6.

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 can breakdown to bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Concentrations of most disinfection byproducts were less than method detection limits with the exception of bromoform with all values less than 12 µg/L and dibromochloromethane with all values less than 6 µg/L. No other VOCs were detected above method detection limits in any of the discharges to the recharge basins.

The analytical data presented in Table 5-3 show that for 2017, the concentrations of all analytes were within effluent standards, except for high detections of chlorides in Basin CSF. Chlorides are found to be higher in samples collected during the winter and are attributed to

Table 5-6. Water Quality Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers for: 2017

Analyte		Peconic River Station Locations HY	Donahue's Pond	Carmans River (Control) HH	NYSDEC Effluent Standard	Typical MDL
No. of samples		2	1	2		
pH (SU)	*min.*	6.4	6.5	6.5	6.5 - 8.5	NA
	max.	7.2	6.5	7		
Conductivity (µS/cm)	*min.*	39	NA	248	SNS	NA
	max.	300	85	252		
	avg.	169.5	NA	250		
Temperature (°C)	*min.*	11.1	NA	17.4	SNS	NA
	max.	20.2	19	18.9		
	avg.	15.7	NA	18.2		
Dissolved oxygen (mg/L)	*min.*	9.8	NA	10.2	> 4.0	NA
	max.	10	6.4	10.5		
	avg.	9.9	NA	10.4		
Chlorides (mg/L)	*min.*	8.2	NA	49	250 (a)	2.8
	max.	76	13	49		
	avg.	42.1	NA	49		
Sulfate (mg/L)	*min.*	1.1	NA	12	250 (a)	0.9
	max.	2.2	5.3	13		
	avg.	1.65	NA	12.5		
Nitrate as nitrogen (mg/L)	*min.*	0.17	NA	0.09	10 (a)	
	max.	0.34	< 0.05	2.7		
	avg.	0.26	NA	1.39		

Notes:
See Figure 5-2 for recharge basin/outfall locations.
Donahue's Pond = Peconic River, off site
HA = Peconic River, off site
HE = Peconic River, upstream of former STP Outfall
HH = Carmans River control location, off site
HM-N = Peconic River on site, at the east firebreak
HM-S = Peconic River tributary, on site
(a) Since there are no NYSDEC Class C surface Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for Class GA groundwater is provided for reference.

road salt used to control snow and ice buildup. The samples with elevated chloride levels from Basin CSF were collected in February and likely reflect the washing out of road salt applied during previous snow events. The data in Table 5-4 show that all parameters complied with the respective water quality or groundwater discharge standards.

5.4.3 Stormwater Assessment

All recharge basins receive stormwater runoff. Stormwater at BNL is managed by collecting runoff from paved surfaces, roofs, and other impermeable surfaces and directing it to recharge basins via underground piping and 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 area surrounding the HFBR. 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 FHWMF.

Table 5-7: Metals Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers for: 2017

METAL		Peconic River Locations						NYSDEC AWQS (a)	Typical MDL
		HY		Donahue's Pond		Control HH			
Total (T) or Dissolved (D)		T	D	T	D	T	D		
No. of samples		2	2	1	1	2	2		
Ag (I) Silver (µg/L)	*min.*	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	0.1	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0		
Al (I) Aluminum (µg/L)	*min.*	350	76	NA	NA	<50.0	<50.0	100	50
	max.	1500	190	150	100	60	<50.0		
	avg.	925	133	NA	NA	51	<50.0		
As (D) Arsenic (µg/L)	*min.*	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	150	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	<20	<20	NA	NA	49	47	SNS	20
	max.	28	<20	23	22	56	56		
	avg.	24	<20	NA	NA	53	52		
Be (AS) Beryllium (µg/L)	*min.*	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	11	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0		
Cd (D) Cadmium (µg/L)	*min.*	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	1.1	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0		
Co (AS) Cobalt (µg/L)	*min.*	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	5	5
	max.	< 5.0	< 5.0	< 5.0	<5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0		
Cr (I) Chromium (µg/L)	*min.*	< 10.0	<10.0	NA	NA	< 10.0	< 10.0	34	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	NA	NA	< 10.0	< 10.0		
Cu (D) Copper (µg/L)	*min.*	13	< 10.0	NA	NA	<10.0	<10.0	4	10
	max.	13	< 10.0	<10.0	<10.0	<10.0	<10.0		
	avg.	13	< 10.0	NA	NA	<10.0	<10.0		
Fe (AS) Iron (mg/L)	*min.*	0.52	0.08	NA	NA	0.42	0.23	0.3	0.05
	max.	1.8	0.25	5.7	4.2	0.57	0.34		
	avg.	1.16	0.17	NA	NA	0.5	0.29		
Hg (D) Mercury (µg/L)	*min.*	< 0.2	< 0.2	NA	NA	< 0.2	< 0.2	0.2	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	NA	NA	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	17	3	NA	NA	110	110	SNS	2
	max.	30	13	440	460	240	240		
	avg.	23.5	8	NA	NA	175	175		
Na Sodium (mg/L)	*min.*	9.3	11	NA	NA	29	29	SNS	0.25
	max.	59	57	9.7	9.9	35	34		
	avg.	34.2	34	NA	NA	32	32		

(continued on next page)

Table 5-7: Metals Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers for: 2017

METAL		Peconic River Locations						NYSDEC AWQS (a)	Typical MDL
		HY		Donahue's Pond		Control HH			
Total (T) or Dissolved (D)		T	D	T	D	T	D		
No. of samples		2	2	1	1	2	2		
Ni (D) Nickel (µg/L)	*min.*	< 10.0	< 10.0	NA	NA	< 10.0	< 10.0	23	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	NA	NA	< 10.0	< 10.0		
Pb (D) Lead (µg/L)	*min.*	4.1	<3.0	NA	NA	< 3.0	< 3.0	0.1	3
	max.	8	<3.0	3.3	<3.0	< 3.0	< 3.0		
	avg.	6.05	<3.0	NA	NA	< 3.0	< 3.0		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	SNS	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0		
Se (D) Selenium (µg/L)	*min.*	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	4.6	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0		
Tl (AS) Thallium (µg/L)	*min.*	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	8	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0		
V (AS) Vanadium (µg/L)	*min.*	6.8	<5.0	NA	NA	< 5.0	< 5.0	14	5
	max.	9	7.1	<5.0	< 5.0	< 5.0	< 5.0		
	avg.	7.9	6.1	NA	NA	< 5.0	< 5.0		
Zn (D) Zinc (µg/L)	*min.*	32	<20.0	NA	NA	< 20.0	< 20.0	37	20
	max.	64	<20.0	< 20.0	< 20.0	< 20.0	< 20.0		
	avg.	48	<20.0	NA	NA	< 20.0	< 20.0		

Notes:
See Figure 5-4 sampling station locations.
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
DP = Donahue's Pond
NA = not applicable
SNS = effluent standard not specified for these elements in Class C surface waters
(a) NYS AWQS for Class C surface waters

Stormwater runoff at the Laboratory typically has elevated levels of inorganics (i.e., metals) and has a 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 on site, BNL has formal procedures for managing and maintaining outdoor work and storage areas. The requirements include covering of equipment and materials (e.g., road salt storage, bins/containers with potential to leak residual oils or any other hazardous materials) 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. Basin sediment sampling is conducted on a five-year testing cycle to ensure these discharges are in compliance with regulatory requirements. Basin sediments were sampled in 2017 and data are presented in Chapter 6. The next sampling event will occur in 2022.

5.5 PECONIC RIVER SURVEILLANCE

Several locations are monitored along the Peconic River to assess the overall water quality of the river and assess any impact from BNL operations. Sampling points along the Peconic River are identified in Figure 5-1. In total, three

stations (two upstream and one downstream of the former STP discharge) were sampled in 2017. A sampling station along the Carmans River (HH) was also monitored as a geographic control location, not affected by Laboratory operations or located within the Peconic River watershed. The following locations were monitored for radiological and nonradiological parameters:

Upstream sampling station
- HY, on site, immediately east of the William Floyd Parkway
- HV, on site, just east of the 10 o'clock experimental hall in the RHIC Ring

Downstream sampling stations
- Donahue's Pond, off site

Control location
- HH, Carmans River

5.5.1 Peconic River – Radiological Analyses

During 2017, radionuclide analyses were performed on surface water samples collected from the three Peconic River sampling locations and the Carmans River control location. The majority of the Peconic River on site was dry throughout 2017 due to continued drought conditions. The radiological data from Peconic River surface water samples are summarized in Table 5-5. Radiological analysis of water samples collected from all locations had very low concentrations of gross alpha and gross beta activity that were attributed to natural sources. All detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected, and neither tritium or Sr-90 were detected above method detection limits in any of the samples.

5.5.2 Peconic River – Nonradiological Analyses

River water samples collected in 2017 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 in any samples collected from the Peconic River or Carmans River stations in 2017.

Water quality parameters measured in the two Peconic River locations (one on site and one off site) and the Carmans River control location (HH) show that all pH, temperature, conductivity, and dissolved oxygen levels were within applicable NYS standards.

Ambient water quality standards (AWQS) 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 2017, 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 aluminum, copper, iron, lead, and zinc were present in concentrations at some locations that exceeded NYS AWQS. Aluminum and iron were detected throughout the Peconic and Carmans River systems at concentrations that exceed the NYS AWQS in both the filtered and unfiltered fractions. Iron and aluminum were found in high concentrations in native Long Island soil and, for iron, at high levels in groundwater. Levels of copper, lead, and zinc at concentrations greater than the NYS AWQS were found in samples collected at station HY, which was immediately east of the William Floyd Parkway and not within the influence of BNL operations. Filtration of the samples reduced concentrations for most metals to below the NYS AWQS, indicating that most detections were due to sediment suspended in the samples.

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6 Natural and Cultural Resources

The Brookhaven National Laboratory (BNL) 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 maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with personnel and the public on ecological issues. BNL focuses on protecting both Federal and 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 the program. In 2017, deer, vegetation, and soil sampling results were consistent with previous years.

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 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) describes the program strategy, elements, and planned activities for managing the various natural resources found on site. The NRMP is updated every five years with the most recent update being completed in 2016 (BNL 2016).

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 2014, the southern pine beetle (SPB) was discovered at a number of locations on Long Island, including BNL. Mapping and tracking this native forest pest that rapidly colonizes and spreads through dense stands of pitch pines began in Spring 2015. The Laboratory has continued to work with the New York State Department of Environmental Conservation (NYSDEC) and the U.S. Forest Service to map and track infestations on the Laboratory site. The efforts combine aerial surveys along with ground truthing surveys and mapping. The results of this effort are maintained within the GIS to track impacts to the forest.

Mapping associated with tracking impacts from the operation of the Long Island Solar Farm (LISF) at BNL continues to be entered into the GIS as a tool to analyze changes to wildlife populations and vegetation. In 2017,

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
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	Likely
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
Mammals			
Northern long-eared bat**	*Myotis septentrionalis*	FT	Confirmed

continued on next page

natural resource personnel and interns looked at use of the LISF site by wildlife; pollinators; 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 (see Table 6-1). The only New York State endangered animal species confirmed as currently inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Endangered plants that have been confirmed on the BNL site include Engelman spikerush (*Eleocharis engelmannii*), Ipecac spurge (*Euphorbia ipecacuanhae*), dwarf huckleberry (*Gaylussacia bigeloviana*), and whorled loosestrife (*Lysimachia quadrifoli*). Three other New York State endangered species have been identified at BNL in the past or are possibly present including: the Persius duskywing butterfly (*Erynnis p. persius*), crested fringed orchid (*Plantathera cristata*), and fireweed (*Erectites heiracifolia var. megalocarpa*).

Seven threatened species in New York State have been positively identified on site and three other species are considered likely to be present. Threatened species include two fish (banded sunfish [*Enneacanthus obesus*] and swamp darter [*Etheostoma fusiforme*]) and three plants (stiff-leaved goldenrod [*Oligoneuron rigida*], stargrass [*Aletris farinose*], and eastern showy

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need *(concluded).*

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	**Scientific Name**	**State Status**	**BNL Status**
Plants			
Small-flowered false foxglove	*Agalinis paupercula*	R	Confirmed
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa ssp. interior*	V	Confirmed
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
Fireweed	*Erectites heiracifolia var. megalocarpa*	E	Possible
Ipecac spurge	*Euphorbia ipecacuanhae*	E	Confirmed
Eastern showy aster	*Eurybia spectabilis*	T	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 orchid	*Platanthera lacera*	V	Confirmed
Prostate knotweed	*Polygonum aviculare ssp. buxiforme*	E	Possible
Bracken fern	*Pteridium alquilinum var. pseudocaudatum*	E	Possible
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
Possum haw	*Viburnum nudum var. nudum*	E	Possible
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 2015
E = endangered
F = federally threatened
R = rate
SC = species of special concern
SGCN = species of greatest conservation need
T = threatened
V = exploitably vulnerable

aster [*Eurybia spectabilis*]). The northern harrier (*Circus cyaneus*) is periodically seen in the fall. Insects listed as threatened include a damselfly, the Pine Barrens bluet (*Enallagma recurvatum*), 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 iris*), 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.

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 longeared bat (*Myotis septentrionalis*) be listed as a threatened species on April 2, 2015, with an effective date of May 4, 2015. A draft rule under section 4(d) of the Federal Endangered Species Act was published concurrent to the determination of threatened status and provided guidance on management requirements. The draft 4(d) rule was finalized in early 2016. The northern longeared 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. The bat has been added to the Laboratory's list of protected species. On January 11, 2017, the FWS published the final rule listing the rusty patched bumble bee (*Bombus affinis*) as an endangered species. The historic range of this bumble bee includes Long Island. In 2016, a researcher working on bumble bees identified a single specimen as the rusty patched bumble bee. However, no photos or specimens were taken and therefore the identification could not be corroborated. Subsequent searches in the area in 2017 did not yield evidence for its presence.

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 buffer areas around tiger salamander habitats of 1,000 feet based on guidance from 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 postponed 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 that 26 on-site ponds are used by eastern tiger salamanders. In 2017, surveys confirmed the presence of salamanders in two of the 26 ponds. Long Island's drought continued into spring 2017, with virtually all on-site ponds remaining dry after winter snow and rains concluded. Ponds began holding water after rains during fall 2017.

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 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. During the last population survey in 2011, approximately 6,400 banded sunfish were counted. In 2015, the only known pond with banded sunfish was nearly dry due to drought conditions. A very small depression remained wet throughout the year and may have harbored fish. However, this area was completely dry during 2016 due to continued drought conditions, with only minimal water through most of 2017. Regionally, NYSDEC determined that only a few populations of banded sunfish survived the drought and they will evaluate the need for restoration efforts after surveys in 2018.

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.

In 2017, monthly surveys were conducted starting at the end of April and extending through the end of August. These surveys identified 72 bird species, compared to the 77 species identified in 2016 and 84 species in 2015. A total of 133 bird species have been identified in surveys in the past 17 years; 59 of these species were present in each of the past 17 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 three 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. No known data on the effects of a large, utility-scale solar array such as the LISF are known within scientific literature. To assess the effects of the LISF on local bird populations, the collection of migratory bird data in both the Biology Field and LISF transects is important. The LISF vegetation and the way it is managed may play a key role as habitat for migratory birds. One species, the indigo bunting (*Passerina cyanea*), was absent along the Biology Field transect in 2011, but was heard along the LISF transect in 2012, returned to the Biology Field transect in 2013, and has been present on both transects since 2014. This temporary absence is thought to be due to disturbance from construction activities while building the LISF.

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 60 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 new boxes were installed around the northern most portions of the LISF in 2012 and are routinely used by bluebirds, house wrens, and tree swallows.

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. Approximately 12 years ago, it was determined that the resident Canada goose population at BNL reached large enough numbers that could result in health and safety issues. Beginning in 2007, under a permit from FWS, the Laboratory began managing the resident goose population by limiting the number of eggs that could hatch. Forty-five nests were treated during 2017 to reduce the number of goslings. The increase over the 20 nests that were treated in 2016 was due to geese that were hatched in 2014 reaching sexual maturity. During 2017, approximately 12 goslings were produced, with minimal survival due to predation. By the end of 2017, the resident goose population was estimated at just over 100 birds.

6.1.2.4 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) has been increasing in population locally on Long Island with eight known nest sites on the island. During 2017, bald eagles were sighted numerous times in the area of the Sewage Treatment Plant (STP), and a single juvenile was documented during the August bird survey. Adult bald eagles were noticed visiting deer carcasses that were purposely placed for camera trap studies. As the eagle population increases on Long Island, the potential for them to nest on the BNL site will increase as well.

6.1.2.5 Northern Long-eared Bat

As discussed in Section 6.1.1, the northern long-eared bat was added to the list of federally threatened species in 2015. BNL began planning for the eventual listing and put in place actions to minimize the likelihood of impacting this species. The two most likely

activities that could impact this bat are building demolition and prescribed fires. Inspections for the presence of bats are conducted in multiple ways prior to a building demolition. During spring, summer, and fall, ultrasonic acoustic monitoring is conducted around buildings scheduled for demolition to determine if there is bat activity. Regardless of the outcome of acoustic monitoring, a final internal inspection of the buildings is conducted approximately 24 hours prior to demolition to verify the absence of bats. For growing season prescribed fire, acoustic monitoring is done within the burn unit to determine if there is bat activity. If positive results are acquired, surveys of the entire burn unit are completed to identify potential roost trees and appropriate protections are put into place to ensure that bats are not impacted by fire. In 2017, only one building was demolished, and there was no impact to bats. Surveys ahead of prescribed fires in 2017 identified no roost trees.

6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, the Laboratory also monitors or 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 2017, the on-site population was approximately 500 birds due to very successful nesting. Each year, NYSDEC manages a five-day hunting period during the week of Thanksgiving, and a youth-only hunt in May for several areas across Long Island, which typically results in over 100 birds taken.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately one square mile. Normally, a population density of ten 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 routine population surveys of the white-tailed deer since 2000. The fall 2017 estimate provided a range of 250-300 animals after completion of culling during spring 2017 (see below).

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, and 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, employee training, and deer management practices.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. Multiple east end towns are now managing deer populations either through culls, hunting, or sterilization programs. In 2008, BNL began developing a deer management plan which included an option to reduce the population through culling. The planning effort 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 New York 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 NYSDEC, the Laboratory is required to implement a deer management program. In February 2015, 300 animals were taken, effectively reducing the population to approximately 530 animals. Furthermore, as many as 100 additional animals did not survive the harsh

winter conditions which resulted in snow cover lasting more than 30 consecutive days. Estimates from fall 2016 surveys indicated that the population ranged between 400-500 animals. A second population reduction occurred in March 2017, with 202 animals being removed, bringing the herd to a range of 200-300 animals. As mentioned above, the population at the end of 2017, accounting for reproduction, was estimated at between 250 and 300 animals.

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 reviews 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. There were no higher level NEPA reviews started or completed in 2017.

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 2017 included funding for investigative studies related to eastern box turtles (see discussion below).

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, routine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-required monitoring results associated with post-cleanup monitoring of the Peconic River is also conducted. 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 attributable to past practices and world-wide fallout can be found in deer and 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 outcompetes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables allows 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 approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The meat available for consumption from local deer ranges from 20 to 40 pounds

per animal. Samples of meat 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.

Since 1996, BNL has routinely collected deer samples from on- and off-site areas. While most off-site samples are the result of car/deer accidents near the Laboratory, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than one mile from BNL have also been made available for analysis. In 1998, a statistical analysis suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. The number obtained each year has not met this preferred level because sample availability depends on accidents between vehicles and deer and people reporting dead deer. In 2017, a total of 18 deer were taken both on and off the BNL site. Figure 6-1 shows the location of all deer samples taken within a five-mile radius of the Laboratory since 2013. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. This distribution is due to the fact that people on their way to work see and report dead deer. Also, 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 Lab's Main Gate is greatest.

Based on more than a decade of sampling, deer taken from more than one mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source. In 2017, two deer were obtained on site, both from car/deer accidents, ten from off-site locations within one mile of the Laboratory, and six from greater than one mile from the BNL boundary. The analytical results of deer sampling are shown in Table 6-2. In addition to deer sampling, BNL conducted a population reduction of the deer herd with meat from the effort donated to food shelters. To ensure that Cs-137 levels were below State health recommendations, 41 composite samples were taken with analytical results shown in Table 6-3.

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 one mile off site. This is most likely because the deer graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cesium-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing/grazing animals or is consumed directly with soil while the animal is grazing. Remediation of contaminated soil areas on site has occurred under the Laboratory's CERCLA program, with all major areas of contaminated soil being remediated by September 2005.

In 2017, Cs-137 concentrations in deer meat samples were obtained from two deer on site with a range of values from 1.16 pCi/g, wet weight, to 1.34 pCi/g, wet weight, and an arithmetic average of 1.25 pCi/g, wet weight, as shown in Table 6-2. The wet weight concentration is before a sample is dried for analysis and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The highest on-site sample in 2017 (1.34 pCi/g, wet weight) was about 21 percent lower than the highest on-site sample reported in 2016 (1.69 pCi/g, wet weight) and nearly nine 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 one mile of BNL (ten samples) and samples taken farther away (six samples), as shown in Table 6-2. Concentrations in meat samples taken within one mile ranged from 0.06 pCi/g, wet weight to 3.33 pCi/g, wet weight, with an arithmetic average of 1.15 pCi/g, wet weight. Because deer on site may routinely travel up to one mile off site, the arithmetic average for deer taken on site and within one mile of the Laboratory is also calculated; for 2017, this was 1.17 pCi/g, wet weight. The six deer sampled from greater than one mile from BNL had Cs-137

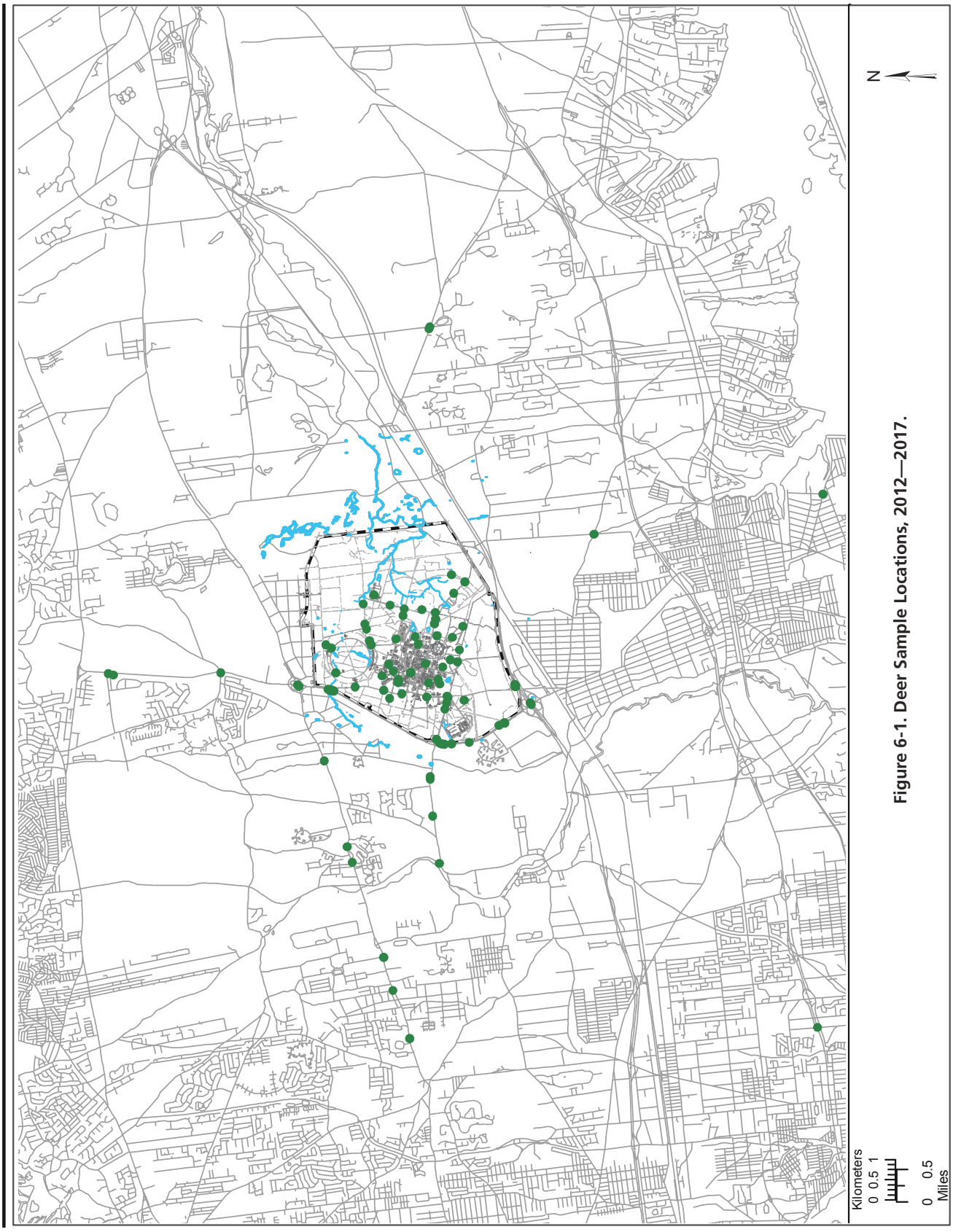


Figure 6-1. Deer Sample Locations, 2012—2017.

Table 6-2. Radiological Analyses of Deer Tissue. (2017)

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL				
East 5th and First St.	1/19/17	Flesh	2.99±0.46	1.16±0.07
	1/19/17	Liver	2.24±0.33	0.26±0.03
BNL Main Gate	11/13/17	Flesh	3.29±0.29	1.34±0.04
	11/13/17	Liver	2.97±0.27	0.51±0.03
< 1 Mile from BNL				
WFPKY at north gate	5/16/17	Flesh	2.88±0.13	0.10±0.01
	5/16/17	Liver	2.60±0.17	0.05±0.01
LIE Exit 68, Sika Deer	9/30/17	Flesh	3.41±0.36	0.88±0.05
	9/30/17	Liver	2.99±0.35	0.68±0.04
Longwood Rd near Junior High School	10/6/17	Flesh	3.00±0.43	0.19±0.03
WFPKY south of Main Gate	10/18/17	Flesh	2.99±0.37	3.33±0.09
	10/18/17	Liver	2.80±0.36	1.11±0.05
WFPKY south of Main Gate deer2	10/30/17	Flesh	3.43±0.48	0.86±0.06
WFPKY & Rte 25	10/30/17	Flesh	2.84±0.32	2.20±0.07
Rte 25 and WFPKY	11/8/17	Flesh	2.94±0.31	2.92±0.07
	11/8/17	Liver	2.81±0.26	1.25±0.04
WFPKY 1/2 mi. South of Main Gate	11/28/17	Flesh	2.69±0.33	0.30±0.03
	11/28/17	Liver	2.00±0.36	0.23±0.03
Longwood Rd. Near JHS	12/12/17	Flesh	2.50±0.36	0.06±0.01
	12/12/17	Liver	2.89±0.32	ND
LIE Service Rd at South Gate	12/29/17	Flesh	3.76±0.35	0.69±0.04
	12/29/17	Liver	2.50±0.32	0.23±0.02
> 1 Mile from BNL				
Middle Island at Sweezey Ln	2/6/17	Flesh	2.73±0.16	0.10±0.01
	2/6/17	Liver	1.48±0.13	0.04±0.01
Rte 25 and Woodlot, Ridge	5/16/17	Flesh	2.55±0.11	0.26±0.01
	5/16/17	Liver	3.23±0.18	0.12±0.01
Manorville, Rte 111	5/31/17	Flesh	2.67±0.33	0.25±0.03
	5/31/17	Liver	2.59±0.32	0.11±0.02
WFPKY at Wiskey Rd.	9/11/17	Flesh	2.83±0.20	0.02±0.01
Rte 111 Manorville	11/2/17	Flesh	2.88±0.26	2.91±0.06
	11/2/17	Liver	3.07±0.25	1.17±0.04
Moriches-Middle Island Rd & Barnes Rd	11/16/17	Flesh	2.93±0.29	0.51±0.03
	11/16/17	Liver	2.69±0.36	0.19±0.03
Averages by Tissue				
Flesh Averages				
All Samples (18)			2.96±1.38	1.00±0.19
BNL Average (2)			3.14±0.55	1.25±0.08
< 1 Mile Average (10)			3.04±1.12	1.15±0.16
BNL + < 1 Mile Average (12)			3.06±1.25	1.17±0.18
> 1 Mile Average (6)			2.77±0.59	0.67±0.08
Liver Averages				
All Samples (14)			2.63±1.10	0.43±0.11
BNL Average (2)			2.61±0.43	0.38±0.04
< 1 Mile Average (7)			2.66±0.83	0.51±0.09
BNL + < 1 Mile Average (9)			2.64±0.93	0.48±0.10
> 1 Mile Average (5)			2.61±0.58	0.33±0.05

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

Table 6-3. Radiological Analysis of Batch Samples from Deer Cull Released for Donation (2017)

Batch Number	Collection Date	K-40 pCi/g (wet)±95% C.I.	Cs-137 pCi/g (wet)±95% C.I.
Day 1 Batch Sampling			
Batch #1	3/24/17	2.76±0.34	0.19±0.02
Batch #2		3.33±0.25	0.10±0.01
Batch #3		2.77±0.20	0.21±0.02
Batch #4		2.70±0.20	0.32±0.01
Batch #5		2.62±0.21	0.25±0.01
Batch #6		2.34±0.16	0.23±0.01
Batch #7		2.56±0.19	0.14±0.01
Day 2 Batch Sampling			
Batch #8	3/25/17	2.48±0.16	0.18±0.01
Batch #9		2.71±0.16	0.22±0.01
Batch #10		2.48±0.16	0.24±0.01
Batch #11		2.72±0.15	0.13±0.01
Batch #12		2.46±0.21	0.10±0.01
Batch #13		2.57±0.16	0.40±0.01
Batch #14		2.75±0.20	0.23±0.01
Batch #15		2.65±0.20	0.24±0.01
Day 3 Batch Sampling			
Batch #16	3/26/17	2.69±0.17	0.24±0.01
Batch #17		2.44±0.17	0.28±0.01
Batch #18		2.62±0.15	0.31±0.01
Batch #19		2.68±0.17	0.44±0.02
Batch #20		2.72±0.17	0.29±0.01
Batch #21		2.61±0.19	0.29±0.02
Batch #22		2.62±0.15	0.37±0.01
Batch #23		2.12±0.22	0.39±0.02
Batch #24		2.34±0.16	0.27±0.01
Batch #25		2.56±0.15	0.24±0.01
Batch #26		2.63±0.17	0.30±0.01
Batch #27		2.49±0.15	0.22±0.01
Day 4 Batch Sampling			
Batch #28	3/27/17	2.52±0.24	0.21±0.02
Batch #29		2.47±0.19	0.37±0.02
Batch #30		2.57±0.20	0.28±0.02
Batch #31		2.59±0.22	0.46±0.02
Day 5 Batch Sampling			
Batch #32	3/28/17	2.23±0.39	0.33±0.03
Batch #33		2.76±0.48	0.36±0.05
Day 6 Batch Sampling			
Batch #34	3/29/17	3.07±0.42	0.22±0.04
Batch #35		2.85±0.45	0.23±0.04
Batch #36		2.33±0.16	ND
Batch #37		2.35±0.27	0.06±0.01
Batch #38		2.85±0.47	0.49±0.05
Batch #39		2.66±0.56	0.19±0.04
Day 7 Batch Sampling			
Batch #40	3/30/17	2.88±0.47	0.32±0.04
Batch #41		3.40±0.67	0.22±0.07
Average Concentrations		2.63±1.79	0.26±0.15

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

concentrations ranging between 0.02 pCi/g, wet weight, to 2.91 pCi/g, wet weight, with an arithmetic average of.0.67 pCi/g, wet weight. Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2017 from four different location groupings. Beginning in 2013, the average Cs-137 content from deer taken within one mile of the Laboratory was lower than the on-site average, and this pattern has been consistent for the past five years. While no definitive explanation can be given to the difference from past results, it could simply be an artifact of low sample numbers and randomness in sample acquisition. Although not shown on Figure 6-2, Cs-137 concentrations in four of the 12 meat samples taken both on and off site were below 0.5 pCi/g, wet weight.

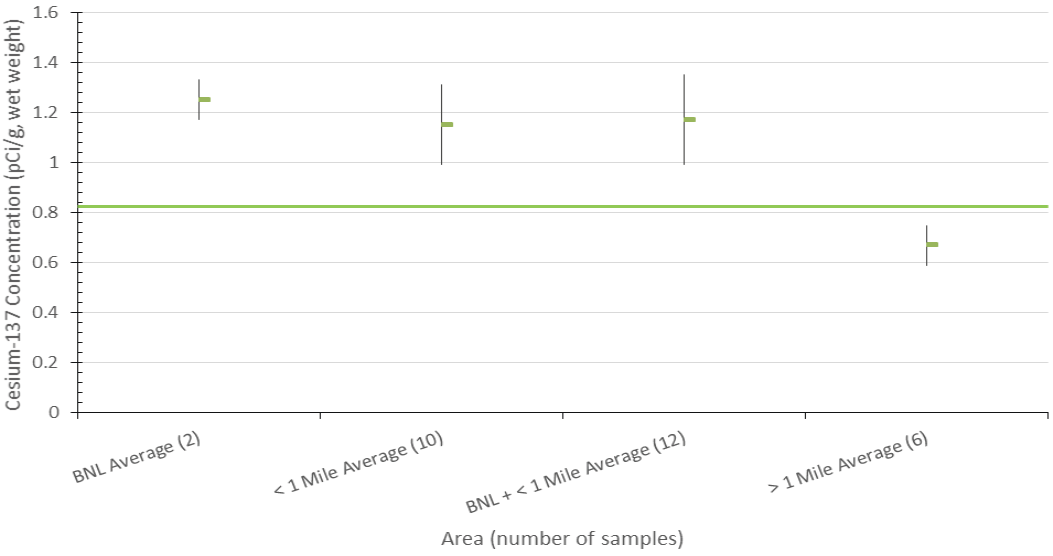
Figure 6-3 presents the ten-year trend of on-site and near off-site Cs-137 averages in deer meat. The 2017 average is approximately one-third lower than the 2008 average and is nearly four times higher than the 2015 value of 0.28 pCi/g wet weight, which was the lowest average seen since trending began in 2000. The higher averages shown are reflective of a significant number of samples taken in the fall when Cs-137 levels are typically higher. However, these sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the trend being downward from 2008 to 2017 and the ten-year average being 0.83 pCi/g.

The effectiveness of the BNL soil cleanup program and the reduction of Cs-137 in deer meat was evaluated by Rispoli, et al. (2014). The average Cs-137 content was shown to be statistically lower than before cleanup. Samples taken at distances greater than one mile from the BNL site were shown to remain consistent before and after clean-up, while the on-site and near off-site values were shown to decline. In preparing for monitoring associated with the reduction of the deer population, the ten-year average for on-site deer samples was calculated to be 1.0 pCi/g, wet weight, and this value was used to establish an administrative release criterion for deer meat made available for donation to the Hunters for the Hungry program.

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 2017, Cs-137 concentrations ranged from 0.26 to 0.51 pCi/g, wet weight, with an average of 0.38 pCi/g, wet weight. The near off-site Cs-137 concentration in liver ranged from non-detect to 1.25 pCi/g, wet weight, with an arithmetic average for off-site liver samples within one mile of 0.51 pCi/g, wet weight. Liver samples from deer taken greater than one mile from BNL ranged from 0.04 pCi/g, wet weight to 1.17 pCi/g, wet weight with the arithmetic average being 0.33 pCi/g, wet weight. The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8.

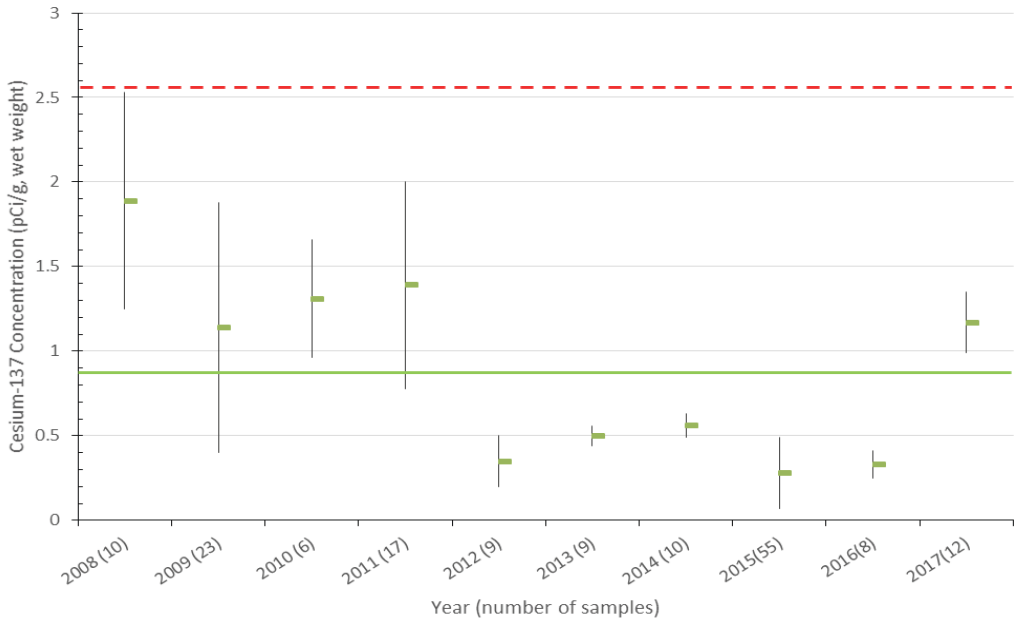
The New York State Department of Health (NYSDOH) has formally considered the potential public health risks associated with elevated Cs-137 levels in on-site deer, and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999). As mentioned above, BNL has established an administrative release criterion of 1.0 pCi/g, wet weight for meat donated from deer removed from the Laboratory and donated through the Hunters for the Hungry program. In 2017, the Lab removed 202 deer from the herd over a seven-day period. Composite samples were acquired during the process in which samples from five deer were combined in a composite sample. A total of 41 samples were sent for analysis. The results of the sampling are presented in Table 6-3. The Cs-137 content in the samples ranged from non-detect to 0.49 pCi/g, wet weight with an arithmetic average of 0.26 pCi/g, wet weight. The range and average were well below the 1.0 pCi/g, wet weight administrative release criteria, therefore all meat was donated.

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA)



Notes: Ten year average of onsite and near offsite deer flesh samples (solid line) is 0.83 pCi/g, wet weight.

Figure 6-2. Comparison of Cs-137 values in deer flesh for onsite, offsite within 1 mile, onsite and near offsite, and offsite greater than 1 mile from the Laboratory.



Notes: Ten year average (solid line) 0.83 pCi/g wet weight.

Figure 6-3. Ten year trend in Cs-137 in deer flesh for samples taken at BNL and within 1 mile of the Laboratory. Average before clean-up (dashed line) 2.57 pCi/g wet weight.

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 three percent of the IAEA threshold. 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. No other animals were sampled in 2017.

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 has been conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring had occurred during even-numbered years and post-cleanup monitoring occurred in odd-numbered years. However, with the discontinuance of discharges from the STP to the Peconic River in September 2014 and current below average amounts of precipitation, the objectives for the fish monitoring program have changed to reflect the current intermittent presence of water in the on-site portions of the river. Fish are now only sampled under the surveillance program when there is sufficient water to support a sufficient population of fish that can be sampled without harm to their population and that are of sufficient size for analysis. Based upon the 2016 CERCLA Five-year Review of the effectiveness of the environmental cleanup and the final supplemental cleanup of a small area within the river during 2017, the Laboratory intends to discontinue fish monitoring under the CERCLA program. Due to lack of water and fish within the on-site portions of the Peconic River, no fish were sampled in 2017.

6.3.3.1 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 2015, even with low water levels in the on-site portion of the Peconic River, indicated that fish populations could maintain themselves. However, the combination of discontinuing STP discharges to the Peconic River and continued drought conditions have resulted in the on-site portions of the Peconic River to be totally dry and no longer able to support fish. The river remained dry throughout 2017. For fish populations to survive and flourish, water levels must be substantial enough to allow migration of fish and maintain their presence for an extended period of time to replenish populations. As mentioned above, new criteria for the collection of fish samples have been developed. These criteria will guide the environmental monitoring approach for fish in the future.

6.3.4 Peconic River Post-Cleanup Monitoring

Approximately 20 acres of the Peconic River were remediated in 2004 and 2005 to remove sediments containing mercury and several other 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. Based upon another five years of monitoring (2011-2015), it was determined that an additional area of approximately 2,600 square feet required remediation. This area was successfully cleaned up in July 2017, and a

final report was submitted to the regulators with a recommendation of no further monitoring.

6.3.5 Vegetation Sampling

6.3.5.1 Grassy Plants and Soil

During 2017, grassy vegetation samples were collected from 12 locations around the Laboratory (Figure 6-4) and a control location at the NYSDEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137 (see Table 6-4). Cs-137 content in vegetation ranged from non-detectable to 10.0 pCi/g, wet weight in the area adjacent to the Former Hazardous Waste Management Facility wetland. The area is known to have residual Cs-137 levels below 23 pCi/g, dry weight in soils. This is confirmed as the associated soil contained a concentration of 10.8 pCi/g, dry weight of cesium. Other soil samples had Cs-137 levels from non-detect to 4.31 pCi/g, dry weight. All values were consistent with historic monitoring and knowledge of cleanup areas. Monitoring results for grassy vegetation and soils are utilized for the annual dose to biota analysis reported in Chapter 8.

6.4 OTHER MONITORING

6.4.1 Basin Sediments

A five-year cycle for the collection of recharge basin sediment samples was established in 2003. There are 11 recharge basins that receive water discharges that are permitted under the Laboratory's State Pollutant Discharge Elimination System permit (see Figure 5-3 for outfall locations). The 11 basins were sampled in 2017, and the samples were analyzed for radionuclides, semi-volatile organic compounds, PCBs and pesticides, and metals. The results of monitoring are discussed below.

Results of the radionuclide analyses were largely negative for gamma-emitting radionuclides. Cesium-137 is the primary radionuclide of concern as it is known to be present at multiple locations on the BNL site that were cleaned up by 2005. Cs-137 concentrations in basin sediments ranged from non-detect in eight of the eleven basins to a maximum of 0.08 pCi/g, dry weight in the Central Steam Facility outfall area. All detectable values were within historic

Table 6-4. Radiological analysis of grassy vegetation and associated soils

Location/Matrix	K-40 pCi/g±95% C.I.	Cs-137 pCi/g±95% C.I.
Corner Brookhaven & Fifth St.		
Vegetation	3.93±0.52	ND
Soil*	6.14±1.14	0.09±0.08
Corner Upton Rd & Cornell		
Vegetation	3.85±0.37	ND
Soil	5.85±1.17	0.25±0.10
Current Landfill		
Vegetation	3.39±0.67	ND
Soil*	5.78±1.00	0.16±0.05
Corner Upton Rd & Bell Ave.		
Vegetation	3.42±0.47	ND
Soil	5.49±1.27	0.25±0.08
No Mow Upton Rd. & Princeton, east side		
Vegetation	4.47±0.60	ND
Soil*	8.42±1.27	0.20±0.06
Railroad Spur at South Boundary		
Vegetation	5.66±0.67	ND
Soil	5.83±1.11	ND
Intersection East Fifth Ave. and First St.		
Vegetation	4.36±0.44	ND
Soil	5.57±1.24	0.42±0.11
Forest Path at outer RHIC Ring Rd.		
Vegetation	2.34±0.58	ND
Soil	4.64±0.88	ND
Ecology Field		
Vegetation	4.71±0.78	ND
Soil*	6.04±0.84	0.12±0.04
Outside FHWMF		
Vegetation	1.75±0.50	10.00±0.23
Soil	5.10±0.75	10.80±0.27
Inside FHWMF Sample 1		
Vegetation	4.75±0.77	ND
Soil	6.51±1.02	4.31±0.19
Inside FHWMF Sample 2		
Vegetation	5.84±0.80	ND
Soil	7.07±0.74	0.27±0.05
NYSDEC Game Farm (Control)		
Vegetation	4.99±0.82	ND
Soil	6.59±0.77	0.26±0.06

Notes:
All values are shown with a 95% confidence interval.
Radiological values for soils are on a 'dry weight' basis.
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
* = estimated value for Cs-137 based on laboratory qualifiers.

range for soils and are comparable to what is known from world-wide fall-out due to historic atmospheric testing of nuclear weapons.

Analysis of sediments for the presence of semi-volatile organic compounds resulted in no detections of any of these compounds. Polychlorinated biphenyl (PCB) and pesticide analysis showed low levels of Dichlorodiphenyl-trichloroethane (DDT) and its breakdown product, Dichlorodiphenyldichloroethylene (DDE), in basin HS. Values were estimated based on laboratory qualifiers at 0.85 µg/kg and 2.2 µg/kg, respectively. The PCB Aroclor 1254 was detected at an estimated 24 µg/kg in basin HN-S and Aroclor 1260 was detected in all basins except for HO, HS, HN-NS-1, and HN-N at concentrations less than 49 µg/kg. The highest concentrations of Aroclor 1260 were found in basins HW and CSF at concentrations of 49 µg/kg and 45 µg/kg, respectively. Both Aroclor 1254 and 1260 were known to be used historically at BNL.Concentrations of these PCBs are well below protection values of 3,200 µg/kg.

Results of metals analysis are presented in Table 6-5. All metals were detected at levels similar to BNL site background levels and below Suffolk County Department of Health Services cleanup levels and action levels. The only exception was the detection of chromium at 24 mg/kg at basin HT-E which was just above the county cleanup objective of 20 mg/kg, but well below the action level of 100 mg/kg. The next round of basin sediment sampling will occur in 2022 under the five-year schedule.

6.4.2 Mercury Monitoring of Precipitation

During 2017, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (Figure 4-2 for station locations). The samples were analyzed for total mercury (Table 6-6). Until 2015, BNL had routinely analyzed precipitation for radiological content. However, with no emissions of significantly long-lived radionuclides from Laboratory operations, the monitoring program objectives were modified to remove testing of precipitation for radiological content beginning in 2016.

Mercury concentrations in precipitation have been measured at BNL since 2007. Analysis of mercury in precipitation is conducted to document mercury deposition that is attributable to off-site sources. This information has been used as a comparison to Peconic River monitoring data and aids in understanding the distribution of mercury within the Peconic River watershed. Mercury was detected in all of the precipitation samples collected at both sampling stations. Mercury ranged from 2.07 ng/L at station S5 in January to 45.1 ng/L at station P4 in July. The 45.1 ng/L concentration is nearly two times higher than the previous high value of 24.6 ng/L, recorded in 2013.

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, foster an interest in science, and provide a meaningful experience for interns in preparation for further studies or a career. 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 routinely update the natural resource inventory records, gain a better understanding of the ecosystem, and guide management planning.

In 2017, BNL hosted 17 student interns and two faculty members within the Natural Resources program. Two of the interns worked with a faculty member from Hofstra University as part of the BNL Visiting Faculty Program (VFP), three worked under a faculty member from Southern University of New Orleans, and 12 interns participated in research associated with various projects including several related to the LISF, turtles, and pollinators. The Natural Resource program supported two Science Undergraduate Laboratory Internship (SULI) interns in the spring, and two in the fall, with the remaining 13 participating in the summer internship programs.

- The VFP team from Hofstra University continued a second year of gathering basic information on small mammals, tick loads, and the incidence of Lyme disease in the ticks. This work is being done in prepara-

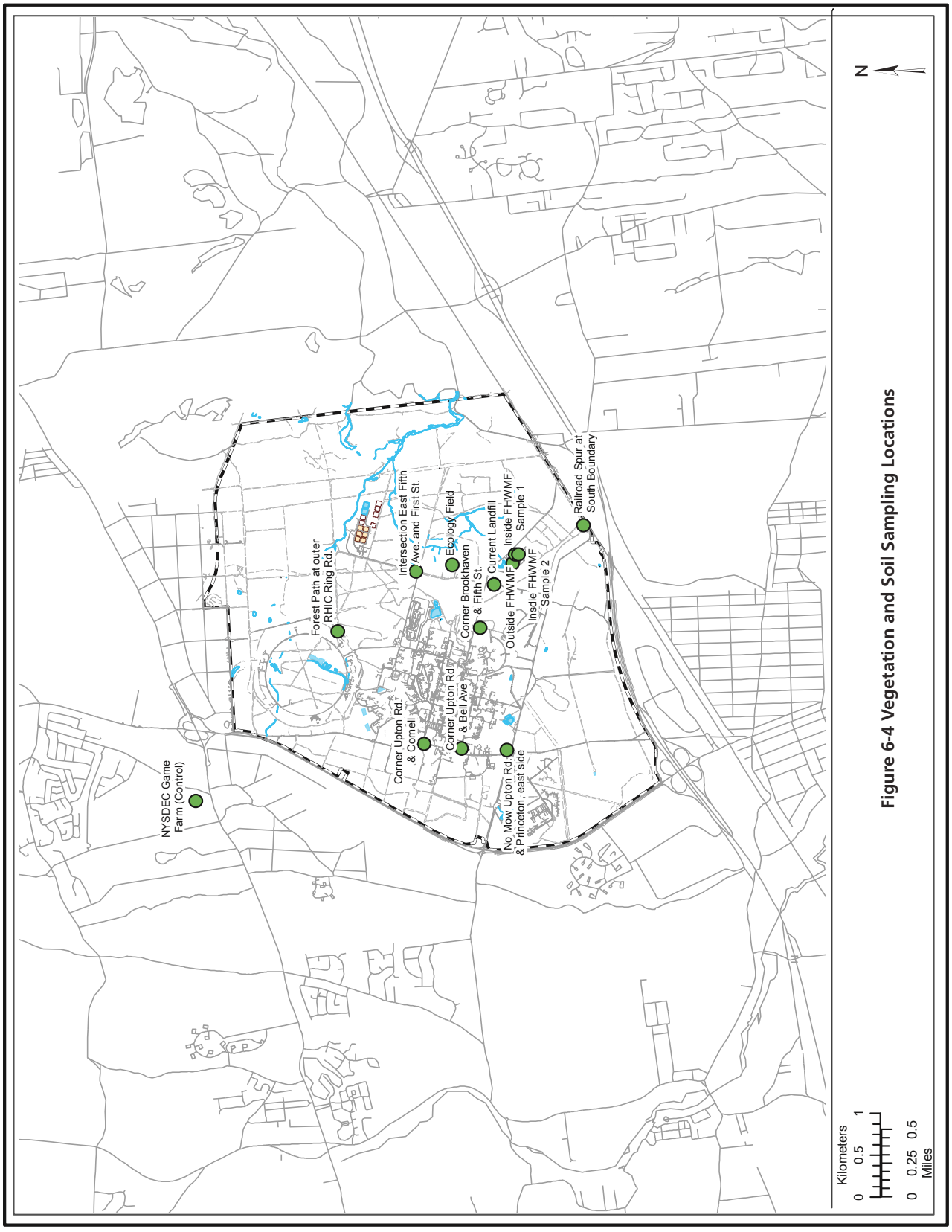


Figure 6-4 Vegetation and Soil Sampling Locations

Table 6-5. Metals analysis of Basin Sediments (2017).

												SCDHS	SCDHS	BNL Site
Basin	**HW**	**CSF**	**HZ**	**HO**	**HT-E**	**HT-W**	**HS**	**HN- NS-1**	**HN-S**	**HN- M**	**HN - N**	**Action Level**	**Clean-up Obj.**	**Background**
Metals	---------- mg/kg ----------													
Aluminum	2,300	2,800	3,100	770	1,900	760	2,000	2500	5,200	3,400	1,800	NS	NS	1,940-16,491
Antimony	0.24	0.29*	0.24	< MDL	< MDL	< MDL	1.8	< MDL	0.35	0.33	< MDL	NS	NS	ND-13.1
Arsenic	1	1.6	1.7	1.1	1.3	< MDL	1	0.68	1.9	1.1	0.58	30	6	0.64-1.9
Barium	5.8	15	16	13	87	5.3	6.1	9.4	22	14	6.7	4,000	820	4.3-37
Beryllium	0.08	0.11	0.13	< MDL	0.75	< MDL	0.06	0.08	0.17	0.11	0.06	240	47	ND-0.5
Cadmium	0.14	0.33	0.18	0.06	0.14	0.03	0.03	0.09	0.45	0.18	0.07	40	7.5	ND-1.5
Calcium	310	3,200	3,200	340	4,200	410	140	310	1,200	500	220	NS	NS	63-580
Chromium	5.2	5.5	6.4	2.3	24	2.6	2.8	5.1	9.9	7	4.5	100	20	3.6-14.2
Cobalt	0.88	3.3	1.9	1.1	14	0.6	0.88	1.2	3.2	1.9	0.85	NS	NS	1.1-4.1
Copper	5.7	24	68	8.1	150	37	4.8	25	84	55	23	8,500	1700	1.8-32
Iron	3,300	8,800	5,300	3,100	9,900	2,000	2,600	3,300	8,100	5,500	2,800	NS	NS	2,690-14,429
Lead	11	75	36	3.1	150	3.4	13	3	38	20	7.9	2000	450	1.4-32
Magnesium	300	1,600	2,200	260	2,200	310	220	540	1,300	860	380	NS	NS	470-2,122
Manganese	29	130	81	180	110	18	16	30	86	37	20	10,000**	10,000**	24-122
Mercury	0.02	0.01	0.02	< MDL	0.24	< MDL	< MDL	< MDL	0.02	0.02	< MDL	3.7	0.7	0.02-0.19
Nickel	3.3	12	6.8	6	5.6	3.2	2.6	4.2	10	6.5	3.3	650	130	4.65-11.4
Potassium	91	270	160	75	110	65	95	150	220	160	91	NS	NS	146-628
Selenium	< MDL	0.45	0.38	< MDL	2.6	< MDL	< MDL	< MDL	0.56	0.31	< MDL	6,800**	6,800**	ND-0.65
Silver	< MDL	< MDL	< MDL	< MDL	0.62	< MDL	< MDL	< MDL	0.14	0.09	< MDL	50	10	ND-2
Sodium	13	74	76	28	320	19	< MDL	18	65	34	12	NS	NS	ND-196
Thallium	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	NS	NS	ND-0.35
Vanadium	6.7	29	12	4.5	9.7	2.2	4.1	5.8	16	10	4.4	NS	NS	ND-26
Zinc	36	82	110	30	380	32	23	63	210	92	40	10,000**	10,000**	4.9-43

Notes:
* = estimated value based on analytical laboratory qualifiers
** = No SCDHS action level listed for this metal. Value used is NYSDEC recommended soil cleanup objective (6 NYCRR Part 375 - Industrial).
MDL = Method Detection Limit
SCDHS = Suffok County Department of Health Services
NS = value not specified

tion for coyotes (*Canis latrans*) migrating to Long Island. Once established, coyotes are expected to alter ecosystems due to competition with other carnivores.

- Work associated with the LISF involved tracking 24 eastern box turtles outfitted with transmitters to determine home range sizes. Many of the turtles were captured in or near the LISF to determine if they utilize habitats found in the facility. Since 2011, student interns have followed a total of 42 turtles; as a result, BNL is building a very good understanding of their habits. Turtles are also permanently marked to facilitate identification of individual turtles as part of a mark recapture effort. Radiotelemetry work included comparison of GPS data logging devices attached for one-week intervals to radiotelemetry surveys. Turtle research also looked at micro- and macro-habitat use.
- A graduate student from Hofstra University working with eastern box turtles to determine food partition and use within Pine Barrens habitats continued to look at food sources, and stable isotope distribution based on blood samples. Early work identified most sources of stable isotopes but a large source was not isolated based on typical food sources. An obvious source of nitrogen (identified using stable isotopes) is likely carrion. Summer 2017 investigations focused on this source and results are expected to be published in 2018.
- A second graduate student, from the State University of New York (SUNY) at Stony Brook, working with box turtles continued camera trapping and mark-recapture studies of box turtles to determine potential impact to box turtles based on expected impacts to meso-predators when coyotes become established on Long Island.
- Interns conducted pollinator surveys of no-mow areas established in 2016 to determine use by various species of bumble bees. Pollinator surveys were also conducted within the north array of the LISF to determine use. The north array had 26 different pollinator species using a variety of native and non-native flowers within the array. No-mow areas were highly variable regarding use by the few bumble bee species identified.
- BNL utilizes prescribed fire as part of its forest management. To accurately develop burn plans, data on vegetation and fuel loads is necessary. Interns continued work to collect and analyze fuel loads within current and planned burn units. Three growing season fires were conducted in 2017 and fire effects monitoring on vegetation are planned for 2018.
- BNL has significant data resources related to breeding bird surveys. Survey data was reviewed and compared by interns participating in the spring SULI program to determine if there was variation in species diversity and richness between wetland areas and upland areas. Wetland areas were determined to have statistically distinct diversity and richness compared to upland areas.

BNL continued working on establishing a Memorandum of Understanding (MOU) with SUNY School of Environmental Science and Forestry (ESF) located in Syracuse, NY. ESF conducts significant research in the natural sciences including wildlife and forestry. The concept of the MOU would encourage ESF to utilize the BNL site for Pine Barrens-related research. By the end of 2017, an MOU between BNL and ESF had been signed and meetings were scheduled to discuss the first round of research to be funded by ESF from funds received from the U.S. Department of Agriculture Forest Service. The initial research planning was to bring in the NYSDEC, U.S. Forest Service, Central Pine Barrens Commission, and BNL. The first meeting was scheduled for January 2018.

In 2017, BNL continued to participate in several events in support of ecological education programs including: providing on-site ecology tours; hosting the Long Island Natural History Conference; participation in the Eighth Annual Pine Barrens Discovery Day held at the Wertheim National Wildlife Refuge; and assisting the Central Pine Barrens Commission on "A Day in the Life of the Rivers," which allowed students from multiple school districts to acquire environmental and biological data about

Table 6-6 Precipitation Monitoring (Mercury)

Location/Period	Mercury ng/L
P4	
1/11/17	5.16
4/7/17	11
7/17/17	45.1
10/10/17	10.1
S5	
1/11/17	2.07
4/7/17	6.72
7/17/17	12.2
10/10/17	7.11

Notes:
Method detection limit for mercury is 0.2 ng/L.
P4 = precipitation sampler near BNL Apartment area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.

ten different rivers on Long Island. On separate days, over 30 partner organizations and agencies, over 40 schools, and over 2,700 students collected scientific information for analysis to be used to portray the status of the rivers and estuary systems. These events provided students hands-on experience with field techniques in catching fish, invertebrate sampling, biodiversity inventory, and water chemistry.

In 2017, BNL entered its 13th year of the Open Space Stewardship Program (OSSP) and worked with 30 schools and over 3,000 students. The OSSP enables students to engage in activities to solve problems within their local community through scientific discovery, conservation, and stewardship. The effort integrates outdoor research with school curricula in language arts, civics, community service, and media arts. Participation in OSSP creates an opportunity for many students to enhance their educational experiences as well as to promote the realization that a career in science and technology is accessible with the proper academic coursework and interaction with teachers and field experts who have a passion for discovery and mentorship.

The Laboratory also hosts 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 that includes the use of prescribed fire for fuel and forest management, and worked with NYSDEC to conduct three growing season fires in northern and eastern sections of the BNL property. These first three successful fires provided significant experience and training for fire crews working in Pine Barrens habitat, improving capabilities of these crews to conduct and manage fire within the Long Island Central Pine Barrens.

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 2013) guides the management for all of the Laboratory's historical resources. 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 four structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, the 1960s-era efficiency apartments, and the WWI training trenches associated with Camp Upton. The trenches are examples of the few surviving WWI earthworks in the United States. Two buildings, Berkner Hall

and Chemistry, are architecturally significant. Other buildings have been identified as being important as examples of periods within the history of the BNL site, such as the Brookhaven Center (built during 1930s Civilian Conservation Corp era) and Building 120 (a former WWII era barracks building).

In 2017, BNL celebrated this landmark anniversary year with two events. The first was the 100th anniversary of the United States entering WWI and the construction of Camp Upton in 1917, and the second was the 70th anniversary of the establishment of BNL in 1947. These combined anniversaries were celebrated as "70 YEARS OF DISCOVERY – A CENTURY OF SERVICE." Cultural resource efforts were focused on the celebration throughout the year.

One of the first efforts regarding the 100th anniversary of the United States entering WWI was to work with the Suffolk County Historical Society and loan them several items from the Camp Upton Historical Collection for a display titled "Over Here and Over There," to give visitors a deeper understanding of America's wartime experience. The initial intent was for the display to be completed by the end of December; due to its success, the display was extended into 2018.

The second effort associated with both the 70th and 100th anniversaries was to focus the first Summer Sundays program on the history of Camp Upton and BNL. Several artifacts, such as uniforms, were placed in display cases at Berkner Hall and a dedicated display of WWI memorabilia from a local family was maintained in Building 400. Along with Camp Upton memorabilia displays, information about BNL's scientific history was presented by BNL employees who volunteered to share BNL's rich history with visitors.

Various other activities associated with the 70th and 100th anniversaries occurred throughout the year. Talks on the history of the BNL site and Camp Upton were provided to Summer Sundays groups, BNL audiences, and local libraries and historical societies. The Lab held a Lab-wide celebration of the 70th and 100th Anniversaries at Berkner Hall and a Lab-wide 70th Anniversary photo was taken with all interested employees as part of the photo. The final activity was a Veteran's Day ceremony held at the flag pole outside of Building 30 sponsored by the Brookhaven Veterans Association and attended by representatives of the Armed Forces, veterans, Dough Boy reenactors, and General Terpeluk, the last commanding general of the 77th Division. (The 77th Regional Readiness Command retired its colors in a 2008 ceremony held at BNL.) The ceremony included dedication of a 100th Anniversary plaque honoring all who served at Camp Upton.

The last cultural resource related item consisted of an article in the local newspaper, Newsday, under the series "Our Towns." The article, published on December 13, 2017, covered the combined celebrations and featured information on both Camp Upton and BNL.

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7 Groundwater Protection

Brookhaven National Laboratory (BNL) has implemented aggressive pollution prevention measures to protect groundwater resources, and an extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. During 2017, BNL collected groundwater samples from 651 permanent monitoring wells and 27 temporary wells during 1,430 individual sampling events. Eight groundwater remediation systems removed 71 pounds of volatile organic compounds (VOCs) and returned approximately 861 million gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the treatment systems have removed 7,526 pounds of VOCs by treating over 26.3 billion gallons of groundwater. Also during 2017, two groundwater treatment systems removed approximately 0.5 millicurie of strontium-90 (Sr-90) while remediating approximately 25 million gallons of groundwater. Since 2003, BNL has removed approximately 32.2 millicuries of Sr-90 from the groundwater while remediating nearly 215 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have been observed in a number of on- and off-site areas.

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 monitoring and remediation requirements defined in Comprehensive Environmental Response, Compensation and Liability Act (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 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 Stakeholder and Community Relations Office works with the Groundwater Protection Program to ensure 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 25 years and continues to make progress in achieving its goal of preventing new impacts to groundwater quality and to remediate previously contaminated groundwater. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance. During 2017, several Per- and Polyfluoroalkyl Substances (PFAS) were detected in water samples collected from three BNL water supply wells. The Suffolk County Department of Health Services conducted the analyses as part of the Safe Drinking Water Act program known

as the Third Unregulated Contaminant Monitoring Rule. Preliminary assessment of possible sources for the PFAS contaminants indicates that they are related to the historical use of fire-fighting foam at the BNL site. Characterization of potential sources of the PFAS contamination will be conducted in 2018.

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, comply with regulatory permit requirements, monitor active research and support facilities, and 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 for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and non-radiological 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 even low concentrations of facility-specific VOCs or radionuclides may provide important early indications of a contaminant release and allow for timely identification and remediation of the source.

BNL maintains an extensive network of groundwater monitoring wells that are located on- and off-site. Water levels are routinely measured in about 725 of the wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions near the Laboratory are shown in Figure 7-1. The Laboratory also routinely collects groundwater samples from approximately 650 of the wells to test for various contaminants that may be in the water (see *SER Volume II, Groundwater Status Report*, for details).

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), Brookhaven Linac Isotope Producer (BLIP), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), and several vehicle maintenance and petroleum storage facilities. Inactive facilities are also monitored, including the former Hazardous Waste Management Facility (HWMF), two former landfill areas, former Waste Concentration Facility (WCF) area, 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 2017, the Facility Monitoring program monitored 93 permanent wells during 121 individual sampling events. The CERCLA groundwater monitoring program monitored 558 permanent wells during 1,309 individual groundwater sampling events. Twenty-seven temporary wells were also installed as part of the CERCLA 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 2017 include:

- Monitoring conducted at BNL's major research facilities (e.g., AGS, RHIC, NSLS-II, and BLIP) and support facilities (STP, WMF, MPF, and vehicle maintenance facilities) did not identify any new impacts to groundwater quality.

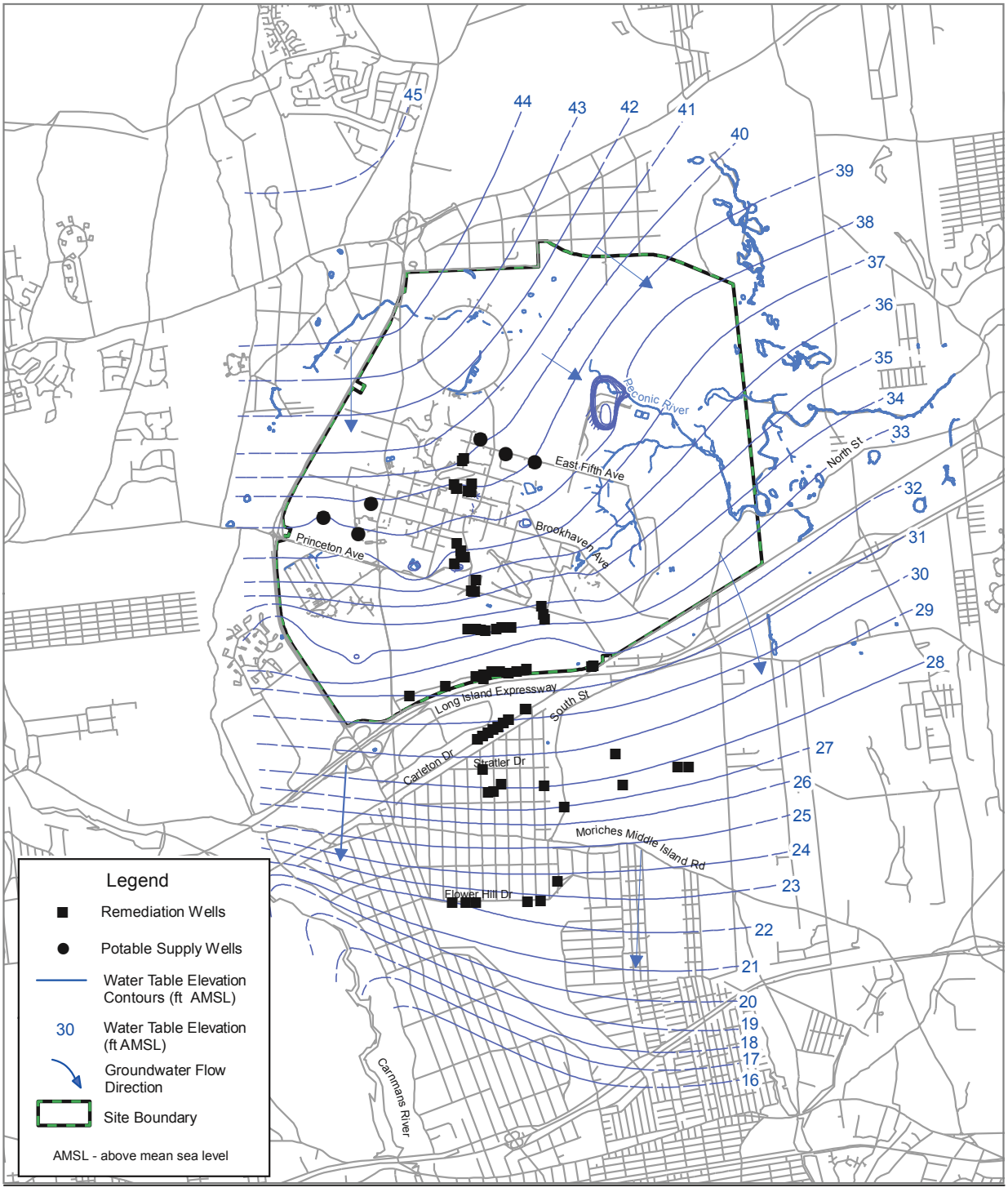

Figure 7-1. Groundwater Flow and Water Table Elevation (December 2017) with Supply and Remediation Wells Shown.

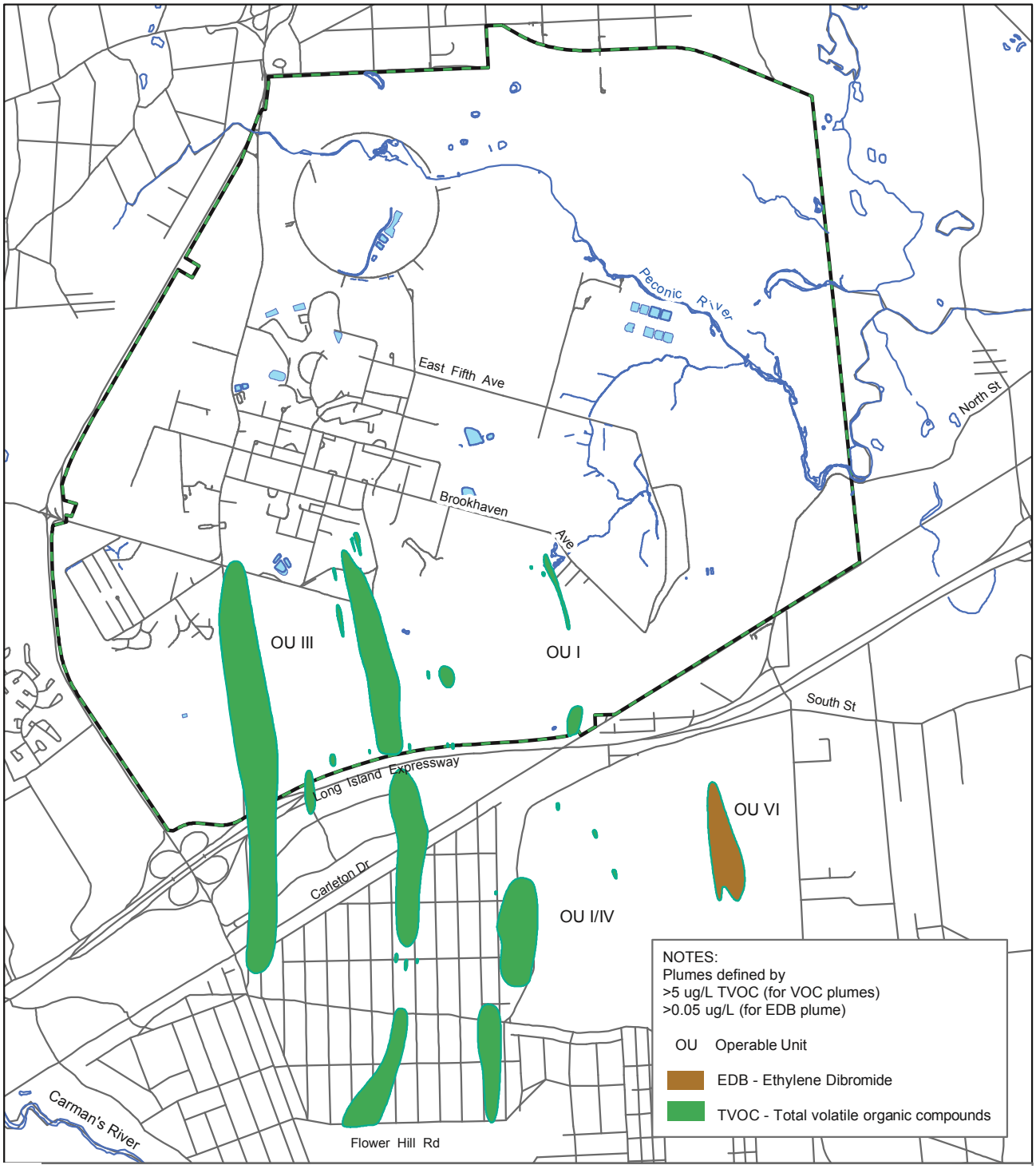

Figure 7-2. Extent of VOC Plumes.

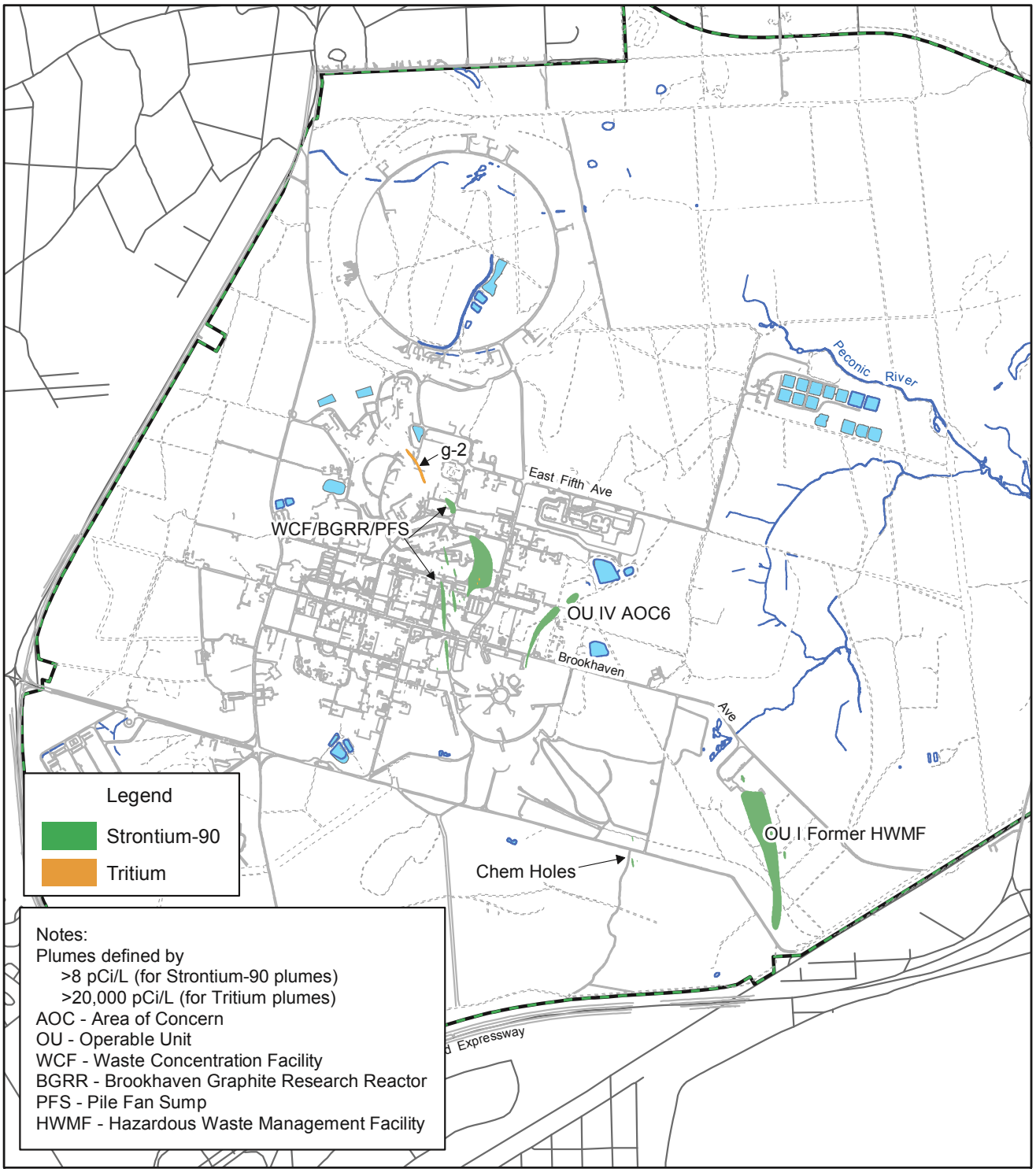

Figure 7-3. Extent of Radionuclide Plumes.

- During 2016-2017, 21 temporary wells were installed to better define VOC concentrations in the Western South Boundary plume. 1,1,1-trichloroethane, 1,1-dichloroethylene, and Freon-12 were detected at unexpected high levels in several areas, with total VOC concentrations in one well reaching 286 µg/L. Because of these higher than expected VOC concentrations, it was determined that four new extraction wells are required to achieve the cleanup goal of meeting Maximum Contaminant Levels (MCLs) in the Upper Glacial aquifer by 2030. The new extraction wells will be installed in 2018.
- The Building 452 Freon-11 treatment system was placed in standby mode in March 2016 following regulatory agency approval of a *Petition for Shutdown*. However, a rebound in Freon-11 concentrations above the 50 µg/L capture goal necessitated the reactivation of the treatment system from November 2016 through February 2017. Freon-11 concentrations remained below the 50 µg/L capture goal for the remainder of 2017.
- Ethylene dibromide (EDB) has been detected in an off-site monitoring well in the North Street East plume since 2015 above the 0.05 µg/L DWS. During the fourth quarter of 2017, EDB was detected at a concentration of 1.06 µg/L in this well. The continued presence of EDB in this well will require additional groundwater characterization of this area in 2018.
- The North Street Treatment System remained in standby mode during 2017. If VOC concentrations remain below the capture goal during 2018, a *Petition for Closure* will be submitted to the regulatory agencies in 2019.
- Sr-90 concentrations downgradient of the former Chemical Holes area have continued to decline and two of three extraction wells are now in standby mode. Because the Sr-90 treatment system has met its cleanup objectives, a *Petition for Shutdown* will be submitted to the regulatory agencies in 2018.
- Sr-90 concentrations downgradient of the BGRR continue to be close to the 8 pCi/L DWS. However, some uncertainty remains about whether the reductions in concentrations are due to lower than normal water table position over the past several years.
- Tritium concentrations downgradient of the HFBR were slightly above the 20,000 pCi/L DWS in one monitoring well, with a maximum concentration of 23,200 pCi/L. Tritium continued to be detected in g-2 source area monitoring wells at concentrations above the 20,000 pCi/L DWS, with a maximum concentration of 33,200 pCi/L.
- Following a 2016 request from NYSDEC, a sampling event for the solvent stabilizing compound 1,4-dioxane was conducted in January 2017 at 22 on- and off-site monitoring wells. Although 1,4-dioxane was detected up to 18.6 µg/L in 17 of the 22 wells, all concentrations were below the current New York State standard of 50 µg/L for unspecified organic contaminants. In December 2017 and January 2018, BNL collected samples from seven additional monitoring wells, and the effluent from five groundwater treatment facilities and the STP. 1,4-Dioxane was detected in five of the seven monitoring wells at concentrations up to 9.1 µg/L, and in four of the six effluent samples at concentrations up to 7.1 µg/L. 1,4-Dioxane was not detected in the STP effluent.

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 MCLs for VOCs in the Upper Glacial aquifer by 2030.
- Achieve MCLs for VOCs in the Magothy aquifer by 2065.
- Achieve MCLs for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070.
- Achieve MCLs for Sr-90 at the Chemical

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2017.

Remediation System	Start Date	1997-2016		2017	
		Water Treated (Gallons)	VOCs Removed (Pounds) (f)	Water Treated (Gallons)	VOCs Removed (Pounds) (f)
OU I South Boundary (a)	12/1996	4,177,473,000	369	0	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	0	0
OU III South Boundary	06/1997	4,934,766,950	3,027	72,384,330	14
OU III Industrial Park	09/1999	2,362,923,330	1,071	116,738,200	3
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	463,688,416	140	15,008,540	1
OU III Middle Road	10/2001	3,097,517,790	1,195	179,029,460	34
OU III Western South Boundary	09/2002	1,587,387,000	135	104,668,000	5
OU III Industrial Park East (e)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street (j)	06/2004	1,680,942,000	342	0	0
OU III North Street East (h)	06/2004	1,009,798,000	44	0	0
OU III LIPA/Airport	08/2004	2,924,751,240	425	196,393,810	13
OU III Building 452 Freon-11 (i)	03/2012	118,521,000	105	6,476,400	1
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	1,936,811,300	(g)	170,246,000	(g)
Total		**25,527,105,101**	**7,455**	**860,944,740**	**71**

Remediation System	Start Date	2003–2016		2017	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	63,387,436	4.92	1,575,120	0.013
OU III BGRR/WCF Sr-90	06/2005	126,427,800	26.8	23,375,000	0.5
Total		**189,815,236**	**31.72**	**24,950,120**	**0.513**

Notes:
(a) System placed in standby mode in 2013.
(b) System 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 decommissioned in 2010.
(e) System decommissioned in 2013.
(f) Values are rounded to the nearest whole number.
(g) Because EDB has only been detected at trace levels in the treatment system influent, no removal of VOCs is reported.
(h) System placed in standby mode in 2014.
(i) System placed in standby mode in March 2016. System was restarted in November 2016 for a period of five months.
(j) System placed in standby mode in August 2016.
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

Holes in the Upper Glacial aquifer by 2040.

- During 2017, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of ten groundwater treatment systems currently in operation. Table 7-1 provides a summary of the amounts of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2017, approximately 71 pounds of

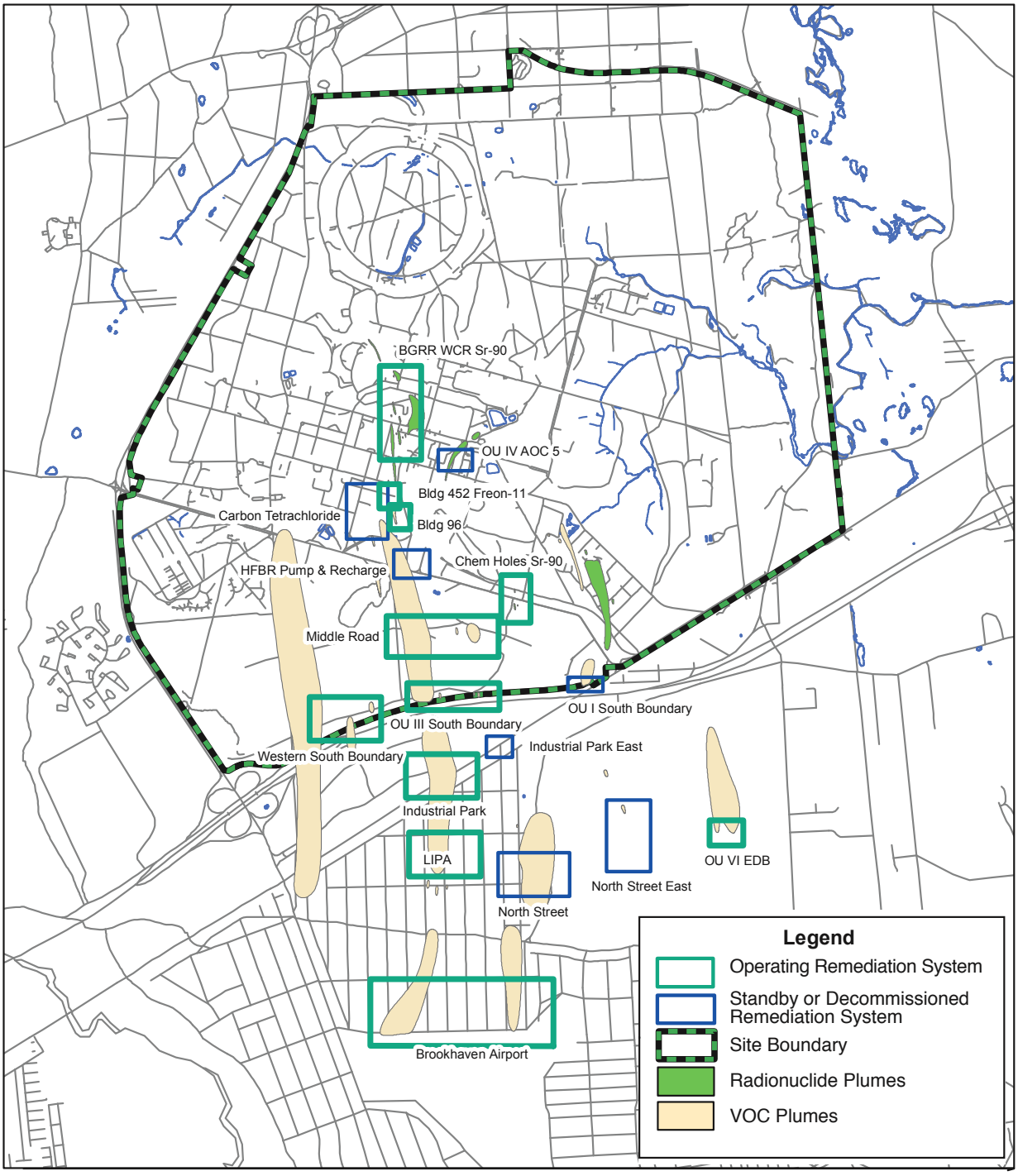

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

VOCs and 0.5 mCi of Sr-90 were removed from the groundwater, and nearly 861 million gallons of treated groundwater were returned to the aquifer.

To date, 7,526 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 32.3 mCi of Sr-90.

During 2017, the North Street Treatment System, North Street East Treatment System, OU I South Boundary Treatment System, and the HFBR Tritium Pump and Recharge System remained in standby mode because they met their active remediation goals for reduction of contaminant concentrations. The Building 452 Freon-11 Groundwater Treatment System which had been placed in standby mode in March 2016, was reactivated in November 2016 due to a short-term rebound in Freon-11 concentrations. The system was returned to standby mode in March 2017. A period of standby monitoring for the plumes associated with these treatment systems will be performed to detect any rebound of contaminant concentrations. Detailed information on the groundwater contaminant plumes and treatment systems can be found in *SER Volume II, Groundwater Status Report.*

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8 Radiological Dose Assessment

Brookhaven National Lab's (BNL) 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 total from direct and indirect dose pathways via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat. In 2017, the total effective dose (TED) of 5.61 mrem (56 μSv) from Laboratory operations was well below the Environmental Protection Agency (EPA) and Department of Energy (DOE) regulatory dose limits for the public, workers, and the environment.

The dose estimates for 2017 were calculated using an updated version of the dose modeling software promulgated by EPA. As such, the effective dose equivalent (EDE) from air emissions in 2017 was estimated at 7.24E-01 mrem (7.2 μSv) to the MEOSI. This BNL dose level from the inhalation pathway was less than eight 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 4.8 mrem (48 μSv) from the consumption of deer meat and 8.75E-2 mrem (0.88 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 at 5.61 mrem (56 μSv), which is less than six percent of DOE's 100-mrem limit. The aggregate population dose was 1.16 person-rem among approximately six million people residing within a 50-mile radius of the Laboratory. On average, this is equivalent to a fraction of an airport whole body scan.

Dose to the maximally exposed individual (MEI) on-site and outside of controlled areas, calculated from thermo-luminescent dosimeter (TLD) monitoring records, was 8 mrem above natural background radiation levels. The average annual external dose from ambient sources on-site was 65 ± 11 mrem (650 ± 110 μSv) and 61 ± 11 mrem (610 ± 110 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 18 off-site TLDs showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level. An additional nine TLDs were used to measure on-site areas known to have radiation dose slightly above the natural background radiation.

Doses to aquatic and terrestrial biota were also found to be well below DOE regulatory limits. In summary, the overall dose impact from all Laboratory activities in 2017 was comparable to that of natural background radiation levels.

8.0 INTRODUCTION

Chapter 8 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. 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 for several years, there was no dose risk from these facilities in 2017. The Laboratory's current radiological risks are from very small quantities of radionuclides used in science experiments, production of radiopharmaceuticals at the Brookhaven LINAC Isotope Producer (BLIP), and small amounts of air activation produced at the BNL accelerators: Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), and the National Synchrotron Light Source II (NSLS-II). 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. The direct measurements taken at the off-site locations are based on the premise that off-site exposures represent true natural background radiation (with contribution from both cosmic and terrestrial sources) with no contribution from Laboratory operations. On- and off-site external dose measurements are averaged and then compared using standard statistical methods 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 plumes, atmospheric particulates, scattered radiation, and the location of radiation-generating devices. The Laboratory perimeter is also posted with TLDs to assess the dose impact, if any, beyond the site's boundaries. On- and off-site locations are divided into grids, and each TLD is assigned a unique identification code based on those grids.

In 2017, a total of 63 environmental TLDs were deployed on site, nine of which were placed in known radiation areas. During the year, three environmental TLDs were relocated and two neutron TLDs at a single location were converted to environmental TLDs and relocated. A total of 16 environmental TLDs were deployed at off-site locations (see Figures 8-1 and 8-2). In 2017, 14 of the 16 wind sectors around the Laboratory had TLDs located in them. An additional 30 TLDs were stored in a lead-shielded container for use as reference and control TLDs for comparison purposes. The total of the control TLD dose values, reported for "075-TLD4" in Tables 8-1 and 8-2, was 29 ± 3 mrem. This dose accounts for any small "residual" dose not removed from TLDs during the 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 measured.

Table 8-1 shows the quarterly and yearly on-site radiation dose measurements for 2017. The on-site average external doses for the first through fourth quarters were 18.7 ± 4.2, 15.9 ± 3.8, 14.9 ± 2.7, and 15.5 ± 2.2 mrem, respectively. The on-site average annual external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 65 ± 11 mrem (650 ± 110 μSv). Table 8-2 shows the quarterly and yearly off-site radiation

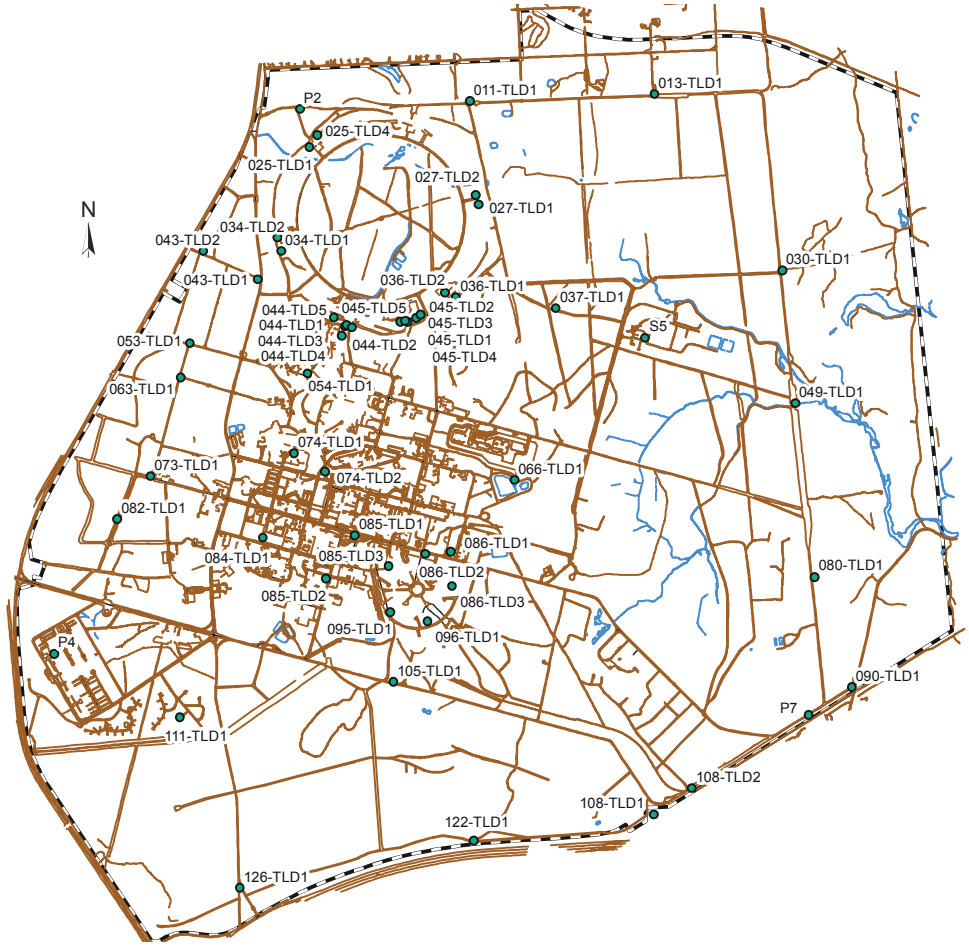

Figure 8-1. On-Site TLD Locations.

dose measurements for 2017. The off-site average external doses for the first through fourth quarters were 16.9± 3.9, 15.3 ± 3.9, 14.1 ± 2.1, and 14.6± 2.5 mrem, respectively. The off-site average annual ambient dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 61 ± 11 mrem (610 ± 110 μSv).

To determine the BNL contribution to the external direct radiation dose, a statistical t-test between the measured on- and off-site external dose averages was conducted. The test showed no significant difference between the off-site dose (61 ± 11 mrem) and on-site dose (65 ± 11 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 2017. The dose to the MEI on site and outside of controlled areas (in the vicinity of Building 356) was measured at 5.5 mrem for the first quarter, 0 mrem for the second quarter, 0.5 mrem for the third quarter, and 1.6 mrem for the fourth quarter of 2017. The total dose to the on-site MEI was 8 mrem, which is less than the dose received from two round-trip flights from Los Angeles, California to New York, New York.

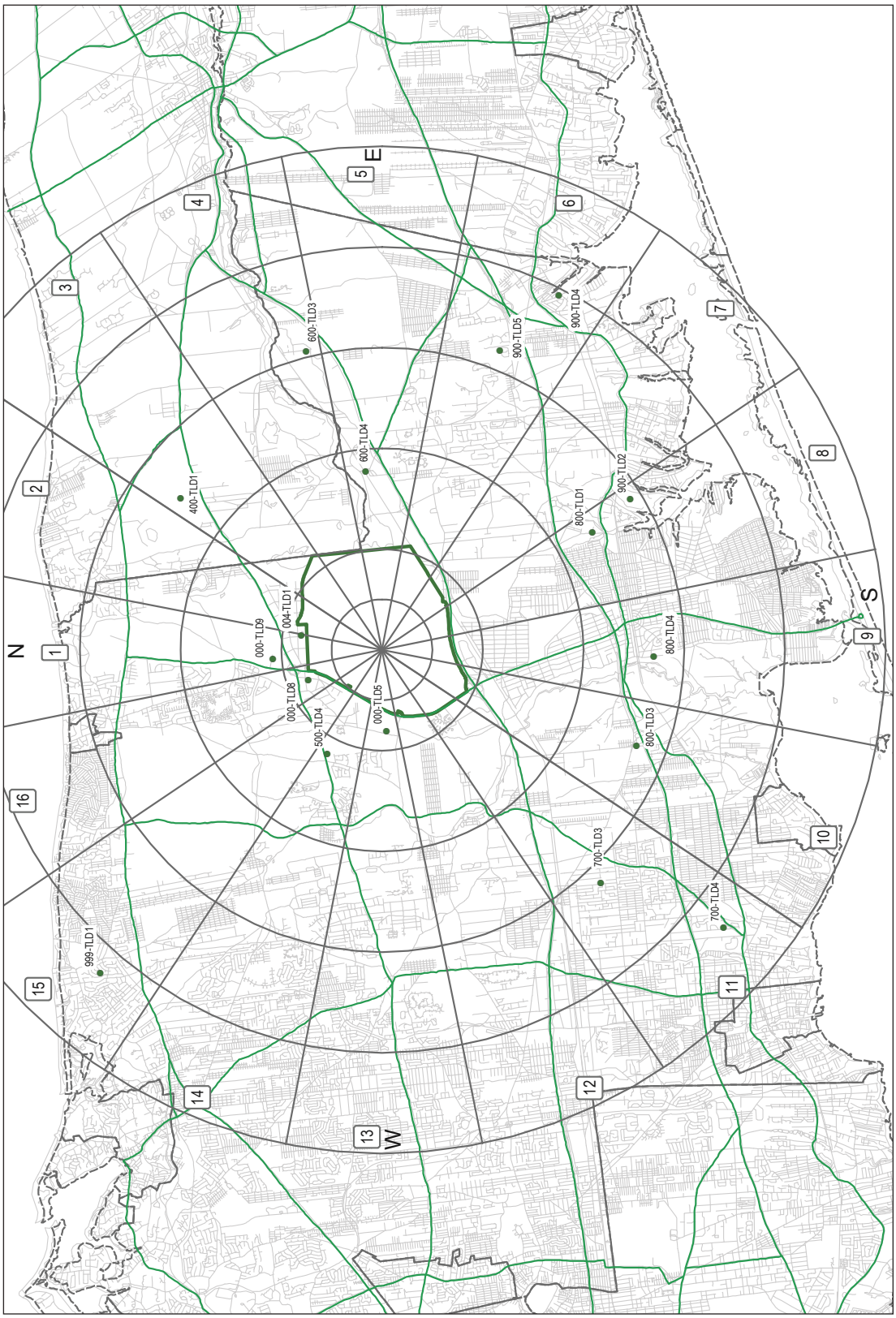

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Figure 8-2. Off-Site TLD Locations.

Table 8-1. On-Site Direct Ambient Radiation Measurements for 2017.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ±2σ (95%)	Annual Dose ±2σ (95%)
		(mrem)					
011-TLD1	North Firebreak	16.5	12.8	13.3	13.2	14±3	56±12
013-TLD1	North Firebreak	16.8	14.1	15.1	15.0	15±2	61±8
025-TLD1	Bldg. 1010, Beam Stop 1	17.4	14.0	13.8	15.9	15±3	61±12
025-TLD4	Bldg. 1010, Beam Stop 4	21.1	17.2	14.2	14.6	17±5	67±22
027-TLD1	Bldg. 1002A South	16.3	14.0	13.8	13.5	14±2	58±9
027-TLD2	Bldg. 1002D East	16.8	14.3	12.5	14.3	14±3	58±12
030-TLD1	Northeast Firebreak	18.3	15.3	15.3	14.8	16±3	64±11
034-TLD1	Bldg. 1008, Collimator 2	18.2	NP	NP	NP	18±0	73±0
034-TLD2	Bldg. 1008, Collimator 4	18.2	16.6	14.8	16.8	17±2	66±9
036-TLD1	Bldg. 1004B, East	16.8	15.2	13.5	12.3	14±3	58±14
036-TLD2	Bldg. 1004, East	17.7	14.6	13.4	15.4	15±3	61±12
037-TLD1	S-13	17.4	14.9	13.9	13.9	15±3	60±11
043-TLD1	North Access Road	17.5	15.8	15.6	16.6	16±1	66±6
043-TLD2	North of Meteorology Tower	19.1	15.6	15.9	16.0	17±3	67±11
044-TLD1	Bldg. 1006	19.2	16.2	15.6	16.2	17±3	67±11
044-TLD2	South of Bldg. 1000E	18.4	17.2	16.1	15.7	17±2	67±8
044-TLD3	South of Bldg. 1000P	18.4	15.3	15.1	16.3	16±3	65±10
044-TLD4	Northeast of Bldg. 1000P	21.1	NP	NP	NP	21±0	84±0
044-TLD5	North of Bldg. 1000P	18.8	19.4	14.1	15.1	17±5	67±18
045-TLD1	Bldg. 1005S	17.2	15.4	13.7	15.4	15±2	62±10
045-TLD2	East of Bldg. 1005S	17.5	14.6	14.4	15.2	15±2	62±10
045-TLD3	Southeast of Bldg. 1005S	17.4	NP	NP	NP	17±0	69±0
045-TLD4	Southwest of Bldg. 1005S	18.4	15.9	14.1	15.2	16±3	64±13
045-TLD5	West-Southwest of Bldg. 1005S	17.3	15.0	13.4	14.8	15±3	60±11
049-TLD1	East Firebreak	18.6	15.2	15.7	15.5	16±3	65±11
053-TLD1	West Firebreak	17.9	15.6	16.0	16.6	17±2	66±7
054-TLD1	Bldg. 914	27.4	25.0	15.1	15.8	21±11	83±44
063-TLD1	West Firebreak	20.2	16.2	16.4	17.1	17±3	70±13
066-TLD1	Waste Management Facility	16.8	13.4	13.0	13.8	14±3	57±12
073-TLD1	Meteorology Tower	19.0	16.8	15.2	15.2	17±3	66±12
074-TLD1	Bldg. 560	22.6	16.4	17.1	16.4	18±5	72±21
074-TLD2	Bldg. 907	17.9	14.7	14.7	15.4	16±3	63±10
080-TLD1	East Firebreak	19.7	16.7	16.6	17.5	18±2	70±10
082-TLD1	West Firebreak	20.5	17.4	16.0	17.0	18±3	71±13
084-TLD1	Tennis courts	17.3	15.4	15.4	15.1	16±2	63±7
085-TLD1	Bldg. 735	19.7	16.1	14.3	15.8	16±4	66±16
085-TLD2	Upton Gas Station	18.0	17.2	16.6	15.7	17±2	67±7
085-TLD3	NSLS-II LOB 745	ND	ND	15.4	16.3	16±1	64±4
086-TLD1	Baseball Fields	17.6	15.1	16.3	15.4	16±2	64±7
086-TLD2	NSLS-II LOB 741	ND	ND	14.4	15.2	15±1	59±3

(continued on next page)

Table 8-1. On-Site Direct Ambient Radiation Measurements for 2017. *(concluded).*

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ±2σ (95%)	Annual Dose ±2σ (95%)
		(mrem)					
086-TLD3	NSLS-II LOB 742	ND	ND	13.3	14.2	14±1	55±4
090-TLD1	North St. Gate	17.9	16.4	15.6	15.9	16±2	66±7
095-TLD1	NSLS-II LOB 744	ND	ND	16.8	17.2	17±0	68±2
096-TLD1	NSLS-II LOB 743	ND	ND	14.3	15.0	15±1	58±3
105-TLD1	South Firebreak	19.1	17.3	16.5	16.9	17±2	70±8
108-TLD1	Water Tower	23.7	16.1	17.2	16.3	18±6	73±25
108-TLD2	Tritium Pole	22.4	18.2	18.8	18.0	19±4	77±14
111-TLD1	Trailer Park	17.3	16.6	15.6	15.2	16±2	65±7
122-TLD1	South Firebreak	19.1	15.0	13.8	16.2	16±4	64±16
126-TLD1	South Gate	21.3	18.0	15.7	17.3	18±4	72±16
P2		15.4	13.4	12.4	14.7	14±2	56±9
P4		19.4	15.8	14.2	15.0	16±4	64±16
P7		19.0	16.1	15.2	15.7	16±3	66±12
S5		16.3	14.5	12.5	15.2	15±3	58±11
On-Site Average		**18.7**	**15.9**	**14.9**	**15.5**	**16±3**	**65±11**
Std. Dev. (2σ)		**4.2**	**3.8**	**2.7**	**2.2**		
075-TLD4: Control TLD Average		**7.7**	**7.3**	**7.4**	**6.8**	**7.3±0.7**	**29±3**

Notes :
See Figure 8-1 for TLD locations.
L = TLD lost
NP = TLD not posted
ND = TLD not deployed.

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 (near "facilities"). 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 location and near S6 on the fence of the Former Hazardous Waste Management Facility (FHWMF). Except for 088-TLD4, which was consistent with the site average dose, the TLDs measured external doses that were slightly elevated compared to the normal natural background radiation doses measured in other areas on site. This can be attributed to the presence of small amounts of contamination in the soil. 088-TLD1 had the highest dose reading of the four, which can be attributed to waste-loading activities at the rail spur in recent years. 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 2017 dose is slightly above natural background levels. The FHWMF is fenced, so access to it is controlled. Two TLDs (075-TLD3 and 075-TLD5) near Building 356 showed a slightly higher quarterly average of 21 ± 6 mrem, which is just above the normal ambient background radiation. The yearly doses were measured at 85 ± 22 mrem (850 ± 220 μSv) for 075-TLD3 and 86 ± 24 mrem (860 ± 240 μSv) for 075-TLD5. These direct doses are higher than the on-site annual average because Building 356 houses a Cobalt-60 (Co-60) source, which is used to irradiate materials, parts, and electronic circuit boards. The slightly elevated dose from Building 356 measured on 075-TLD3 is attributed to the "sky-shine" phenomenon. This building

Table 8-2. Off-Site Direct Radiation Measurements for 2017.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ± 2 σ (95%)	Annual Dose ± 2 σ (95%)
		(mrem)					
000-TLD5	Longwood Estate	15.8	14.8	13.1	14.4	15±2	58±8
000-TLD9	Private property	15.1	14.2	12.6	14.3	14±2	56±7
000-TLD10	Private Property	17.3	15.1	15.8	17.1	16±2	65±7
400-TLD1	Calverton Nat. Cemetery	20.2	15.8	15.8	16.4	17±4	68±14
500-TLD4	Private property	14.4	14.8	ND	ND	15±0	58±2
600-TLD3	Private property	16.9	15.1	14.3	15.6	15±2	62±8
600-TLD4	Maples B&G	16.1	14.4	13.3	13.4	14±2	57±9
700-TLD3	Private property	16.9	14.1	13.1	13.8	14±3	58±12
700-TLD4	Private property	16.5	14.4	14.6	14.7	15±2	60±7
800-TLD1	Private property	20.7	15.3	14.5	14.6	16±5	65±21
800-TLD3	Suffolk County CD	16.8	15.3	15.0	15.3	16±1	62±5
800-TLD4	LI Nat'l Wildlife Refuge	15.8	16.2	13.4	12.9	15±3	58±12
900-TLD2	Private property	21.1	14.1	13.0	14.0	16±6	62±26
900-TLD4	Private property	16.6	22.4	14.9	ND	18±6	72±26
900-TLD5	Private property	14.4	13.7	12.9	12.8	13±1	54±5
999-TLD1	Private property	16.7	14.3	14.7	15.6	15±2	61±7
Off-site average		**16.9**	**15.3**	**14.1**	**14.6**	**15±3**	**61±11**
Std. Dev. (2σ)		**3.9**	**3.9**	**2.1**	**2.5**		
075-TLD4 : Control TLD Average		**7.7**	**7.3**	**7.4**	**6.8**	**7.3±0.7**	**29±3**

Notes:
See Figure 8-2 for TLD locations.
NP = TLD not posted
TLD = thermoluscient dosimeter

Table 8-3. Facility Monitoring Area for 2017.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Average ± 2σ (95%)	Annual Dose ± 2σ (95%)
		(mrem)					
054-TLD2	NE of Bldg. 913B	30.9	24.2	14.3	16.0	21±13	85±53
054-TLD3	NW of Bldg. 913B	26.4	21.4	12.9	14.9	19±11	76±43
S6		20.3	16.4	16.0	17.4	18±3	70±13
088-TLD1	FWMF, 50' East of S6	21.5	20.2	20.9	19.7	21±1	82±5
088-TLD2	FWMF, 50' West of S6	20.5	17.8	16.9	18.1	18±3	73±11
088-TLD3	FWMF, 100' West of S6	21.6	19.1	18.8	17.6	19±3	77±12
088-TLD4	FWMF, 150' West of S6	17.8	15.9	15.7	15.8	16±2	65±7
075-TLD3	Building 356	25.9	20.1	18.8	19.8	21±6	85±22
075-TLD5	North Corner of Bldg. 356	25.9	20.9	17.5	21.5	21±6	86±24

Notes:
See Figure 8-1 for TLD locations.
FHWMF = Former Hazardous Waste Management Facility

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 these sites was measured at 30.9 mrem for 054-TLD2 and 26.4 mrem for 054-TLD3 (compared to the site-wide first-quarter dose of 18.7 ± 4.2 and off-site dose of 16.9 ± 3.9 mrem). The second-quarter dose at these sites was measured at 24.2 mrem for 054-TLD2 and 21.4 mrem for 054-TLD3 (compared to the site-wide second quarter dose of 15.9± 3.8 mrem and off-site dose of 15.3 ± 3.9 mrem). During the third and fourth quarters, both TLDs showed dose comparable to natural background radiation. The slightly higher levels of the first and second quarters are expected because the operating period for the AGS is typically in the first half of the calendar year.

The AGS accelerates protons to energies up to 30 GeV and heavy ions up to 15 GeV/amu. RHIC has two beams circulating in opposite directions and can accept 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. In 2017, 12 pairs of neutron-monitoring TLDs (Harshaw Badge 8814) were posted at strategic locations

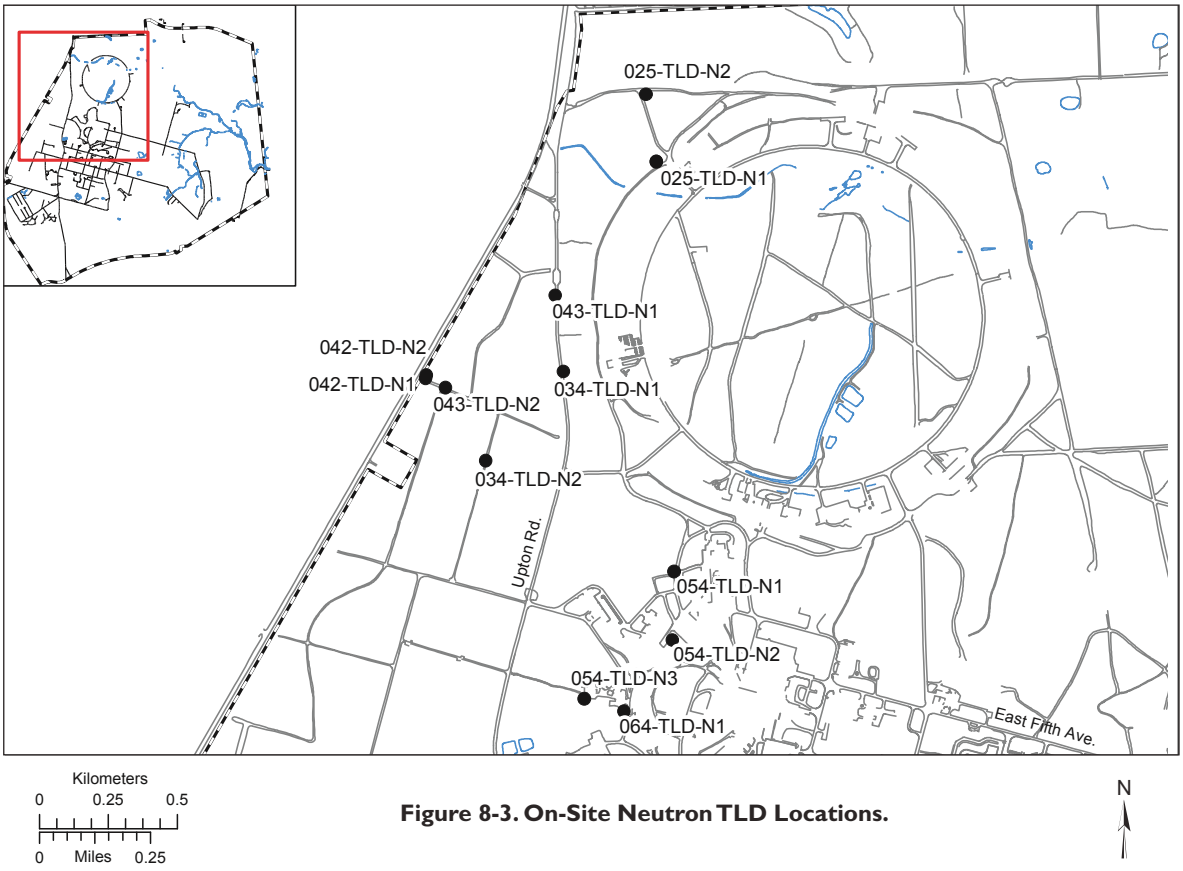

Figure 8-3. On-Site Neutron TLD Locations.

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. The neutron TLDs are placed in pairs for three reasons. The dose registered on these TLDs is low, so a matching number on the second TLD adds a measure of confidence to the dose measured by the first one. Two neutron TLDs side-by-side decreases the potential dependence of measured dose on directional orientation. Only the neutron TLDs are mounted on polyethylene cylinders so that incident neutrons, which are at a high enough energy to pass through the TLD undetected, are thermalized by the hydrocarbons in the polyethylene. This allows the incident neutrons to be counted when reflected back out.

In the first quarter of 2017, passive monitors for neutron dose showed 1 mrem neutron dose at 025-TLD-N2, 1 mrem at 034-TLD-N2, and 2 mrem at 054-TLD-N2. In the second quarter, neutron TLDs showed no neutron doses. In the third quarter, a TLD at 054-TLD-N2 showed 1 mrem. Finally, 1 mrem neutron dose was recorded in the fourth quarter at 025-TLD-N2, 034-TLD-N1, 043-TLD-N1, and 064-TLD-N1. See Table 8-4 for the neutron dose data. The RHIC/BLIP runs at slightly higher current and energy during the beginning of the third quarter for approximately one month, but is turned off for the remainder of the third quarter. In the fourth quarter, the RHIC/BLIP runs for a two-week period at the end of the calendar year at low, startup-testing levels. These low-level neutron doses indicate that engineering controls (i.e., berm shielding) in place at AGS and RHIC are effective.

8.2 DOSE MODELING

The 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 greater than 10 mrem (100 μSv) in a year from airborne emissions. The emission monitoring requirements are set forth in Sub-part 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 one 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 8-5, and the actual air emissions for 2017 are discussed in detail in Chapter 4.

As a part of the NESHAPs review process at BNL, any emission source, such as a stack, that has the potential to release airborne radioactive materials is evaluated for regulatory compliance. Under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), certain restoration activities are also monitored and assessed for any potential to release airborne radioactive materials, and to determine their dose contribution, if any, to the environment. Any new radiological processes or activities are also evaluated for compliance with NESHAPs regulations using the EPA's approved dose modeling software (see Section 8.2.1 for details). Because this model is 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, modeling 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). This computer program uses a Gaussian plume

Table 8-4. Neutron Dose Report for 2017.

Neutron TLD #	Location ID No.	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Neutron Dose
		(mrem neutron)				
TK275	025-TLD-N1	0	ND	ND	ND	0
TK276	"	0	ND	ND	ND	0
TK277	025-TLD-N2	0	0	0	0	0
TK278	"	1	0	0	1	2
TK279	034-TLD-N1	0	0	0	1	1
TK280	"	0	0	0	0	0
TK281	034-TLD-N2	0	0	0	0	0
TK282	"	1	0	0	0	1
TK283	043-TLD-N1	0	0	NP	0	0
TK284	"	0	0	0	1	1
TK285	043-TLD-N2	0	0	0	0	0
TK286	"	0	0	0	0	0
TK287	042-TLD-N1	0	0	0	0	0
TK288	"	0	0	0	0	0
TK289	042-TLD-N2	0	0	0	0	0
TK290	"	0	0	0	0	0
TK291	054-TLD-N1	0	0	0	0	0
TK292	"	0	0	0	0	0
TK293	054-TLD-N2	0	0	1	0	1
TK294	"	2	0	0	0	2
TK295	054-TLD-N3	0	0	0	0	0
TK296	"	0	0	0	0	0
TK297	064-TLD-N1	0	0	0	1	1
TK298	"	0	0	0	0	0
PM-bkg		0	0	0	1	1

Note:
NP = TLD Not Posted
ND = TLD Not Deployed

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 the air, the rate of deposition on ground surfaces, and the 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 dose estimates. For the purpose of modeling the dose to the MEOSI, all emission points are colocated at the BLIP Facility, which is used to represent 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 also factored into the dose

Table 8-5. Maximally Exposed Off-site Individual Effective Dose Equivalent From Facilities or Routine Processes, 2017.

Building No.	Facility or Process	Construction Permit No.	MEOSI Dose (mrem) (a)	Notes
197	Nonproliferation & Nuclear Safety	None	ND	(f)
197B	Nonproliferation & Nuclear Safety	None	ND	(f)
348	Instrumentation & Calibration	None	1.69E-11	(b)
463	Biology	None	4.02E-08	(b)
480	Condensed Matter Physics	None	ND	(h)
490	Radiation Therapy Facility	BNL-489-01	ND	(e)
490/490A	Personnel Monitoring	None	9.24E-08	(b)
491	BMRR	None	ND	(e)
510	Calorimeter Enclosure	BNL-689-01	ND	(e)
510A	Physics	None	1.71E-11	(b)
535	Instrumentation	None	7.56E-15	(b)
555	Chemistry Facility	None	ND	(j)
725	Computational Science Initiative	None	ND	(h)
734	Interdisciplinary Science Building	None	1.86E-13	(b)
735	Center for Functional Nanomaterials	None	ND	(h)
740	Nuclear Science & Technology	None	2.21E-14	(b)
740	NSLS-II	None	1.49E-09	(b)
750	HFBR	None	9.59E-05	(c)
750	Nonproliferation & Nuclear Safety	None	1.16E-13	(b)
801	Target Processing lab	None	1.88E-03	(c)
802B	Evaporator Facility	BNL-288-01	ND	(e)
815	Nonproliferation & Nuclear Safety	None	ND	(h)
820	Accelerator Test Facility	BNL-589-01	ND	(f)
830	Environmental Science Department	None	ND	(h)
865	Waste Managerment Facility	None	ND	(i)
901	BioSciences Department	None	ND	(h)
902	Superconducting Magnet Division	None	ND	(h)
906	Imaging Lab	None	ND	(h)
911	Collider Accelerator	None	ND	(h)
925	RF Systems	None	ND	(h)
931	BLIP	BNL-2009-01	7.22E-01	(c)
938	REF/NBTF	BNL-789-01	ND	(f)
942	AGS Booster	BNL-188-01	ND	(g)
---	RHIC	BNL-389-01	ND	(i)
Total Potential Dose from BNL Operations			**7.24E-01**	
EPA Limit (Air Emissions)			**10**	

Notes:
MEOSI = Maximally Exposed Off-site Individual
(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) ND = No Dose from emissions source in 2017.
(e) NO = Not Operational in 2017.
(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 2017.
(j) No detectable emissions from the Waste Management Facility in 2017.

assessment. Weather data are supplied by measurements from the Laboratory's meteorological towers. These measurements include wind speed, direction, and frequency, as well as air temperature and precipitation amount (see Chapter 1 for details). A population of six million (6,031,539) 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).

The 2017 effective dose equivalents were estimated using Version 4.0.1.17 of CAP88-PC. The following approaches were taken and assumptions made in determining 2017 dose estimates for this report:

- A conservative approach is used for agricultural data input into the CAP88 modeling program, in that 92 percent of vegetables, 100 percent of milk, and 99 percent of meat are considered to be from the assessment area.
- The velocity of the exhaust from the BLIP facility stack was updated to reflect current operation. The average volumetric flow rate of the BLIP exhaust system in 2017 was 516.9 cfm, or 0.244 m3/sec. With an exit diameter of 0.1 m, the exit velocity was 31.05 m/sec, up slightly from last year's 30.95 m/sec.
- The method of characterizing atmospheric stability for purposes of estimating effluent dispersion was the Solar Radiation/Delta Temperature method for conservatism.

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 emission point of the BNL site boundary. This person is also assumed to consume significant amounts of fish and deer containing radioactivity assumed to be attributable to Laboratory operations, based on projections from the New York State Department of Health (NYSDOH). In reality, it is highly unlikely that such a combination of "maximized dose" to any single individual would occur, but the concept is useful for evaluating maximum potential dose and risk to members of the public. The dose to the on-site maximally exposed individual who could receive any dose outside of BNL's controlled areas was also determined by 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. Site meteorology data were used to calculate annual emission 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 the 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 pico-Curies 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 in (rem/yr) = intake (kg/yr) × activity in flesh (μCi/kg) × dose conversion 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 same 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 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 potential dose impact to members of the public. No NESHAPs reviews were requested or performed in 2017.

8.3.1 Remediation Work

In 2017, no remediation work requiring NESHAPs evaluation or monitoring was undertaken.

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 one percent of the EPA limit (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 gaseous emissions are directly and continuously measured in real time with an inline, low-resolution, Sodium Iodide (NaI) gamma spectrometer. The spectrometer system is connected to a computer workstation that is used to display and continuously record emission levels. The particulate emissions are sampled for gross alpha and gross beta activity weekly using a conventional fiberglass filter, which is analyzed at an off-site contract analytical laboratory. Likewise, exhaust samples for tritium are also collected continuously using a silica gel adsorbent and are then analyzed at an off-site contract analytical laboratory on a weekly basis.

In 2017, the BLIP facility operated over a period of 26 weeks. During the year, 3,553 Ci of C-11 (half life: 20.4 minutes) and 7,107 Ci of O-15 (half life: 122 seconds) were released from the BLIP facility. A small quantity (1.34E-02 Ci) of Tritiated water vapor from activation of the targets' cooling water was also released. The EDE to the MEOSI was calculated to be 7.22-01 mrem (7.2 μSv) in a year from BLIP operations.

8.4.2 Target Processing Laboratory

In 2017, there were no detectable levels of emissions from the Target Processing Laboratory.

8.4.3 High Flux Beam Reactor

In 2017, the residual tritium emissions from the HFBR Facility were measured at 0.391 Ci, and the estimated dose attributed was 9.59E-5 mrem (0.96 μSv) in a year.

8.4.4 Brookhaven Medical Research Reactor

In 2017, 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 in 2017.

8.4.5 Brookhaven Graphite Research Reactor

In 2017, long-term surveillance of the BGRR continued, as well as the maintenance and periodic refurbishment of structures, systems, and components. This status will continue

Table 8-6. BNL Site Dose Summary, 2017.

Pathway	Dose to Maximally Exposed Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose per year
Inhalation			
Air	7.24E-01	<1%	1.16 Person-rem
Ingestion			
Drinking Water	None	None	None
Fish1	8.80E-02	<0.1%	Not Tracked
Deer	4.8	<5%	Not Tracked
All Pathways	**5.61**	**<6%**	**1.16 Person-rem**

Note:
1 - Source River remained dried up in 2017, so 2015 fish data was used to represent magnitude since sampling was not possible in 2017.

throughout the period of radioactive decay. There were no radionuclides released to the environment from the complex in 2017.

8.4.6 Waste Management Facility

In 2017, there were no detectable levels of emissions from the Waste Management Facility.

8.4.7 Unplanned Releases

In 2017, there were no unplanned releases.

8.5 DOSE FROM INGESTION

Radionuclides in the environment may bioaccumulate in deer and fish tissue, bones, and organs; consequently, samples from deer and fish are analyzed to evaluate the contribution of dose to humans from the ingestion pathway. As discussed in Chapter 6, deer meat samples collected on- and off-site but near the BNL boundary were used to assess the potential dose impact to the MEOSI. The maximum tissue concentration in the deer meat (flesh) collected for sampling was used to calculate the potential dose to the MEOSI. Potassium-40 (K-40) and Cs-137 were detected in the tissue samples. K-40 is a naturally-occurring radionuclide and is not related to BNL operations.

In 2017, BNL collected samples from 18 animals and analyzed for K-40 and Cs-137. It should be noted that since the site boundaries are not fenced, deer are able to travel short distances back and forth across the site boundary. The average K-40 concentrations in deer tissue samples (BNL Average) were 3.14 ± 0.55 pCi/g (wet weight) in the flesh and 2.61 ± 0.43 pCi/g (wet weight) in the liver. The maximum Cs-137 concentration was 1.34± 0.04 pCi/g (wet weight) in the flesh on site (see Table 6-2). The average Cs-137 concentration from all deer sampled was 1.00 ± 0.19 pCi/g. However, the maximum Cs-137 concentration of 3.33 pCi/g from a deer sample collected less than a mile from BNL was used for MEOSI dose calculations. Therefore, the maximum estimated dose to humans from consuming deer meat containing the maximum Cs-137 concentration was estimated to be 4.8 mrem (48 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. The Peconic River is an intermittent stream, with flow occurring predominantly via groundwater discharge in the spring and fall (a "gaining" stream) and completely drying up during dry periods (a "losing" stream). In 2017, the Peconic River was completely dry for a second year, so there were no samples of fish to analyze for radioactivity. Therefore, as a representative estimate of dose due to fish consumption from local freshwater bodies for 2017, the most recent year's measured concentration of Cs-137 at 0.25 ± 0.06 pCi/g was used to estimate the EDE to the MEOSI. Accordingly, the potential dose from consuming 15 pounds of such fish annually was estimated at

8.75E-2 mrem (0.88 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. The RESRAD-BIOTA 1.8, 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 2017, the terrestrial animal and plant doses were evaluated based on 10.8 pCi/g of Cs-137 (see Table 6-3) found in soil just outside the FHWMF and a strontium-90 (Sr-90) concentration of 0.46 pCi/L in the surface waters collected at the Station HQ location in 2015. No on-site Peconic River surface water samples were collected in 2017 due to drought conditions. Therefore, the 2015 Sr-90 value was used to calculate the terrestrial animal and plant doses. The dose to terrestrial animals was calculated to be 520 μGy/day, and to plants, 48.9 μGy/day. The dose to terrestrial animals was well below the biota dose limit of 1 mGy/day, and the plant dose was below the limit of 10 mGy/day for terrestrial plants.

To calculate the dose to aquatic and riparian animals, a similar conservative approach was taken due to drought conditions throughout the year. A Sr-90 radionuclide concentration value for surface water collected in 2015 from the eastern site boundary at Station HQ was used and an estimated Cs-137 concentration was used from a vegetation sample that was collected just outside the FHWMF. The estimated Cs-137 concentration in sediment at the FHWMF was 10.0 pCi/g, and the Sr-90 concentration in surface water at HQ was 0.46 pCi/L. The 2015 Cs-137 concentration was decay-corrected for one year's decay. Thus, the calculated dose to aquatic animals was 2.11 μGy/day and the dose to riparian animals was 4.85 μGy/day. Therefore, the dose to aquatic animals was well below the limit of 10 mGy/day. Finally, the dose to riparian animals was also well below the 1 mGy/day limit specified by the regulations.

8.7 CUMULATIVE DOSE

Table 8-6 summarizes the potential cumulative dose from the BNL site in 2017. The total dose to the MEOSI from air and ingestion pathways was estimated to be 5.61 mrem (56 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 1.16 person-rem (1.16E-2 person-Sv) in the 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 doses 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 approximately 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 5.61 mrem from all environmental pathways is a minute fraction of the dose from that of several routine diagnostic procedures as well as natural background radiation.

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9 Quality Assurance

Quality assurance is an integral part of every activity at Brookhaven National Laboratory (BNL). A comprehensive Quality Assurance/Quality Control (QA/QC) Program is in place to ensure that all environmental monitoring samples are representative and that data are reliable and defensible. 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 2017 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 DOE 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 to do the following:

- 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. An

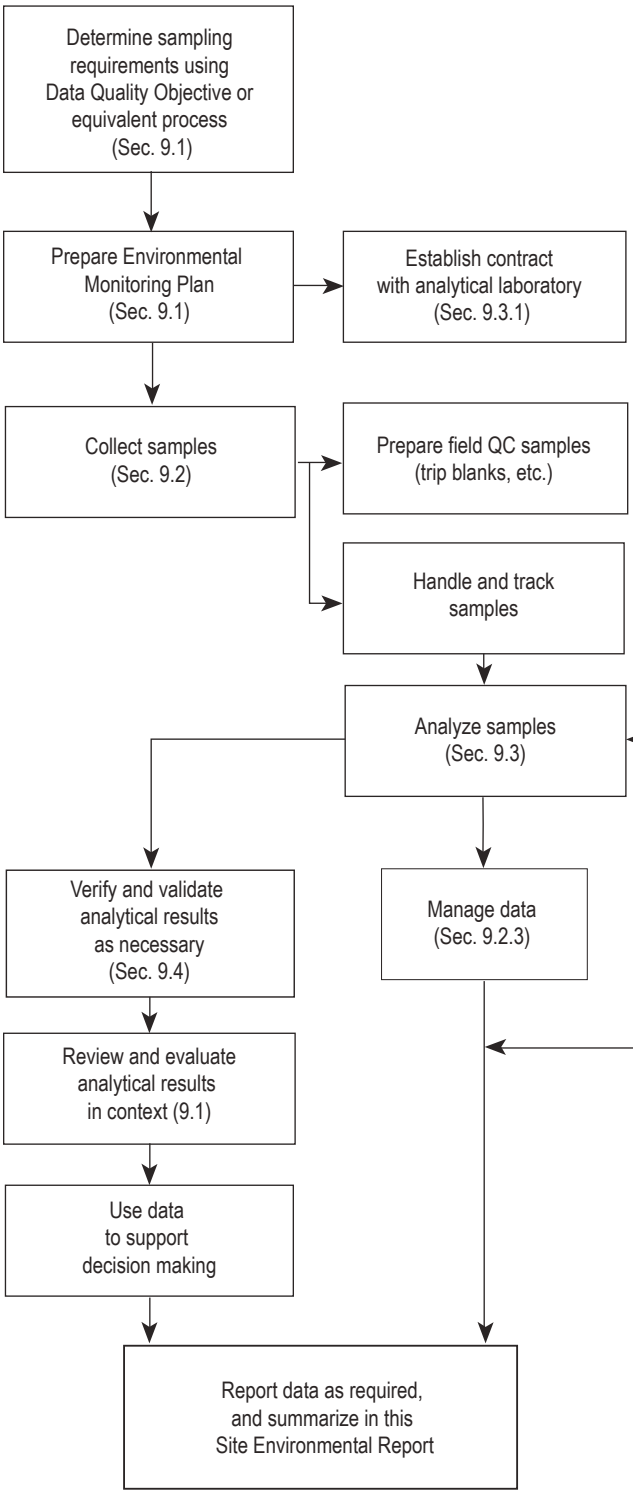


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

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 and 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 2017, environmental monitoring samples were collected, as specified, by EM-SOPs, the BNL Environmental Monitoring Plan Update (BNL 2017), 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 2017. 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 2015).

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 are 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. The contract laboratory confirms preservation upon receipt of the samples. BNL is notified as soon as practical if a sample arrives unpreserved or at the wrong temperature. This notification typically occurs on the day or receipt, but for weekend deliveries, the notifications occur Monday morning. If a sample arrives with an incorrect pH, the lab has been instructed to attempt to correct the pH. If the sample matrix does not allow this correction, the analysis is conducted on a priority basis. Sample preservations, including incorrect preservation, is noted on the sign in documentation and included with every data package. If the BNL Project Manager, with the help of a QC chemist and/or radiochemist, determines that an incorrect preservation issue would result in data that does not meet the data quality objectives of the project, the analysis is cancelled prior to BNL receiving any data.

On three occasions during 2017, shipments of samples were delayed due to unforeseen circumstances. This resulted in volatile organic compounds (VOCs) samples arriving significantly above the required temperature. In these instances, the analyses were cancelled and the samples were recollected.

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 and 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 2017.

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 VOCs. The use of trip blanks provides a way to determine whether contamination of a sample container occurred during shipment from the manufacturer, while the container was in storage, 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 are 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 2017.

Field blanks are collected to check for cross-contamination that may occur during sample collection. A field blank consists 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 2017 (as in other years), the most common contaminants detected in the trip, field, and equipment blanks included trace to low levels of chloroform and methylene chloride. This is believed to be a byproduct of the hydrochloric acid preservative used for the samples. These compounds are commonly detected in blanks and do not pose significant problems with the reliability of the analytical results. Other compounds were also detected such as acetone 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 2017 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 five percent of the total number of samples collected for a project per sampling round.

During 2017, a total of 35 duplicate samples were collected for non-radiological analyses and 23 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 2,217 parameters analyzed, only 21 (0.09 percent) of the non-radiologic analyses failed to meet QA criteria. For the radiologic parameters, only three of the 97 parameters (three 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 2017 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 a contract analytical laboratory; Chemtex Lab 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 Department of Energy (DOE) Brookhaven Site Office staff using a web-based data query tool.

9.3 SAMPLE ANALYSIS

In 2017, environmental samples were analyzed by five contract analytical laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to Environmental Protection Agency (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 2017:

- American Radiation Services (ARS) in Port Allen, Louisiana, for radiological analytes;
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes;
- General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes;
- PACE Lab in Melville, New York, for nonradiological analytes; and
- Test America (TA), based in St. Louis, Missouri, for radiological and nonradiological analytes.

The process of selecting contract analytical laboratories involves the following factors: 1) their record on performance evaluation 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 2017 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 a 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* – 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 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. When analyses are determined to be outside of QC parameters, a qualifier is applied to the result stored in the EIMS. Results that have been rejected are qualified with an R. Rejected results are not used in the preparation of this report.

The most common QC issue determined during 2017 was the presence of low-level contamination of trip, field, and method blanks used in VOC analyses. Results for the trip and field blanks are summarized on Table 1. This resulted in minor qualification of sample results. Minor violations of laboratory control sample results are also common. In most cases, the violation does not result in qualified sample results.

9.4.1 Checking Results

Nonradiological data analyzed in 2017 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 2017, 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 2017, 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

Four of the contract analytical laboratories (ARS, GEL, PACE, and TA) participated in several national and state PE testing programs in 2017. 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

Table 1. Summary of Detections inTrip and Field Blank Samples.

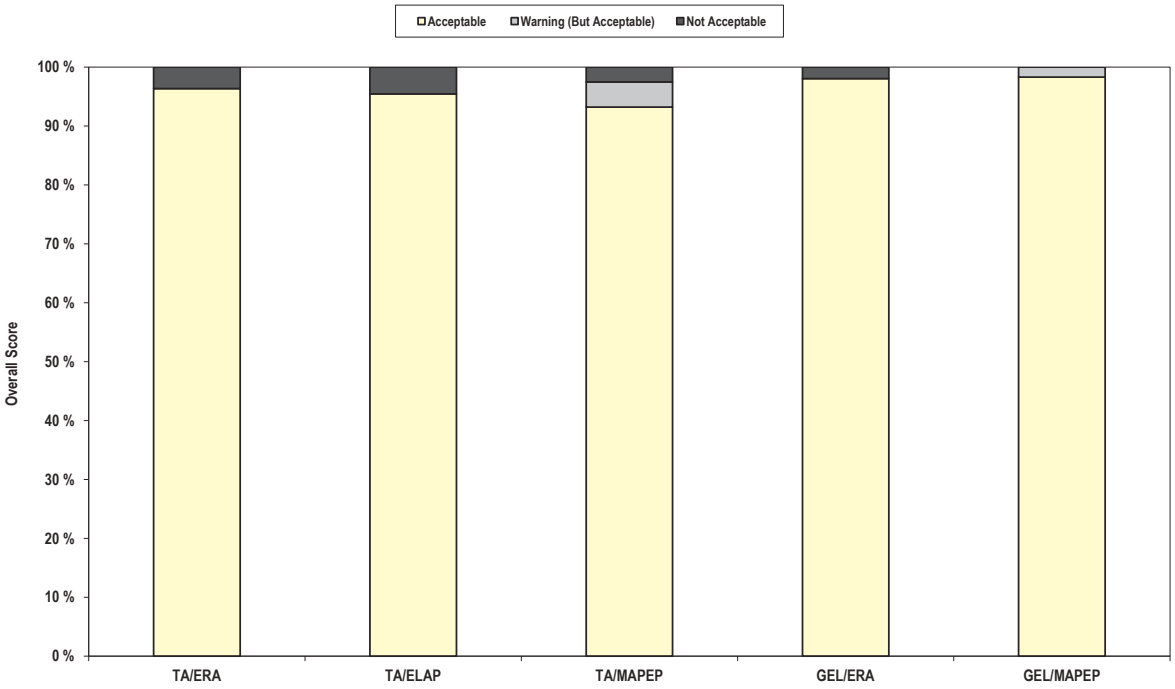
Constituent	Number of Analyses	Number of Detects	Minimum	Maximum	Typical Reporting Limit	Units
Trip Blank Results						
1,1,1-Trichloroethane	85	1	3.2	3.2	0.5	µg/L
1,1,2,2-Tetrachloroethane	85	1	0.33	0.33	0.5	µg/L
1,1-Dichloroethane	85	1	0.14	0.14	0.5	µg/L
1,1-Dichloroethylene	85	2	0.14	1.9	0.5	µg/L
Acetone	1	1	3.6	3.6	10	µg/L
Carbon tetrachloride	85	1	1.5	1.5	0.5	µg/L
Chlorobenzene	85	4	0.16	0.22	0.5	µg/L
Chloroform	85	2	0.1	0.34	0.5	µg/L
Methyl chloride	85	1	0.11	0.11	0.5	µg/L
Methylene chloride	85	43	0.26	12	0.5	µg/L
Tetrachloroethylene	84	2	0.38	40	0.5	µg/L
Trichloroethylene	85	1	1.1	1.1	0.5	µg/L
Field Blank Results						
Organic Compounds						
Acetone	2	1	2.3	2.3	10	µg/L
Chloroform	34	14	0.22	3.17	0.5	µg/L
Methylene chloride	37	2	0.17	0.33	0.5	µg/L
Metals						
Iron	2	1	39	39	30	µg/L
Potassium	2	1	54.9	54.9	50	µg/L
General Chemistry Parameters						
Ammonia (as N)	2	2	0.0249	0.0296	0.017	mg/L
Nitrate	2	2	0.0388	0.0446	0.033	mg/L
Chloride	2	2	0.102	0.107	0.067	mg/L
Total Dissolved Solids	2	2	11.4	27.1	3.4	mg/L

µg/L Micrograms per liter.
mg/L Milligrams per liter.

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 the NYSDOH Environmental Laboratory Accreditation Program (ELAP). The results from these tests are summarized in Section 9.6.1.

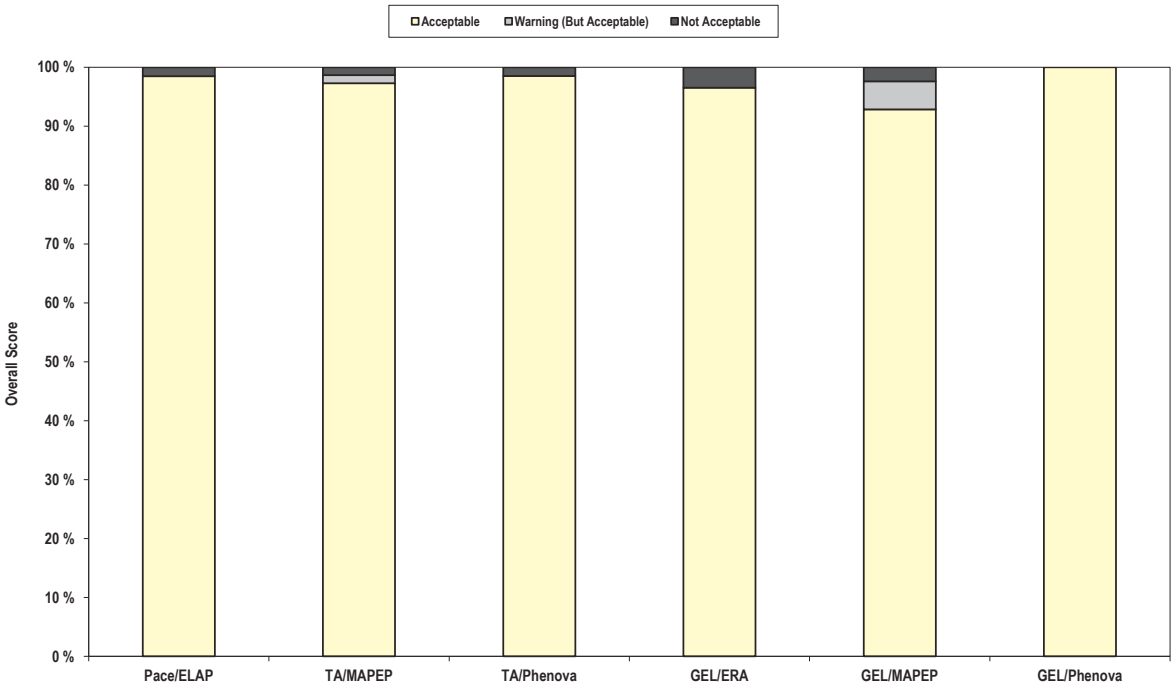
9.6.1 Summary of Test Results

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



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.

value—a criterion set by the independent testing organizations.

Figure 9-2 summarizes radiological performance scores in the ERA, MAPEP, and ELAP programs. GEL and TA had average overall satisfactory scores of 99 and 96 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, Pace, and TA) in the ERA, MAPEP, Phenova, and ELAP tests. For nonradiological tests, the all three laboratories received overall satisfactory results of 98 percent. Additional details on nonradiological evaluations are discussed in Section 9.6.1.2.

9.6.1.1 Radiological Assessments

GEL and TA participated in the ERA and MAPEP radiological PE studies. Of GEL's radiological test results, 99 percent were in the Acceptable range; and of TA's radiological test results, 98 percent were in the Acceptable range. TA participated in the ELAP evaluations; 95 percent of TA's ELAP tests on radiological samples were in the Acceptable range. The ELAP testing is based on a small sample group (21 tests), while the ERA and MAPEP studies use a much larger sample size (more than 250 tests per year).

9.6.1.2 Nonradiological Assessments

During 2017, PACE participated in the NYSDOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 98 percent of PACE's nonradiological tests to be in the Acceptable range. GEL participated in the ERA water supply and water pollution studies. ERA found that 96 percent of GEL's tests were in the Acceptable range. TA and GEL participated in the MAPEP water supply and water pollution studies. MAPEP found that 99 percent and 98 percent of TA's and 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 percent of TA's results were in the Acceptable range and 100 percent of GEL's results were in the Acceptable range.

9.7 AUDITS

As part of DOE's Consolidated Audit Program, TA, GEL, and ARS were audited in 2017 (DOE 2017a,b,c). During the audits, errors were categorized into Priority I and Priority II findings. Priority I finding results from a documented deficiency from a requirement that represents a substantial risk and liability to DOE. Priority II findings results from a documented deviation from a requirement Results are summarized on Table 2.

Both TA and ARS had Priority I findings documented in their audits. The TA Priority I finding resulted from the failure to pass two MAPEP studies for strontium-90 in a vegetative matrix. Since BNL did not use TA to analyze strontium-90 in this matrix, the finding does not affect BNL data. The ARS Priority I finding was for the failure of two MAPEP studies for americium-241 in a soil matrix. Since BNL only uses ARS for the analysis of tritium in groundwater, this finding did not affect BNL data.

With respect to the Priority II findings, many of these findings dealt with inaccuracies in SOPs used by the contractor laboratories. In all instances concerning parameters required by BNL, these findings indicated that the analyses were performed correctly, but the SOP needed to be updated to match the actual work practices. TA had one Priority II finding for incorrectly calibration pH analyses. The pH equipment was not calibrated correctly for pH values above seven. Since BNL does not use any pH results from TA for reporting purposes, this did not affect the use of data for BNL. Since the audit, TA has corrected its calibration procedure to correctly calibrate pH meters. The Audit for ARS did find a significant number of Priority II findings that would affect analytical results for nonradionuclide and radionuclide analyses. However, none of these issues affect the analysis tritium in a water matrix. As previously stated, BNL only uses ARS for the analysis of tritium. The tritium data from ARS undergoes 100 percent verification at BNL and the data also undergoes a comparison to historic results. Therefore, these findings do not affect the use of BNL data.

Based on the audits, the analytical laboratories met BNL criteria for Acceptable status.

Table 2. Summary Results of 2017 DOCAP Audits

Laboratory	Finding Priority	Area of Concentration	Number of Findings
Test America, Earth City Missouri			
	I	Radiochemistry	1
	II	Quality Assurance	1
	II	Organic Analyses	2
	II	Inorganic Analyses and Wet Chemistry	4
	II	Radiochemistry	3
	II	Materials Management	4
GEL Laboratories			
	II	Quality Assurance	4
	II	Radiochemistry	1
ARS International			
	I	Radiochemistry	1
	II	Quality Assurance	1
	II	Inorganic Analyses and Wet Chemistry	6
	II	Laboratory Information Management Systems	1
	II	Materials Management	2

9.8 CONCLUSION

The data validations, data verifications, and DQO checks conducted on analytical results at BNL are designed to eliminate any data that fails to meet the DQO of each project. The results of the independent PE assessments and audits of contractor laboratories summarized in this report are also used to assess the quality of the results. The data used in 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.

AEC	Atomic Energy Commission
AFV	Alterntaive Fuel Vehicles
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
ATF	Accelerator Test Facility
AWQS	Ambient Water Quality Standards
BAF	Booster Applications Facility
BGD	belowground duct
BGEPA	Bald and Golden Eagle Protection Act
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
CAFE	Corporate Average Fuel Economy
CAP	Clean Air Act Assessment Package
CBS	chemical bulk storage
CCR	Consumer Confidence Report
CCWF	Central Chilled Water Facility
CEDR	Consolidated Energy Data Report
CEMS	continuous emission monitoring systems
CERCLA*	Comprehensive Environmental Response, Compensation and Liability Act
Cf-252	californium-252
CFC-11	chloroflourocarbon an ozone-depleting refrigerant
cfm, cfs	cubic feet per minute, per second
CFN	Center for Functional Nanomaterials
CFR	U.S. Code of Federal Regulations
CHP	combined heat and power
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
CSI	Computational Science Initiative
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 Purchasing
ERP	Environmental Restoration Projects
ERA	Environmental Resource Associates
ERD	Environmental Restoration Division
ES*	environmental surveillance
ESF	SUNY School of Environmental Science and Forestry
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
FCA	Facility Condition Assessment
FCM	Facility Complex Manager
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
FPM	Facility Project Manager
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
GSA	US General Services Administration
GSF	gross square feet
GWh	gigawatt hour
GWP	Global warming potential
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
ILA	industrial, landscaping, and agricultural
IPM	Integrated Pest Management
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
LTRA	Long Term Remedial Action
mA	milli-amperes
M&V	Measurement and Verification
MACT	Maximum Available Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
MAR	Materials-at-risk

MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MDL*	minimum detection limit
MEG	Miller Environmental Group
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
MOU	Memorandum of Understanding
MPF	Major Petroleum Facility
MPN	most probable number
MPO	Modernization Project Office
mrem	milli (thousandth of a) rem
MRC	Medical Research Center
MRI	Magnetic Resonance Imaging
MSL*	mean sea level
mSv	millisievert
MTBE	methyl tertiary butyl ether
MW	megawatt
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
NHTSA	National Highway Traffic Safety Administration
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
OEP	Office of Education Programs
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
PEMP	Performance Evaluation Management Plan
PET	positron emission tomography
PFCs	Perfluorocarbons
PIC	potential impact category
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
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
RCA	recycled concrete aggregate
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
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
SCR	Stakeholder and Community Relations
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
SPB	Southern Pine Beetle
SPCC	Spill Prevention Control and Countermeasures
SPDES*	State Pollutant Discharge Elimination System
SPO	Sustainability Performance Office
SPOFOA	Sustainability Performance Office Funding Opportunity Announcement
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
SULI	Science Undergraduate Laboratory Internship
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
TA	Test America
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
TTA	Tolytriazole
TVDG	Tandem Van de Graaff
TVOC*	total volatile organic compounds
UESC	Utility Energy Services Contract
µg/L	micrograms per liter
UIC*	underground injection control
UPS	uninterrupted power supplies
UST*	underground storage tank
VFP	Visiting Faculty Program
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

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.

WTP	Water Treatment Plant
ZEV	zero emission vehicle

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 measure-

ment 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 450.1A – This order, Environmental Protection Program, is dated 6/04/08. It revises DOE Order 450.1, issued in January 2003, to incorporate and implement the new requirements of Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management, issued in January 2007.

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 manage-

ment 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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APPENDIX B

Understanding Radiation

This section introduces the general reader to some basic concepts of radioactivity and an under- sta-ding 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, micro-waves, 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 x 106, which represents "2.5 multiplied by 10 raised to the power of 6." Since even "2.5 x 106" 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 minus sign follows the E rather

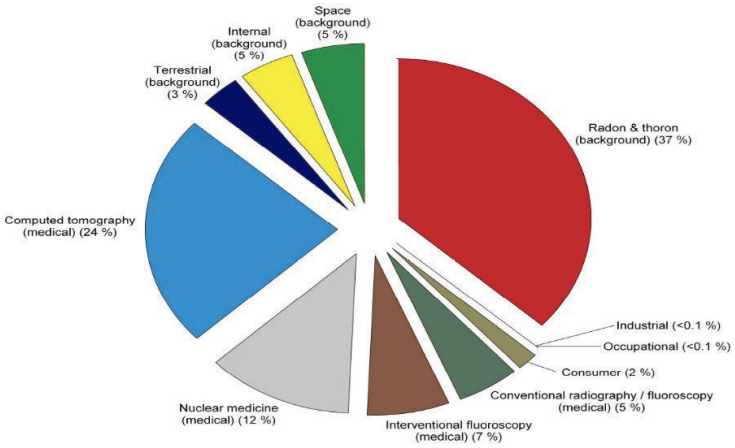

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 160 (NCRP 2009)*

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, such as 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 human-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 31 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 21 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 31 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 230 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, Computed Tomography (CT), mammography, thallium heart stress tests, and tumor irradiation therapies. The average doses from primary sources of medical exposure are as follows: CT at 150 mrem, nuclear medicine at 74 mrem, and radiography/fluoroscopy at 74 mrem.

Anthropogenic – Sources of anthropogenic (human-made) radiation include consumer products such as static eliminators (containin 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 13 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 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 wave-length. 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 pro-

cessed 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 five 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 and 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 fall-out 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 by-product 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 four 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 H2O 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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APPENDIX C

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	~4.5 billion yrs (4.468E9)

APPENDIX D

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

DOE DIRECTIVES, REGULATIONS, AND STANDARDS

DOE O 231.1B	Order: Admin Change 1: Environment, Safety and Health Reporting	11/28/2012
DOE O 414.1D	Order: Admin Change 1: Quality Assurance	05/08/2013
DOE O 435.1	Order: Change 1: Radioactive Waste Management	08/09/1999
DOE P 450.4A	Integrated Safety Management Policy	04/25/2011
DOE P 450.5	Policy: Line Environment, Safety, and Health Oversight	06/26/1997
DOE O 458.1	Order: Change 3: Radiation Protection of the Public and the Environment	02/15/2013

FEDERAL LAWS AND REGULATIONS

EO 13148	Greening of the Government Through Leadership in Environmental Management
EO 13693	Planning for Federal Sustainability in the Next Decade
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 61, A, H	National Emission Standards for Hazardous Air Pollutants
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 Management 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
50 CFR 21	Migratory Bird Treaty Act
50 CFR 22	Bald and Golden Eagle Protection Act

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	General Provisions
6 NYCRR 201	Subpart 201-1: General Provisions
6 NYCRR 202	Part 202: Emissions Verification
6 NYCRR 205	Architectural and Industrial Maintenance (AIM) Coatings
6 NYCRR 207	Control Measures for an Air Pollution Episode
6 NYCRR 208	Landfill Gas Collection and Control System for Certain Municipal Solid Waste Landfills
6 NYCRR 211	General Prohibitions
6 NYCRR 212	Process Operations
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 226	Solvent Metal Cleaning Processes
6 NYCRR 227	Subpart 227-2: Reasonable Available Control Technology (RACT) for Major Facilities of Oxides of Nitrogen (NOx)
6 NYCRR 228	Subpart 228-1: 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 for New and Modified Facilities
6 NYCRR 234	Graphic Arts
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 Classification 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	Solid Waste Management Facilities General Requirements
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

2017 Site Environmental Report

Reader Response Form

The 2017 Site Environmental Report (SER) was written to inform regulators, the public, and BNL employees of the Laboratory's environmental performance for the calendar year in review. The report summarizes the Laboratory's on-site environmental data; environmental management performance; compliance with applicable regulations; and environmental, restoration, and surveillance monitoring programs.

BNL welcomes your comments, suggestions for improvements, or any questions you may have. Please fill in the information below, and mail your response form to:

Brookhaven National Laboratory
Environmental Protection Division
Attention: SER Project Coordinator
Building 860
P.O. Box 5000
Upton, NY 11973-5000

Name _____

Address _____

_____

Phone _____

Email _____

Comments, Suggestions, or Questions

_____

_____

_____

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☐ I would like to be added to your Environmental Issues mailing list.

BROOKHAVEN
NATIONAL LABORATORY

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