BROOKHAVEN NATIONAL LABORATORY

Site Environmental Report 2019

VOLUME 1

Despite being found on nearly every continent and being the fastest diving bird in the world, the peregrine falcon (*Falco peregrinus*) was once nearly extinct in the mid-19th century. From the 1940s to the 1970s, peregrine reproduction took its own steep decline due to the widespread use of devastating pesticides such as Dichlorodiphenyltrichloroethane (DDT) which caused hatchling eggshells to thin. As a result, this majestic and fabled bird of prey (i.e., raptor) was listed as U.S. federally endangered.

Thanks to a combination of conservation efforts, such as the release of young captive birds, nesting management, and the banning of DDT and other chemical pesticides, the population of peregrine falcons has gradually increased in the United States and Canada. While it was removed from the federally endangered list in 1999, it maintains this status in New York State.

According to the New York State Department of Environmental Conservation, peregrine falcons have made a resurgence in a variety of habitats in the state, and true to their nature to nest in high-altitude locations, have been found commonly nesting on bridges and building ledges in and near a number of major New York cities, as well as along cliff ledges in the Adirondack mountain region.

Peregrines will utilize other birds' nests when available, just as a pair of peregrines did on the Brookhaven National Lab site when they forced common ravens to abandon their nest on the High Flux Beam Reactor (HFBR) stack in 2019. This pair of peregrines produced two to three offspring.

One or two peregrines had been observed around the HFBR stack in 2017 and 2018 but no nesting was confirmed at that time.

In 2020, authorized Laboratory staff removed the ravens' nest to discourage the peregrines from nesting due to planned demolition of the stack. Since that time, a couple of falcons have been seen in the area, one of which may have been an immature bird from the previous summer.

The subject of this year's Site Environmental Report cover was taken by Lab employee Rodger Hubbard, who surveys and aligns components in the National Synchrotron Light Source-II Accelerator Division.

Hubbard observed the bird at "the entrance to the picnic area in an old oak tree that was recently trimmed. He had just finished a meal of a wood duck which I missed but found the remains."

As raptors, peregrines are known to capture their prey while soaring high then diving precipitously or knocking prey out of the air and feeding on it after it falls to the ground.

Photo credit: Nathaniel Foster

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SITE ENVIRONMENTAL REPORT

BROOKHAVEN NATIONAL LABORATORY

Volume I

October 2020

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EXPLORING EARTH'S MYSTERIES
…PROTECTING ITS FUTURE

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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 over 70 years, the Laboratory has played a lead role in the DOE Science and Technology mission and continues to contribute to the DOE's 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 its environmental history since the Laboratory's inception in 1947.

Volume II of the SER, the Groundwater Status Report, is also 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 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 its employees, and the security of the site. Specific environmental commitments in the policy include compliance, pollution prevention, conservation, community outreach, and continual improvement. The policy is posted throughout the Laboratory and on the BNL website. It is also included in all training programs for new employees, guests, and contractors.

The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized ISO 14001 Environmental Management Standard. BNL was the first 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 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 2019, an EMS certification audit determined that BNL continues to conform to the ISO 14001:2015 Standard.

BNL follows Executive Order (EO) 13834, Efficient Federal Operations, which replaced EO 13693, Planning for Federal Sustainability in the Next Decade, in 2018. The order establishes sustainability goals for federal agencies with a focus on sustainability initiatives that save money and increase efficiency across the government with guidance, recommendations, plans, and numerical targets. 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 13693. 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. For a status summary of BNL's 2019 SSP, see Appendix E.

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 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 2019, these efforts resulted in nearly $3.1 million in cost avoidance or savings and approximately 1.6 million pounds of materials being reduced, recycled, or reused annually.

BNL continues to decrease its energy consumption and increase savings. In the past ten years, water consumption total was approximately half the 1999 total—a reduction of nearly 30 million gallons per year. In 2019, natural gas was used to meet over 99 percent of the heating and cooling needs of the Laboratory's major facilities, further reducing greenhouse (GHG) emissions. The Laboratory also scheduled operations at the Relativistic Heavy Ion Collider to avoid peak demand periods. This reduced the electric demand by approximately 25 megawatts (MW), saving approximately $1.0 million in electric demand costs. In addition, the 2019 output from the Lab's Long Island Solar Farm was 50.6 million kWh and resulted in an avoidance of approximately 33,000 tons of carbon. Chapter 2 of this report further describes these and other sustainability

efforts, as well as implementation of BNL's EMS and P2 Program, in more detail.

BNL'S ENVIRONMENTAL MANAGEMENT PROGRAM

BNL's Environmental Management Program consists of several Laboratory-wide and facility-specific environmental monitoring and surveillance programs. These programs identify potential pathways of public and environmental exposure and evaluate the impacts BNL activities may have on the environment. An overview of the Laboratory's environmental programs and a summary of performance for 2019 are 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 2019, the Laboratory operated in compliance with most of the requirements, and any instance of noncompliance was reported to regulatory agencies and corrected expeditiously or a plan was put in place to come into compliance. Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility (CSF) were well within permit limits in 2019. Recorded excess opacity measurements from CSF boilers were investigated and documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to the New York State Department of Environmental Conservation (NYSDEC).

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 2019. 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 to eliminate possible ozone-depleting substance emissions.

With the exception of a violation for missing the collection of an iron sample at the Water Treatment Plant in June, BNL's drinking water and the supply and distribution system were in compliance with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting in 2019. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System (SPDES) permit requirements.

An investigation into the cause(s) of Tolyltriazole (TTA) exceedances at the Sewage Treatment Plant (STP) and associated corrective actions continued throughout 2019. TTA is a corrosion inhibitor. BNL staff continue to work closely with the DOE and NYSDEC on this issue to identify possible solutions.

Also in 2019, groundwater monitoring at the Laboratory's Major Petroleum Facility (MPF) and Waste Management Facility (WMF) demonstrated that current operations are not affecting groundwater quality.

Efforts to minimize impacts of spills of materials continued in 2019. There were 23 spills in 2019 and ten of those spills met regulatory agency reporting criteria.

BNL participated in 11 environmental inspections or reviews by external regulatory agencies in 2019. These inspections included STP operations; hazardous waste management facilities; regulated emission sources; and the potable water system. Immediate corrective actions were taken to address all compliance issues raised during these inspections.

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs and performed two surveillances of BNL operations in 2019: a surveillance of BNL's compliance with National Emission Standards for Hazardous Air Pollutants, specifically, 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*, and an assessment of BNL's Packaging and Transportation Program, as required by DOE O 460.2A, Departmental Material Transportation and Packaging Management. For the first assessment, no findings were identified. For the Transportation and Packaging assessment, four Level 3 Findings, five Observations, three Improvement Opportunities, four Best Practices, and one Noteworthy Practice were identified. A causal analysis was performed and corrective actions

were developed to minimize the risk of recurrence.

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 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 2019, BNL facilities released a total of 19,022 curies of short-lived radioactive gases. Oxygen-15 and Carbon-11 emitted from the Brookhaven Linac Isotope Producer (BLIP) constituted more than 99.9 percent of the site's radiological air emissions. The remaining 0.1 percent was due to tritium releases from the High Flux Beam Reactor.

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 99.6 percent of the heating and cooling needs of the Laboratory's major facilities in 2019. 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.

In 2019, there were five recorded excess opacity measurements. Three recorded readings on January 23 were due to the start-up and shutdown of Boiler 6 in preparation for periodic emissions tests conducted later that day, and two Boiler 6 excess opacity readings on December 30 were due to unknown causes. 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.

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 gross alpha and beta airborne activity. The annual average gross alpha and beta airborne activity levels for the four monitoring stations were 0.0011 and 0.0128 pCi/m^3, respectively.

Airborne tritium in the form of tritiated water (HTO) is monitored throughout the BNL site. In 2019, tritium samples were collected from four sampling stations every two weeks to assess potential impacts from the Laboratory's two tritium sources. The average tritium concentrations at all the sampling locations were less than the typical minimum detection limits, ranging from 4.0 to 11.0 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. All but five of the BNL samples 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.

In 2019, BNL took several actions to meet DOE GHG reduction goals. Fifty million kilowatt-hours of solar energy were provided to Long Island from the BNL-based Long Island Solar Farm (LISF). This equates to 33,828 metric tons CO_2 equivalents ($MtCO_2e$) GHG offset or reduction. Also in 2019, BNL consumed 118,847 megawatts of hydropower, providing a net combined GHG reduction of 97,629 $MtCO_2e$ from the LISF and hydropower. In 2016, BNL completed an expansion of the Northeast Solar Energy Research Center, a solar photovoltaic facility that has a capacity of 816 kW. In 2019, it provided 1,018,000 kWh and offset 1,179 $MtCO_2e$. Chapter 4 of this report describes BNL's Air Quality Program, monitoring data, and other GHG-reducing efforts in further detail.

WATER QUALITY SURVEILLANCE PROGRAM

Wastewater generated from BNL operations is treated at the 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 2019 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, with the exception of multiple TTA exceedances, organic and inorganic parameters were within SPDES effluent limits 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. 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.

The Peconic River flowed the first half of 2019, then stopped flowing offsite by July as groundwater levels began subsiding. 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 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.

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 program includes protecting and monitoring the ecosystem on site, conducting research, and communicating the results with the public, stakeholders, and staff members.

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.

To evaluate Cs-137 in deer, BNL has established a routine on and off-site deer sampling program. In 2019, three deer were obtained on site, five from off-site locations within one mile of the Laboratory, and three from greater than one mile from the BNL boundary. 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).

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. 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. At the end of 2018, the herd was estimated at between 350 and 450 animals; in April 2019, a harvest was conducted during which 250 animals were taken, effectively bringing the population to approximately 200 animals. With a reproduction rate of approximately 60 percent, the population at the end of 2019 was estimated at 300 to 350 deer.

During 2019, grassy vegetation samples were collected from ten locations around the Laboratory and a control location in Ridge, New York. All samples were analyzed for Cs-137 which ranged from non-detectable to 0.07 pCi/g, wet weight at a single location. Soil samples had Cs-137 levels ranging from non-detect to 0.84 pCi/g, dry weight. All values were consistent with historic monitoring. Monitoring results for grassy

vegetation and soils were utilized for the annual dose to biota analysis reported in Chapter 8.

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. During 2019, precipitation samples were collected quarterly at two air monitoring stations. Mercury was detected in all the precipitation samples collected at both stations. Mercury ranged from 3.55 ng/L at station P4 in October to 13.1 ng/L at station S5 in July. The 13.1 ng/L concentration is 3.4 times lower than the highest value of 45.1 ng/L, recorded in 2017.

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 2019, BNL hosted 16 student interns, a graduate student, and two faculty members within the Natural Resources program. One intern conducted statistical analysis of bird survey data during the spring, and a second worked on statistics of the 4-Poster™ tick management program in the fall. During summer, 14 interns participated in programs looking at forest health of the Long Island Pine Barrens, pollinator use of the Long Island Solar Farm, modified feeding effects on effectiveness of the 4-PosterTM tick management devices, and mapping valves and other infrastructure associated with the Laboratory's potable water system.

Also in 2019, BNL continued its active support of ecological education programs by hosting the Long Island Natural History Conference; participating in the Tenth Annual Pine Barrens Discovery Day at the Wertheim National Wildlife Refuge; and assisting the Central Pine Barrens Commission with "A Day in the Life of the Rivers," which allowed students from multiple school districts to acquire environmental and biological data around 11 different rivers on Long Island. In 2019, BNL entered its 15th year of the Open Space Stewardship Program and worked with 30 schools and nearly 2,500 students.

The Laboratory also hosted the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. BNL has developed and is implementing a Wildland Fire Management Plan that includes the use of prescribed fire for fuel and forest management. No prescribed fires were conducted in 2019.

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. The 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.

Due to the detection of Per- and Polyfluoroalkyl Substances (PFAS) in water samples collected from three BNL water supply wells in 2017, BNL conducted a search of available records to determine a source of PFAS. In 2018, BNL identified eight areas where PFAS-containing firefighting foam had been used for firefighter training or fire suppression system maintenance from 1966 until 2008. Groundwater characterization confirmed the presence of PFAS in each of the eight areas, with the highest concentrations detected at the location of the BNL's former firehouse (1947-1985) and at the current firehouse (1986-present). The Laboratory continues its 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. In addition to water quality assessments, water levels are routinely measured in 725 wells to assess variations in the direction

and velocity of groundwater flow.

During 2019, BNL collected groundwater samples from 625 permanent monitoring wells and 32 temporary wells during 1,704 individual sampling events. Seven groundwater remediation systems removed 61 pounds of volatile organic compounds and returned approximately 750 million gallons of treated water to the Upper Glacial aquifer. Also, one groundwater treatment system removed approximately 0.8 millicurie of strontium-90 (Sr-90) while remediating approximately 14 million gallons of groundwater. Since 2003, BNL has removed approximately 33.6 millicuries of Sr-90 from the groundwater while remediating 245 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have occurred in several on- and off-site areas. Chapter 7 of this report provides an overview of this program, and the SER Volume II, Groundwater Status Report, provides detailed descriptions, data, and maps relating to all groundwater monitoring and remediation performed in 2019.

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 2019, the total effective dose (TED) to the MEOSI of 2.8 mrem (28 μSv) from Laboratory operations was well below the dose limit of 100 mrem in a year required by DOE Order 458.1, as well as all other EPA and DOE regulatory dose limits for the public, workers, and the environment.

Dose to the maximally exposed individual (MEI) on site and outside of controlled areas, calculated from thermo-luminescent dosimeter monitoring records, was 25 mrem above natural background radiation levels, also well below the 100-mrem DOE limit on dose.

Based on five-year analysis of measurement data for ambient radiation dose, the radiological footprint at BNL increased slightly due to the production of Ac-225 at the BLIP. The ambient dose decreased slightly in 2019 as readiness reviews took place in preparation for ramping up production testing for the same process.

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 2019 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 and 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 2019, environmental samples were analyzed by five contract analytical laboratories. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available. In addition, field sampling technicians performed field monitoring for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity. In 2019, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology.

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

2019 SITE ENVIRONMENTAL REPORT TEAM

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

The SER Team

(Back row, left to right) Jennifer Higbie, Timothy Green, Douglas Paquette, Jason Remien, and William Dorsch. (Front row, left to right) Larry Singh, Robert Howe, Jeffrey Williams, Amber Aponte, and Timothy Welty (not pictured: Deborah Bauer).

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(From left to right) James Milligan, Robert Metz, Richard Lagattolla, AJ Scheff, and Melissa Yost.

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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 1921 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 ecosystems.

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; and
- 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 responsibly, with the cooperation and involvement of the local, state, and international scientific communities. BNL's Environmental, Safety, Security, and Health (ESSH) Policy articulates 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 its 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 Organization for Standardization (ISO) 14001 environmental management standard. This program is 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 energy security, environment, and human health; quantum chromodynamics, using colliding sub-atomic 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 other 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. RHIC has been continuously upgraded and its productivity now exceeds its

initial design by 100 times. The most recent upgrade is the Low-Energy RHIC Electron Cooling project, which supports a new research program.

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 semi-conductor 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 in collaboration with BP Solar, Long Island Power Authority, the State of New York, and other organizations. 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. Compared to conventional electric-generating facilities on Long Island, the LISF drastically reduces local sources that contribute to climate change, such as reducing the amount of carbon dioxide by 30,950 metric tons per year and methane by 80 metric tons over 40 years.

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 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 an ever-expanding fleet of computing cores (50,000 as of 2015) and a suite of tools developed specifically for interactive visual and statistical data analysis. 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, nano-science, 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 STP, ecology field, housing facilities, and fire breaks
- 400 acres of roads, parking lots, and connecting areas
- 200 acres occupied by the LISF

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 and 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-strip-

Figure 1-1. Major Scientific Facilities at BNL.

1. Relativistic Heavy Ion Collider
2. NASA Space Radiation Laboratory
3. Alternating Gradient Synchrotron
4. Alternating Gradient Synchrotron Booster
5. Brookhaven Linac Isotope Producer and Linear Accelerator
6. Tandem to Booster
7. Interdisciplinary Science Building
8. Center for Functional Nanomaterials
9. National Synchrotron Light Source II
10. Computational Science Initiative
11. Tandem Van de Graaff and Cyclotron
12. Accelerator Test Facilities
13. Medical Isotope Research Laboratories

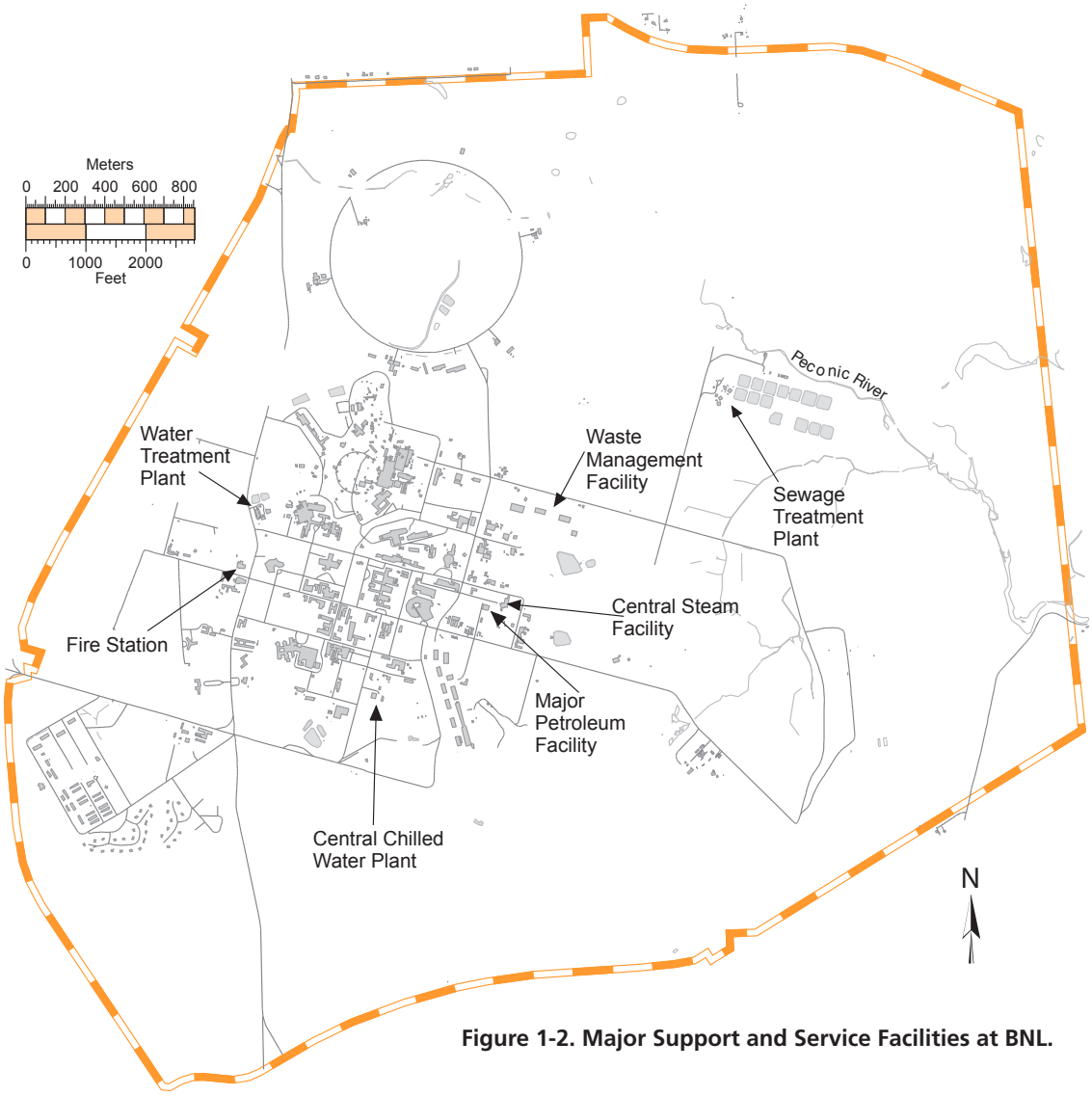


Figure 1-2. Major Support and Service Facilities at BNL.

ping 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 control bacteria.

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, 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 2,550 employees who include scientists, engineers, technicians, and support staff. In addition, the Laboratory annually hosts more than 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 more than 2,500 employees, 5,075 visiting facility users and guest researchers, and a fiscal year 2019 budget of $681 million, the Lab has a significant economic impact on New York State. In 2019, Lab employee salaries, wages, and fringe benefits accounted for approximately $384 million, or 56 percent of its total budget. Supporting local and state businesses whenever possible, the Lab spent more than $108 million in 2019 on goods and services in New York State alone, $87 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 five 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 near the Laboratory indicate that the uppermost Pleistocene deposits, composed of highly permeable glacial sands and gravel, are between 120 and 250 feet thick (Warren et al., 1968; Scorca et al., 1999). Water penetrates these deposits readily and there is little direct runoff into surface streams unless precipitation is intense. The sandy deposits store large quantities of water in the Upper Glacial aquifer. On average, 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 on site 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 2019, approximately 357 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

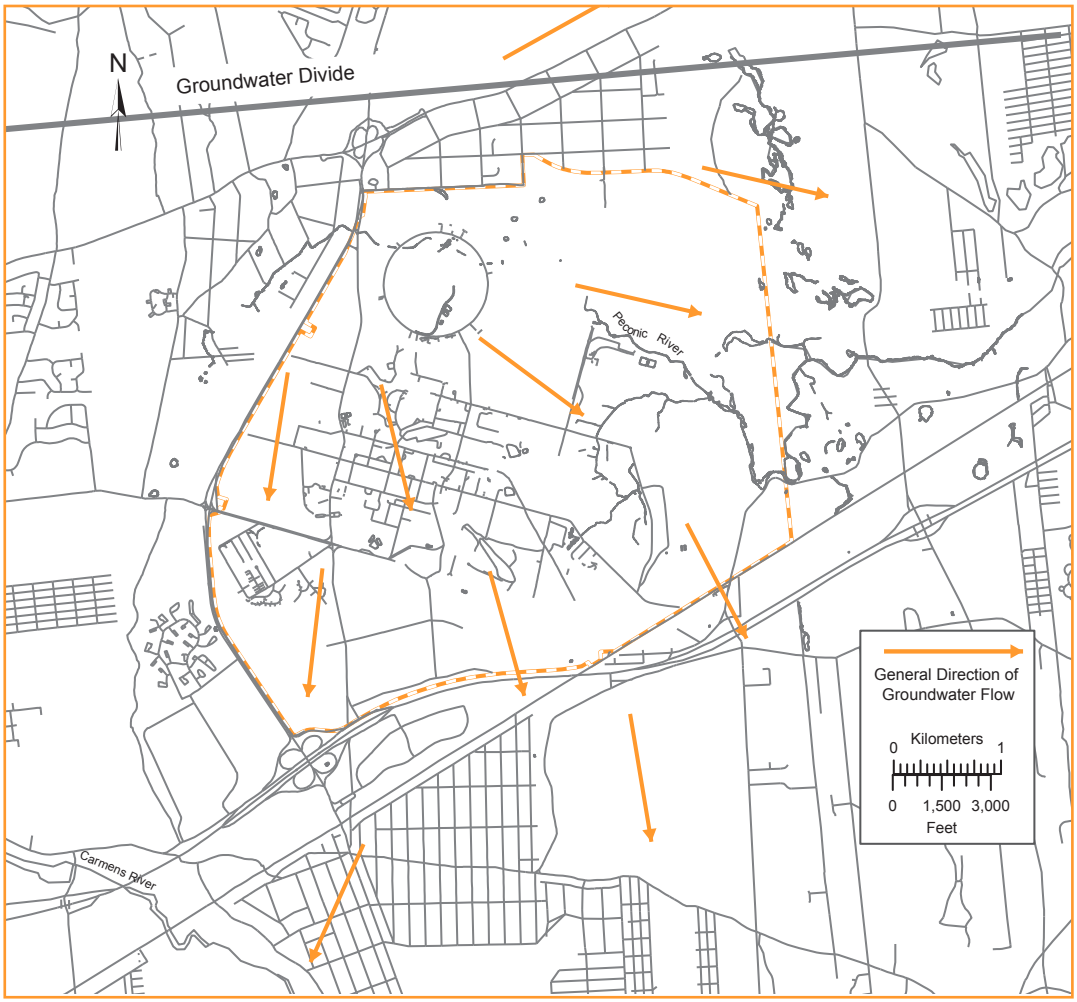


Figure 1-3. BNL Groundwater Flow Map.

for approximately 20 to 22 years as it moves from the central, developed area of the site to the Laboratory's southern boundary.

1.7 CLIMATE

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 2019 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 50.5°F. The coolest month of the year, January, had a monthly average temperature of 30.1ºF while the warmest month of the year, July, had a monthly average temperature of 75.1ºF. Figures 1-5 and 1-6 show the 2019 monthly mean temperatures and the historical annual mean temperatures, respectively. The total annual precipitation in 2019 was 49.02 inches.

Figures 1-7 and 1-8 show the 2019 monthly and the 69-year annual precipitation data. The yearly total snowfall for 2019 was 8.69 inches, well below the 33.0 inches average yearly snowfall for this area of Long Island.

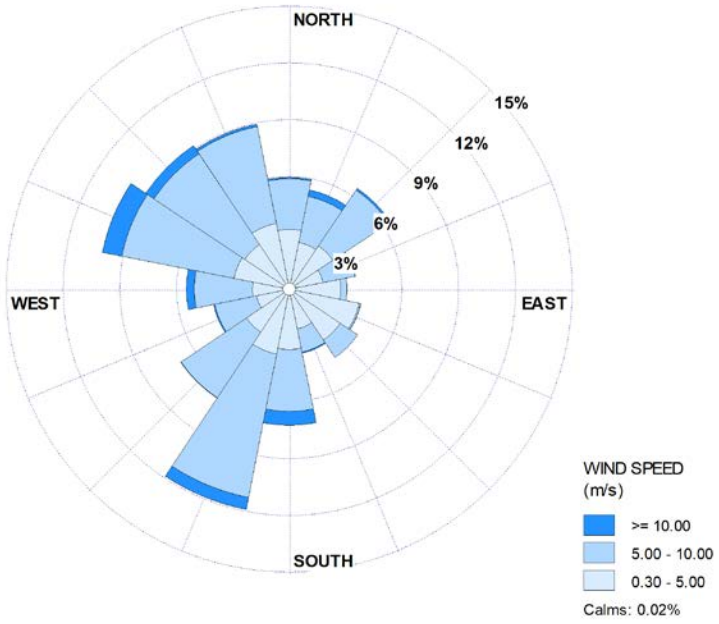
1.8 NATURAL RESOURCES

The Laboratory is located in the oak and 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.

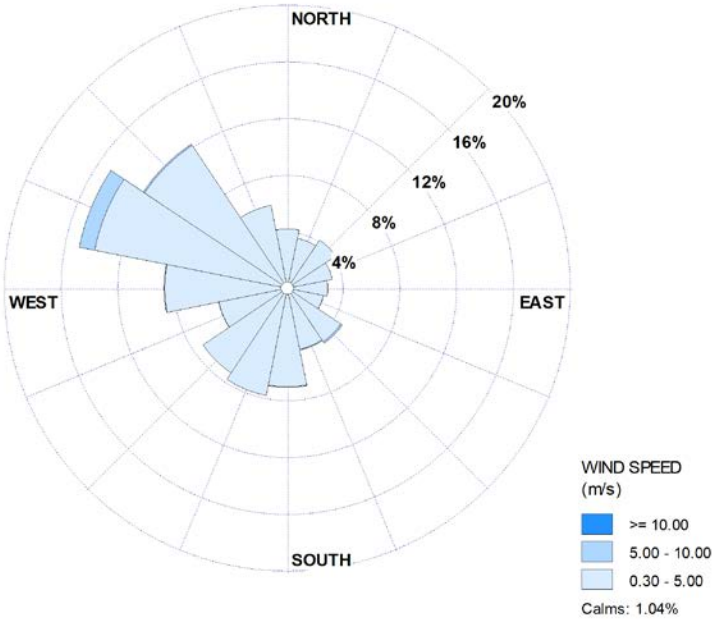
Vegetation on site is in various stages of succession, which reflects a history of disturbances to the area. For example, when Camp Upton was constructed in 1917, the site was entirely cleared of its native pines and oaks. Although portions of the site were replanted in the 1930s, portions were cleared 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



Wind Rose for Jan. 1 to Dec. 31, 2019 taken at the 85m height



Wind Rose for Jan. 1 to Dec. 31, 2019 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 seven percent of the time. The predominant wind direction in 2019 was from the northwest at the 10-m level and from the southwest at the 85-m level.

Figure 1-4. BNL Wind Rose (2019).

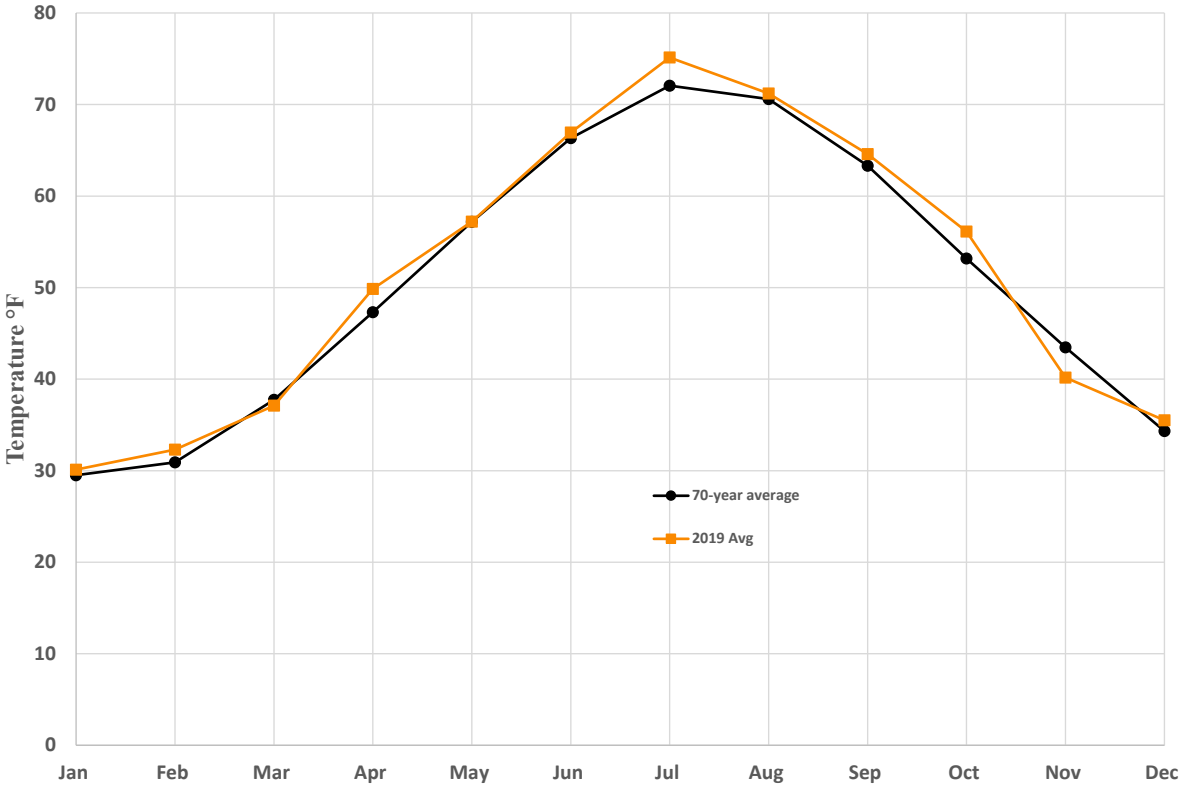


Figure 1-5. BNL 2019 Monthly Mean Temperature versus 70-Year Monthly Average.

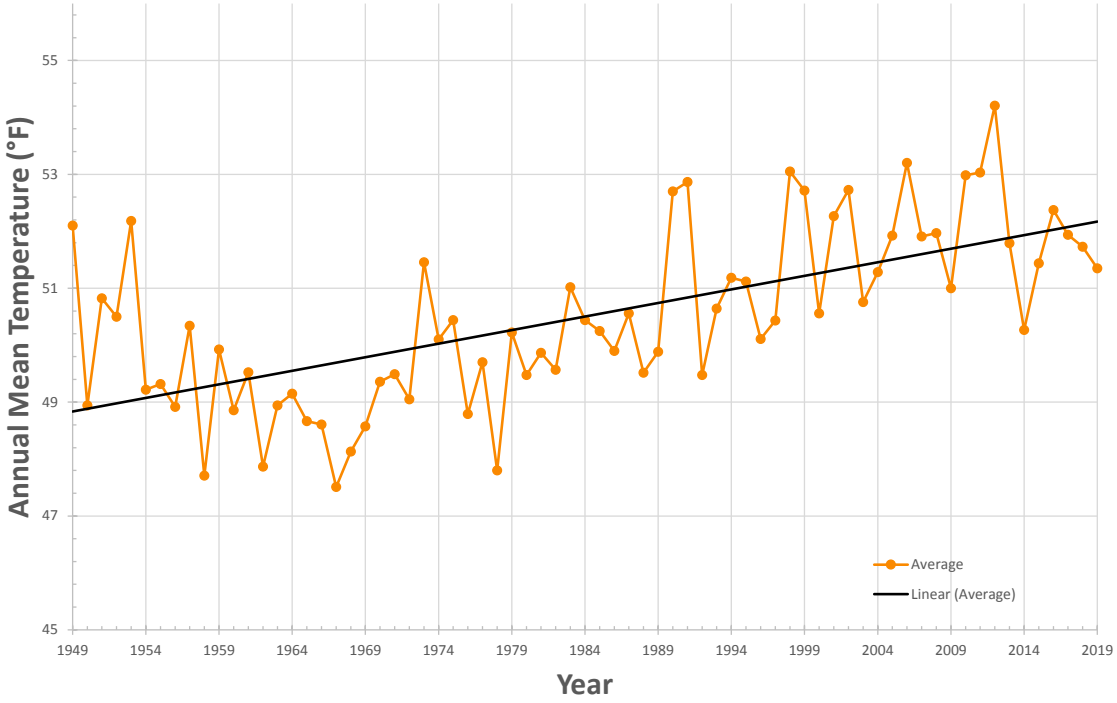


Figure 1-6. BNL 2019 Annual Mean Temperature Trend (70 Years).

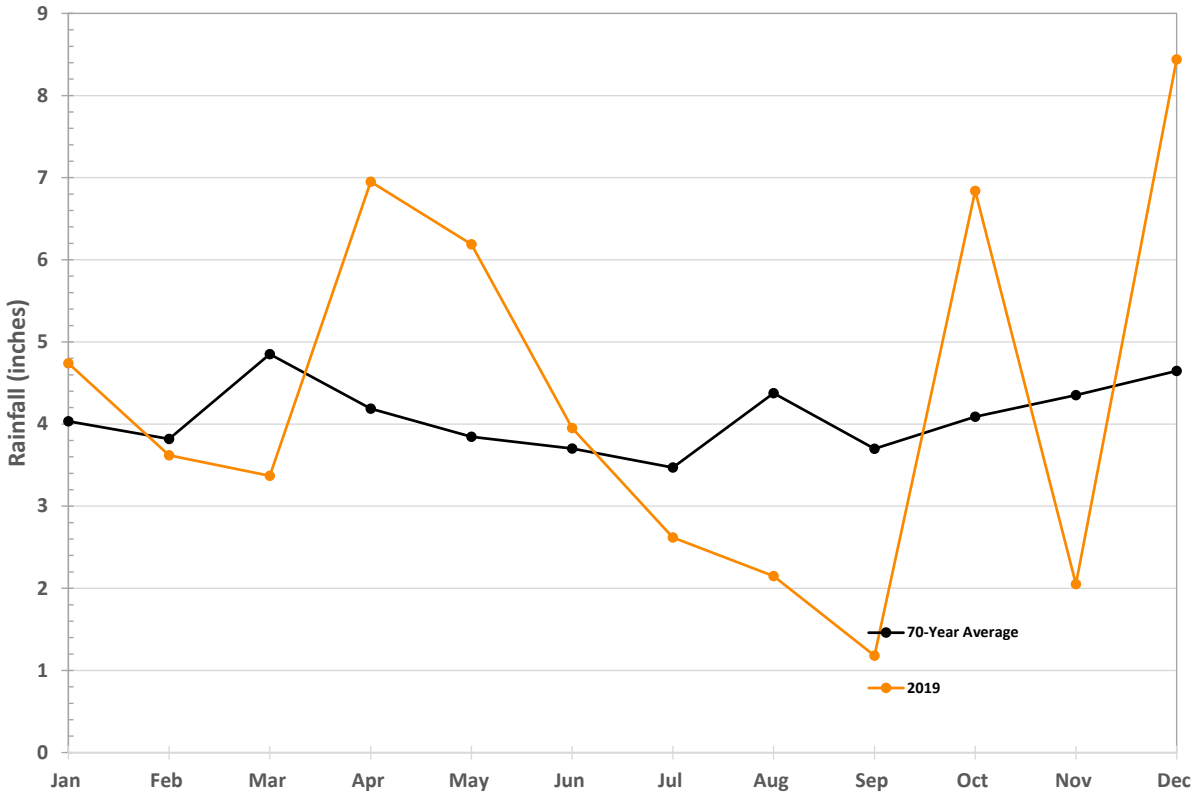


Figure 1-7. BNL 2019 Monthly Precipitation versus 70-Year Monthly Average.

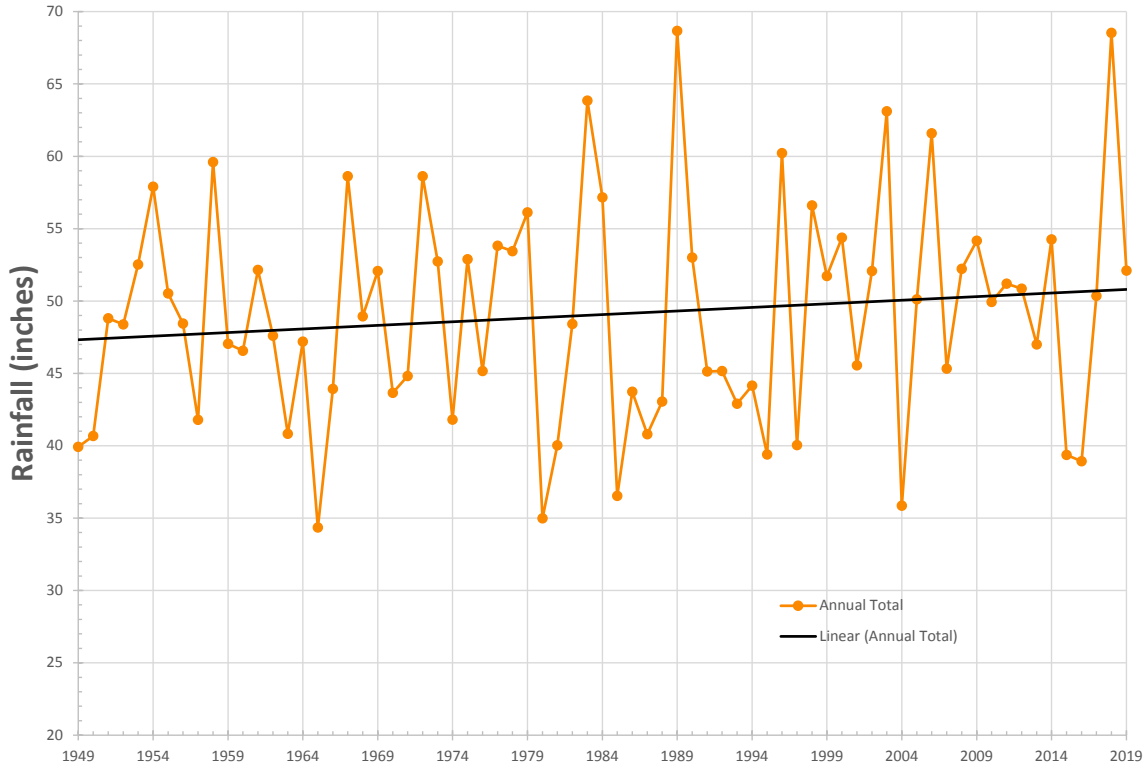


Figure 1-8. BNL 2019 Annual Precipitation Trend (70 Years).

for Ecological Research in the Northeast. Management of the Upton Reserve falls within the scope of BNL's Natural Resource Management Plan, and the area will continue to be managed for its key ecological values and as an area for ecological research (BNL 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 multiple facilities classified as eligible for listing on the National Register of Historic Places: the BGRR complex, the HFBR complex, the 1960s-era apartments, Berkner Hall, Chemistry, Physics, Computational Sciences, Instrumentation, Building 120 (original barracks), 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 by an independent third party are required to maintain an EMS registration; an audit of the entire EMS occurs every three years. In 2019, an EMS surveillance audit determined that BNL continues to conform to the revised ISO 14001:2015 Standard.

The Laboratory continues its strong support of its Pollution Prevention Program, which seeks ways to eliminate waste and toxic materials on site. In 2019, pollution prevention projects resulted in nearly $3.1 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 1.6 million pounds of waste. Also, the Pollution Prevention Program funded four new proposals, investing approximately $14,000. Anticipated annual savings from these projects are estimated at approximately $4,000, for an average payback period of 3.5 years.

The ISO 14001-registered EMS and the nationally recognized Pollution Prevention Program continue to contribute to the Laboratory's success in promoting pollution prevention. Additional support was provided in 2019 to line organizations for lab cleanouts and disposal of chemicals. As a testament to its strong environmental program, the Lab received the Green Electronics Council's Electronic Product Environmental Assessment Tool (EPEAT) Award, the DOE's GreenBuy Award, and a second GreenBuy Prime 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 AND ISO 14001

The Laboratory's Integrated Safety Management System (ISMS) integrates environmental protection, 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.

- *Analyze the hazards:* 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 and continuous improvement:* Feedback information on the adequacy of controls is gathered; opportunities for improving the definition and planning of work are identified and implemented.

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

- *Line management responsibility for safety:* Line management is directly responsible for the protection of the workers, the public, and the environment.
- *Clear roles and responsibilities:* Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at all organizational levels within the Department and its contractors.
- *Competence commensurate with responsibilities:* Personnel possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.
- *Balanced priorities:* Resources are effectively allocated to address safety, programmatic, and operational considerations. Protecting the workers, the public, and the environment is a priority whenever activities are planned and performed.
- *Identification of safety standards and requirements:* Before work is performed, the associated hazards are evaluated and an agreed-upon set of safety standards and requirements is established which, if properly implemented, will provide adequate assurance that the workers, public, and 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 processes within ISMS contributed to BNL achieving ISO 14001 registration. The ISO 14001 Standard is globally recognized and defines the structure of an organization's EMS for purposes of improving environmental performance. The process-based structure of the ISO 14001 Standard is based on the "Plan-Do-Check-Act" improvement cycle. The ISO 14001 standard requires 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 has been officially registered to the ISO 14001 Standard since 2001. The Laboratory was the first DOE Office of Science Laboratory to achieve this registration. The certification requires the Laboratory to undergo annual audits by an accredited, third-party registrar to assure that the systems are maintained. BNL's external certification organization, ERM Certification Verification Services, conducted an external surveillance audit of BNL's conformance to the ISO 14001 Standard in July 2019. The Surveillance identified no nonconformances and determined that the Laboratory was in full conformance to the Standard and, therefore, BNL will maintain its current certification.

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/esh/policy.php.* The Policy's goals and commitments focus on compliance, pollution prevention, community outreach, and continual improvement:

- *Environment:* We protect the environment, conserve resources, and prevent pollution.
- *Safety:* We maintain a safe workplace, plan our work, and perform it safely.
- *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; evaluate applicable compliance obligations; establish objectives and targets; create action plans to achieve the objectives and targets; and 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 compliance obligations, 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.

BNL follows Executive Order (EO) 13834, Efficient Federal Operations, which replaced EO 13693, Planning for Federal Sustainability in the Next Decade, in 2018. The order establishes sustainability goals for federal agencies with a focus on sustainability initiatives that save money and increase efficiency across the government with guidance, recommendations, plans, and numerical targets.

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 13693. 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, which can be found in Appendix E and identifies the DOE SSP goals, the Laboratory's performance in 2019, 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 13834;
- Significant environmental aspects;
- Risk and vulnerability (primarily, threat to the environment);
- Compliance obligations (e.g., 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 2019, BNL's environmental objectives included maintaining ISO 14001 certification and the Laboratory's performance in purchasing environmentally preferable items and reducing the overall hazard footprint by reducing chemical inventories.

2.3.4 Environmental Management Programs

The Environmental Protection Division (EPD) takes on the largest role for developing action plans for implementing institutional environmental priorities, while other organizations within BNL develop action plans as applicable to their operations. The plans detail how the organization will achieve its 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, monitoring drinking water systems for emerging contaminants, 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 restore groundwater quality by integrating pollution prevention efforts, monitoring, groundwater restoration projects, and communicating performance. The Laboratory has developed a Groundwater Protection Contingency Plan that defines an orderly process for quickly verifying the results and taking corrective actions in response to unexpected monitoring results (BNL 2018). 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 2019.

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. BNL's Waste Management Facility (WMF), operated by the EPD, is responsible for collecting, storing, transporting, and managing the disposal of these specialized wastes. This modern facility was designed for handling hazardous, industrial, radioactive, and mixed waste, and is comprised of two staging areas: a facility for hazardous, 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. Waste can either be generated from

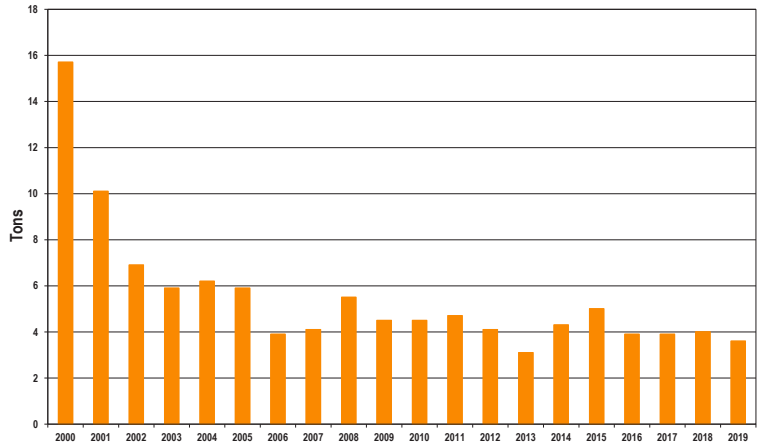

Figure 2-1a. Hazardous Waste Generation from Routine Operations, 2000 – 2019.

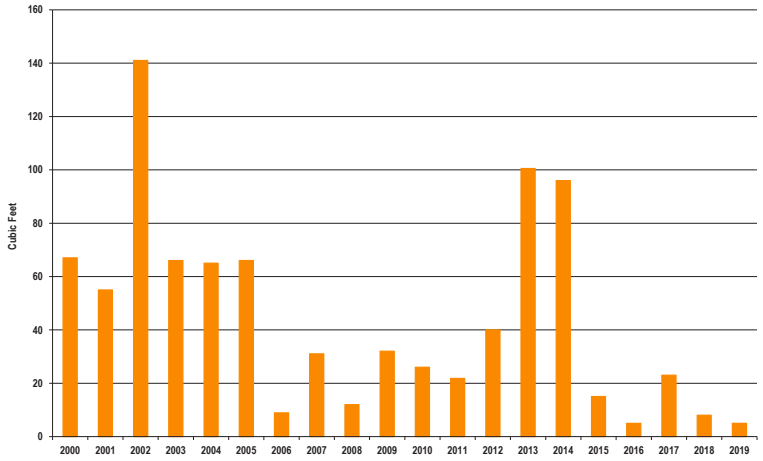

Figure 2-1b. Mixed Waste Generation from Routine Operations, 2000 – 2019.

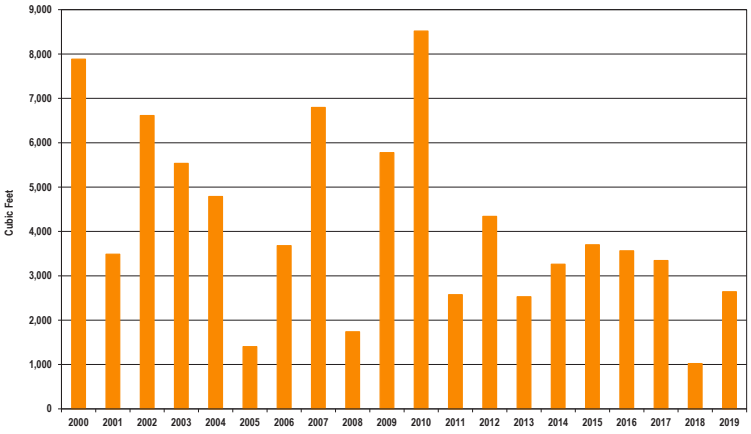

Figure 2-1c. Radioactive Waste Generation from Routine Operations, 2000 – 2019.

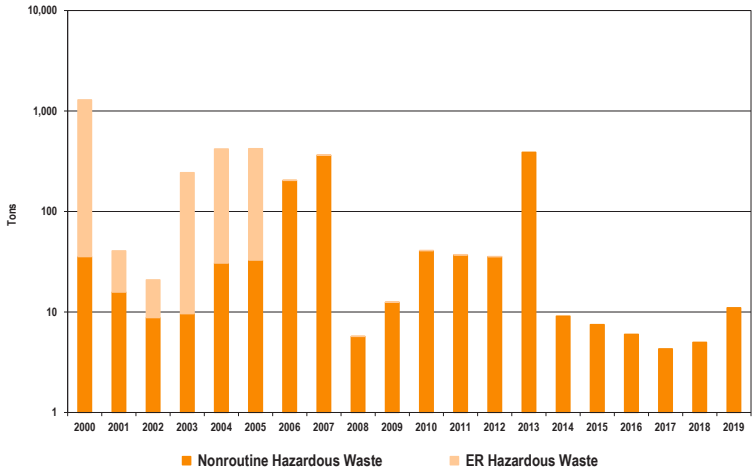

Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 2000 – 2019.

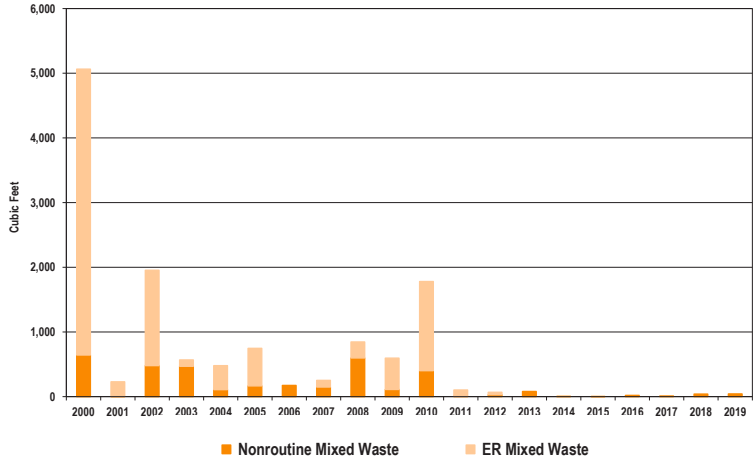

Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 2000 – 2019.

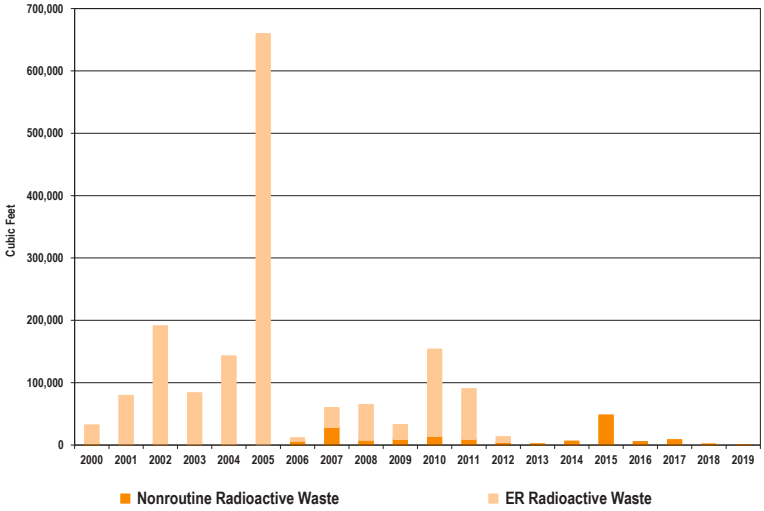

Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 2000 – 2019.

routine operations, defined as ongoing industrial and experimental operations, or from non-routine, defined by that generated by remediation projects, facility decommissioning activities, or one-time events (e.g., lab cleanouts). In 2019, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 3.6 tons
- Mixed waste: 5 ft^3
- Radioactive waste: 2,642 ft^3

Hazardous waste from routine operations in 2019 stayed consistent with 2018 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 decreased from 2018 rates, as shown in Figure 2-1b. The change is due to fluctuations in operations at BNL's accelerator facilities. Fluctuations in radioactive waste quantity shown in Figure 2-1c for routine operations are also indicative of routine fluctuations of the generating process.

BNL's inventory of legacy waste has been significantly reduced over the years. Figures 2-1d through 2-1f show waste generated from non-routine operations. Waste generation from these activities can vary significantly from year to year as various decommissioning and remedial actions are conducted. Non-routine waste generation in 2019 mainly consisted of hazardous waste associated with the demolition of modular buildings attached to Buildings 526 and 902. Site

improvement activities are causing an uptick in hazardous waste generation rates.

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, 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, though 2018 and 2019 show an uptick in hazardous waste generation resulting from building demolition debris. However, pollution prevention planning remains well integrated into the Laboratory's work planning process. The positive trends are also driven by the EMS emphasis on preventing pollution and establishing objectives and targets to reduce environmental impacts. Table 2-1 describes the P2 projects implemented through 2019, 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 2019, these efforts resulted in nearly $3.1 million in cost avoidance or savings and approximately 1.6 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 2019, BNL collected approximately 513 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 2-2 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 2019 annual recycling rate was 55 percent. The 14 percentage point reduction from last year's rate of 69 percent was due to changes in how construction and demolition debris is managed as well as storing of certain recycling streams for processing during 2020 (e.g., concrete crushing and garnet recycling) and process fluctuations (e.g., oil, Blasocut).

In 2019, BNL's sustainability program was honored by receiving the Green Electronics Council's Electronic Product Environmental Assessment Tool (EPEAT) Award for purchasing EPEAT-registered electronic products which meet strict environmental criteria that address the full product lifecycle, from energy conservation to toxic materials to product longevity and end-of-life management. BNL also received the DOE's GreenBuy Award and GreenBuy Prime Award. The GreenBuy Award recognizes DOE sites for purchases of materials that are energy and water efficient and made from biobased or recycled content material. The GreenBuy Prime Award identifies BNL as a site that has achieved GreenBuy Gold status three times.

2.3.4.5 Water Conservation

BNL's water conservation program has achieved dramatic reductions in water use since

Table 2-1. BNL Pollution Prevention, Waste Reduction, and Recycling Programs, 2019.

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2019	Waste Type	Potential Costs for Treatment and Disposal	Revenue/(Cost) of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Office Paper	Recycled	119,240	Regular Trash	7,035	(6,500)	535	Cost avoidance was based on $118/ton for disposal as trash. Cost to recycle was $6,500 ($13,000 flat fee for paper/cardboard combined).
Cardboard	Recycled	141,460	Regular Trash	8,346	(6,500)	1,846	Cost avoidance was based on $118/ton for disposal as trash. Cost to recycle was $6,500 ($13,000 flat fee for paper/cardboard combined).
Bottles/Cans	Recycled	21,260	Regular Trash	1,254	0	1,254	Cost avoidance was based on $118/ton for disposal as trash. No charge, no revenue.
Printer Toner Cartridges	Recycled	1,952	Regular Trash	115	0	115	Printer toner cartridges were picked up by vendor for recycling, saving the cost to dispose as regular municipal solid waste.
Metals	Recycled	1,026,860	Regular Trash	60,585	34,562	95,147	Cost avoidance was based on $118/ton for disposal as trash, plus $34,462 revenue (various pricing).
Electronic Waste	Recycled	187,742	Electronic Waste	187,740	82,606	270,346	Cost avoidance was based on $118/ton for disposal as trash, plus $82,606 revenue based on $0.44/lb.
Electronic Reuse	Reuse	35,060	Electronic Waste	2,690,700	(20,232)	2,670,468	The Laboratory tracked electronic equipment and took a reuse credit for transfer of equipment to another user. Savings were based on the cost to purchase a new version of the item minus the scrap value of that item.
Building 452 Oil Skimmer	Source Reduction	0	Industrial Waste	0	0	0	Reduced oily water waste stream (non-halogenated oil) from air compressors by skimming off oil and leaving water phase. Water may be discharged to sanitary system. In 2019, no oil was sent for reprocessing.
Used Motor Oil	Energy Recovery	7,920	Industrial Waste	3,049	(550)	2,499	Used motor oil from Building 452 and the motor pool was given to Strebel's Laundry Service to fire their boilers. In 2019, they collected 1,100 gallons (7,920 lbs) of oil at $0.50 /ga, which avoided the costs for disposal and 20 shipping drums ($120/drum).

(continued on next page)

Table 2-1. BNL Pollution Prevention, Waste Reduction, and Recycling Programs, 2019 *(concluded).*

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2019	Waste Type	Potential Costs for Treatment and Disposal	Revenue/(Cost) of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Blasocut Machining Coolant	Recycled/ Reused	10,272	Industrial Waste	36,227	0	36,227	Central Shops Division operated a recycling system that reclaimed Blasocut machining coolant and supplied it Laboratory-wide. In 2019, 1,292 gallons (10,272 lb) of Blasocut lubricant were recycled. Recycling involved aeration, centrifuge, and filtration. This avoided cost of disposal as industrial waste as well as the cost of buying 24 drums of concentrate ($1,357/drum) and empty drums for shipping ($120/drum).
Building Demolition Recycling	Recycling	14,000	C&D Debris	665	192	857	Materials collected during 2019 were from the demolition of modular buildings attached to 526 and 902 and included 47 tons of construction and demolition (C&D) debris (sheetrock and wood), two tons of metal sent for recycling, and 2.6 Y (5 tons) of concrete retained for crushing and reuse onsite during 2019. C&D material was landfilled at a cost of $4,465 ($95/ton). The steel was recycled, generating $192 revenue. If the concrete and steel were landfilled, the cost would have been $665.
Construction Debris - Concrete	Recycled	0	C&D Debris	0	0	0	Concrete has been collected from demolition activities, but no concrete was crushed during 2019.
Tires	Recycled	22,080	Regular Trash	1,303	0	1,303	Truck tires were sent for recycling from the motor pool. Cost savings were based on cost to dispose of as trash.
Lead Acid Batteries	Recycled	25,640	Universal Waste	6,923	0	6,923	Avoided universal waste disposal costs for lead and sulfuric acid batteries.
Fluorescent Bulbs	Recycled	4,680	Universal Waste	6,318	(1,682)	4,636	Fluorescent bulbs were collected and sent to a recycling facility under the Universal Waste exemption rule. Savings were in comparison to cost to dispose of them as hazardous waste versus the cost to have them recycled.
Garnet	Recycled	0	Industrial Waste	0	0	0	No garnet from machine shop activities was sent for recycling during 2019.
	TOTALS	**1,618,166**		**3,010,260**	**81,896**	**3,092,156**	

Table 2-2. BNL Recycled Program Summary, 2007-2019.

Recycled Waste	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Mixed paper	177	151	127	174	186	142	160	150	91	89	84	65	60
Cardboard	121	147	152	141	126	100	97	78	12.4	73	74	74	71
Bottles/Cans	24.4	19.6	23.7	24	22.5	18	16.5	17.1	22.1	11	7.9	10.2	10.6
Tires	19.9	34.5	15.5	10.1	9.2	10	7.1	7.6	5.4	6.4	5.2	8.8	11
Construction Debris	287	302	312	416	256	380	304	351	372	266	0	0	0
Used motor oil	8.1	6.0	7.2	6.8	5.7	6.3	6.2	8.0	5.3	10.9	12.5	9.3	4.0
Metals	382	460	91	131	84	278	174	256	737	426	621	559	513
Automotive & UPS batteries	2.5	2.7	4	1.6	2.1	2	2.1	1.4	1.9	1.4	0.6	15	13
Printer/Toner cartridges	0	1.5	1.7	2.1	2.1	2.1	5.6	1.1	1.0	n/a	1.2	1.1	1.0
Fluorescent bulbs	12.7	18.4	6.3	4.4	10.1	7.9	6.8	9.9	8.0	4.8	2.5	2.3	2.3
Blasocut coolant	9.7	13.4	15.2	19.3	22.6	22.4	22.6	19.4	10.2	9.4	7.8	11.7	5.1
Electronic reuse	0	16.3	11.4	12	11.6	3.2	1.4	10.5	25	17	19	21.7	17.3
Scrap electronics	40.5	48.9	17	16.7	19.9	30.9	23	29.3	42	24	23.1	53.3	93.9
Garnet	---	---	---	---	---	---	---	---	---	---	20.5	21	0
Recycling Rate (%)	64	68	59	63	59	63	76	58	77	74	69	69	55
Demolition Projects													
Metals	0	0	0	0	0	60	90	0	0	0	0	51.5	2
Concrete	6,175	0	0	4,050	0	4,050	3,500	4,000	0	4,200	3,500	0	5
Construction and demolition	0	0	0	0	0	0	0	0	0	0	0	664	47

Notes: All units are tons, except where noted.

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 85 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 20-year trend of water consumption. Total water consumption in 2019 was down slightly from 2018. The water intensity (gallon/gross 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

The Laboratory's Energy Management Group continues 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

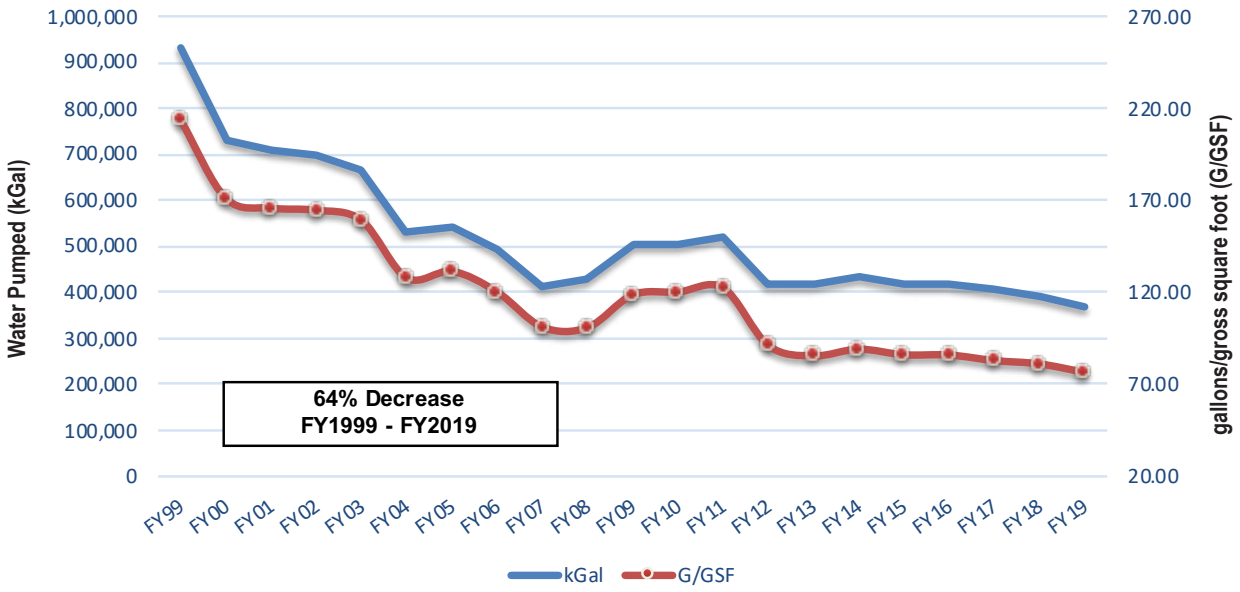

Figure 2-2. Annual Potable Water Use, 1999-2019.

management efforts and assisting DOE in meeting the energy and sustainability goals in EO 13834, DOE Order 436.1, and the U.S. Secretary of Energy's initiatives. The Laboratory's SSP addresses all aspects of the DOE energy, water, transportation, and other sustainability goals.

BNL has more than 4.8 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 2019, BNL used 269 million kilowatt hours (kWh) of electricity, 100,698 gallons of fuel oil, 13,411 gallons of propane, and 599 million cubic feet 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 2019, natural gas prices were lower than fuel oil prices for the entire year. As a result, natural gas was used to meet over 99 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 when available. Through these programs, the Laboratory agrees 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. This scheduling reduces the electric demand by approximately 25 megawatts (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 its users' needs. BNL also maintains a contract with the New York Power Authority that resulted in an overall cost avoidance of $27.7 million for 2019.

In 2019, BNL's energy supply included 119 million kWh of clean, renewable hydropower energy, 1.0 million kWh of on-site generated solar photovoltaic (PV), and 20 million kWh of purchased renewable energy certificates (REC). The Laboratory will continue to seek alternative

Northeast Solar Energy Research Center (NSERC)

View of the Northeast Solar Energy Research Center (NSERC)

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 Long Island Solar Farm (LISF) on BNL property. The array is currently the largest solar 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 2019 was 50.6 million kWh and resulted in an avoidance of approximately 33,000 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 50.9 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 2015, 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 2019, the NSERC generated 1,018,429 kWh of electricity for use on site. To reduce energy use and costs at non-research facilities, several activities were continued or undertaken by the BNL Energy Management Group in 2019:

- NYPA Power Contract: Eighth full year of a 10-year contract that includes 15 MW of renewable (nearly zero greenhouse gas [GHG]) hydropower. This contract saved $27.7 million in 2019.
- 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 occurred on several initiatives included in BNL's annual SSP in 2019, such as the following: New electric, chilled water, and steam meter installations; funding for energy conservation initiatives; 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 the National Grid which 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 mm British thermal units (Btu)/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 five years of operation.

- UESC II: BNL completed an Investment Grade Audit (IGA) for a potential second UESC effort. The IGA identified several projects that will reduce BNL's deferred maintenance backlog while reducing energy intensity and GHG's. A contract for the second UESC project is expected to be awarded in 2020.
- 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 has achieved compliance in the EPA Portfolio Manager program. BNL is currently on target to meet or exceed the HPSB goal.
- Renewable Energy: Project support continues for the LISF and NSERC facilities and annual purchases of REC's to meet targeted goals.
- The Central Chilled Water Facility (CCWF): The CCWF 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 $2.1 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 and/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 2019 was approximately 27 percent less than in 2003, producing annual savings of $2.4 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 improve federal building design to reduce energy consumption per square foot (Energy Intensity). Current goals included with EO 13834 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 2019 was 27 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. In 2019, energy intensity was 2.7 percent less than the base year of 2015.

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 for the Lab 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 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),

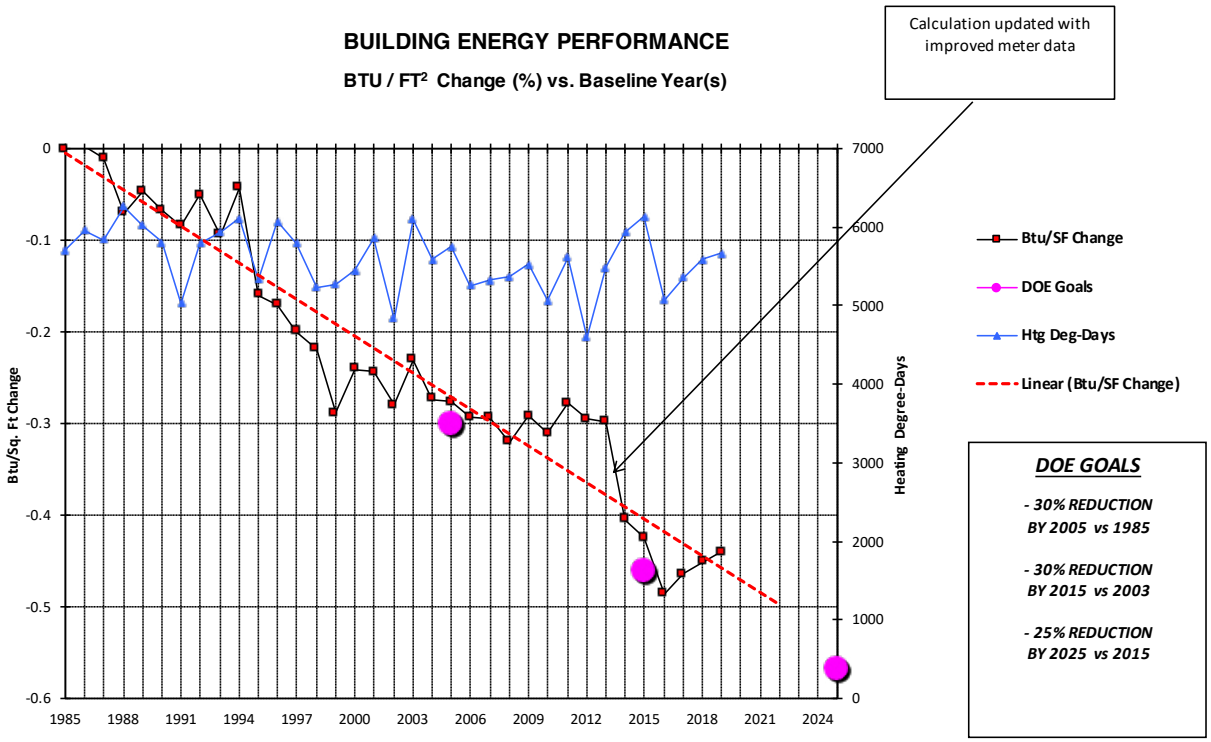

Figure 2-3. BNL Building Energy Performance for 2019 (Btu/SF Change Percent vs. Baseline Years).

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 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 corrective action selected.

In 2019, BNL's eight active groundwater treatment systems removed approximately 61 pounds of volatile organic compounds (VOCs) and 0.8 millicurie (mCi) of strontium-90 (Sr-90) and returned 0.8 billion gallons of treated water to the sole source aquifer. A modification to the Western South Boundary Groundwater Treatment System, which included the installation of four new extraction wells, was completed. The system became operational in March 2019. The North Street East Groundwater Treatment System was also modified to include the installation

of two additional extraction wells to remediate an ethylene dibromide (EDB) plume. The system will become operational in mid-2020. Petitions for Closure of the HFBR Tritium Pump and Recharge System, the Freon-11 Treatment System, the North Street Treatment, and the OU I South Boundary Treatment System were approved by the regulatory agencies. Due to continued observance of low VOC concentrations, the two remaining extraction wells for the Industrial Park Treatment System were shut down and placed in stand-by mode.

In early 2019, groundwater samples collected from 33 permanent wells and 11 temporary wells along the southern boundary were analyzed for 1,4-dioxane and per- and

Table 2-3. Summary of BNL 2019 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 seven groundwater treatment systems that remove volatile organic compounds (VOCs) and one system that removes strontium-90 (Sr-90). ▪ Removed 61 pounds of VOCs and 0.8 mCi of Sr-90 during the treatment of 0.8 billion gallons of groundwater. Since the first groundwater treatment system started operating in December 1996, approximately 7,650 pounds of VOCs and 34 mCi of Sr-90 have been removed, while treating approximately 28 billion gallons of groundwater. ▪ Collected and analyzed approximately 1,110 sets of groundwater samples from 534 monitoring wells. ▪ Installed 32 temporary wells and collected multiple samples from each location.
	Emerging Contaminants Monitoring	▪ Continued collection of groundwater samples for 1,4-dioxane and PFAS analyses.
Peconic River	OU V	▪ Performed post-cleanup monitoring of Peconic River vegetation.
Reactors	Brookhaven Graphite Research Reactor (BGRR)	▪ Continued long-term surveillance and maintenance, including repair to the window gaskets, replacing the broken glass on the east bay window, repair trim around the entry door to the below ground ducts, removal of vegetation, and sealing of cracks in the engineered cap.
	High Flux Beam Reactor (HFBR)	▪ Continued long-term surveillance and maintenance, including repair to the east exterior periphery wall to prevent water intrusion into the building, repairs to the roof over the machine shop, and repairs to the cracks and holes above the generator room door to prevent water, bird, or wildlife intrusion.
	Stack (Building 705)	▪ Continued long-term surveillance and maintenance, including pump-out of the stack drain tank and collection and disposal of stack paint chips on the grounds. ▪ An Updated HFBR Stack Demolition Remedial Design/Remedial Action Work Plan was submitted to regulators in November 2019. ▪ The U.S. Army Corps of Engineers was awarded a contract for demolition of the stack in January 2020.
	Brookhaven Medical Research Reactor (BMRR)	▪ Continued surveillance and maintenance activities.
Former Buildings 810/811	Former Radiological Liquid Processing Facility	▪ Maintained institutional controls of the area.
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.

polyfluoroalkyl substances (PFAS). The results for these samples, along with the monitoring results for samples collected from 2017 through 2018, were summarized in the 2018 Groundwater Status Report (BNL 2019). Additional groundwater characterization for these emerging contaminants will be conducted in 2020.

The groundwater systems operated in accordance with the Operations and Maintenance manuals, while the Peconic vegetation and surface soil cleanup areas were monitored via the Soil and Peconic River Surveillance and Maintenance Plan (BNL 2013b). Institutional controls were 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 was submitted to the regulators. Table 2-3 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. In 2019, BNL continued the surveillance and maintenance of the Brookhaven Graphite Research Reactor (BGRR) and the HFBR. In accordance with the ROD, planning was conducted for the demolition of the HFBR stack, with the goal of completing the demolition project by the end of fiscal year 2020.

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. Environmental Compliance Representatives (ECRs) are deployed to organizations throughout the Laboratory as 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 Stakeholder and Community Relations (SCR) 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. SCR 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. SCR 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, SCR's Stakeholder Relations Office, in coordination with the EPD, participates in or conducts on- and off-site meetings which include discussions, presentations, roundtables, and workshops. Stakeholder Relations and EPD 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 SCR'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, 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 26 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 meeting six months a year. 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. 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 2,500 visitors in 2019.
  - *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 2019, more than 4,700 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 2019, science-interested community members and BNL and Stony Brook University researchers discussed topics such as Building Blocks of Matter, Big Bang Physics and Sculpture, Sound and Simulation.

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, the New York City Maker Faire, 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, such as *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 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 2019, 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:* The CAC received updates on BNL's natural resources, such as the 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. Cultural resource updates included status of current historical determinations for buildings over 50 years old.
- *Environmental Updates:* In 2019, the CAC also received environmental updates such as the general status of the groundwater contaminant plumes and remediation systems; completion of modifications to the Western South Boundary (WSB) treatment system; planned modifications to the North Street East treatment system needed to remediate EDB; cleanup of contaminated soil in the area of former Building 811; plans for the demolition of the HFBR Stack; continued characterization of PFAS and 1,4 Dioxane in groundwater and proposed NYS drinking water standards for these contaminants; and the cooperative agreement with the SCDHS to sample private wells south of the Laboratory for PFAS and 1,4-dioxane.

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 2-4, in 2019, there were 8,865 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.

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 (STP). 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. 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.

Samples are analyzed for organic, inorganic, and radiological contaminants. Additionally, data collected using thermoluminescent dosimeters (i.e., devices that 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 media-specific monitoring data and analysis, and Chapter 9 provides supporting information for understanding and validating the data shown in this report.

2.4.4 EMS Assessments

To periodically verify that the Laboratory's EMS is operating as intended, 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, and facilitates the identification and communication of best management practices used in one part of the Laboratory that could improve performance in other parts of the Lab.

Compliance assessments are also performed by BNL staff members who do not have line

Table 2-4. Summary of BNL Sampling Program Sorted by Media, 2019.

Environmental Media	No. of Sampling Events(a)	Purpose
Groundwater	3,204	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	82	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	55 ES 221C	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)	130	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.
Air – Tritium	180	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	384 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 as part of their program to assess radiological air concentrations statewide. See Chapter 4 for further detail.

(continued on next page)

Table 2-4. Summary of BNL Sampling Program Sorted by Media, 2019 *(concluded).*

Environmental Media	No. of Sampling Events(a)	Purpose
Fauna	255 Deer culling	Fish and deer are monitored to assess impacts on wildlife associated with past or current BNL operations. See Chapter 6 for further detail.
Flora	12	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	33	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	664	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	1,793	Samples are collected from groundwater treatment systems and as long-term monitoring after remediation completion under the Comprehensive Environmental Response, Compensation, and Liability Act program. The Laboratory has nine operating groundwater treatment systems. See discussion in Chapter 7.
State Pollutant Discharge Elimination System (SPDES)	312	Samples are collected to ensure that the Laboratory complies with the requirements of the New York State Department of Environmental Conservation-issued SPDES permit. Samples are collected at the STP, recharge basins, and four process discharge sub-outfalls to the STP.
Flow Charts	558	Flowcharts are exchanged weekly as part of BNL's SPDES permit requirements to report discharge flow at the recharge basin outfalls.
Floating Petroleum Checks	98	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	511	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)	315	To ensure that the concentrations of contaminants reported in the Site Environmental Report are accurate, additional samples are collected. These samples detect if contaminants are introduced during sampling, transportation, or analysis of the samples. QA/QC samples are also sent to the contract analytical laboratories to ensure their processes give valid, reproducible results.
Total number of sampling events	**8,865**	The total number of sampling events includes all samples identified in the Environmental Monitoring Plan (BNL 2019), 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

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 events and 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 ongoing process evaluations, the work planning and control system, and the management systems for groundwater protection, environmental restoration, and information management. Compliance assurance programs have improved the Laboratory's compliance status and pollution prevention projects have reduced costs, minimized waste generation, and reused and recycled significant quantities of materials. BNL is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and progress.

To maintain stakeholder trust, the Laboratory will continue to deliver on commitments and demonstrate improvements in environmental performance. The Site Environmental Report is an important communication mechanism, as it summarizes BNL's environmental programs and performance each year.

Additional information about the Laboratory's environmental programs is available on BNL's website at http://*www.bnl.gov.* Due to external recognition of the Laboratory's knowledge and unique experience implementing the EMS program, BNL is often asked to share its experiences, lessons learned, and successes. The Laboratory's environmental programs and projects have been recognized with international, national, and regional awards, and audits have consistently observed a high level of management involvement, commitment, and support for environmental protection and the EMS.

For over 70 years, the unique, leading-edge research facilities and scientific staff at BNL have made many innovative scientific contributions possible. Today, BNL continues its research mission while focusing on cleaning up and protecting the environment.

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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 2019, 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 2019. There were five recorded excess opacity measurements. Three were due to the start-up and shutdown of Boiler 6 in preparation for periodic emission tests conducted in January, and two Boiler 6 excess readings in December were from unknown causes. All 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 2019, 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.

With the exception of a violation for missing the collection of an iron sample at the Water Treatment Plant in June, BNL's drinking water and the supply and distribution system were in compliance with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting in 2019. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System (SPDES) permit requirements. An investigation into the cause(s) of Tolyltriazole (TTA) exceedances at the Sewage Treatment Plant and associated corrective actions continued throughout 2019. BNL staff continue to work closely with the Department of Energy (DOE) and NYSDEC on this issue to identify possible solutions. 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 implement release prevention measures and minimize impacts of spills of materials continued in 2019. There were 23 spills in 2019 and ten of those spills met regulatory agency reporting criteria.

BNL participated in 11 environmental inspections or reviews by external regulatory agencies in 2019. These inspections included Sewage Treatment Plant operations; hazardous waste management facilities; regulated emission sources; and the potable water system. Immediate corrective actions were taken to address all compliance 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. A list of all applicable environmental regulations is contained in Appendix D.

3.2 ENVIRONMENTAL PERMITS

3.2.1 Existing Permits

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

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370	The Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) of inactive hazardous waste disposal sites. Regulators include EPA, DOE, and the New York State Department of Environmental Conservation (NYSDEC).	Since 1992, BNL has been 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 the long-term surveillance and maintenance mode for the groundwater treatment systems, former soil/sediment cleanup areas, and the reactors, and 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 are subject to NHPA include the HFBR, the Brookhaven Graphite Research Reactor (BGRR) complex (bldgs. 701, 703, 705, and 801), 1960's era Apartments (bldgs. 364, 365, 366, and 367), Bldg. 120, Berkner Hall (bldg.488), Chemistry (Bldg. 555), Physics (Bldg. 510), Computational Sciences (Bldg. 515), Instrumentation (Bldg. 535), and the World War I training trenches found throughout the site.	There are now multiple buildings and features at BNL that have been determined to be National Register Eligible (see list to the left). 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. BNL has a Cultural Resource Management Plan to ensure compliance with cultural resource regulations. Buildings that are 50 years old or older are reviewed under Section 106 of NHPA when proposed projects may significantly alter the structure or for building demolition. See Chapter 6 for detailed information on Cultural Resources.	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 non-radiological 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, with the exception of radiological air emissions. Sources of such emissions are registered with the EPA.	3.5
EPA: 40 CFR 109–140 40 CFR 230, 231 40 CFR 401, 403 NYSDEC: 6 NYCRR 700–703 6 NYCRR 750	The Clean Water Act (CWA) and NY State Environmental Conservation Laws seek to improve surface water quality by establishing standards and a system of permits. Wastewater discharges are regulated by NYSDEC permits through the State Pollutant Discharge Elimination System (SPDES).	At BNL, permitted discharges include treated sanitary waste, and cooling tower and stormwater discharges. With the exception of five excursions at BNL's sewage treatment plant, these discharges met the SPDES permit limits in 2019.	3.6

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 141–149 NYSDOH: 10 NYCRR 5	The Safe Drinking Water Act (SDWA) and New York State Department of Health (NYSDOH) standards for public water supplies establish minimum drinking water standards and monitoring requirements. SDWA requirements are enforced by the Suffolk County Department of Health Services (SCDHS).	BNL maintains a sitewide public water supply. With the exception of a violation for missing the collection of an iron sample at the Water Treatment Plant in June, BNL's drinking water and the supply and distribution system were in compliance with all applicable county, state, and federal regulations regarding drinking-water quality, monitoring, operations, and reporting in 2019. Corrective actions for all identified operation and maintenance deficiencies identified during the annual SCDHS sanitary survey 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 2019.	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. As part of the permit requirements the restoration process requires evaluation of vegetation for at least two growing seasons after completion. The clean-up area was evaluated, and most of the area is considered 'open water' which does not have a vegetative cover standard; therefore, the area is meeting permit requirements. After evaluation of the area in 2019, a request to close the permit was sent to NYSDEC and included a request for a verification visit during the next growing season in 2020.	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. Bald Eagles have been seen routinely at various locations on the BNL site and a pair of eagles were observed investigating the use of an osprey nest. NYSDEC was consulted for requirements should the eagles establish a nest. See Chapter 6 for more on migratory birds and bald eagles.	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 Health and Safety Administration (OSHA) reports. The Laboratory developed the ORPS Subject Area for staff and management who perform specific duties related to discovery, response, notification, investigation, and reporting of occurrences to BNL and DOE management. The ORPS Subject Area is supported by: Occurrence Reporting Program Description, Critiques Subject Area, Occurrence Categorizer's Procedure, and the ORPS Office Procedure.	All chapters
DOE: Order 414.1D 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 though both of those orders were replaced by EO 13693 "Planning for Federal Sustainability in the Next Decade". However, O 436.1 is still 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 14001:2015 revised standard in 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 how 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[3]	None	NA	NA
EPA - NESHAPs	705	Tritium Evaporator	BNL-288-01[3]	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
EPA - NESHAPs	REF	Radiation Effects/Neutral Beam	BNL-789-01	None	NA	NA
EPA - NESHAPs	RTF	Radiation Therapy Facility	BNL-489-01[3]	None	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	Western 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 - Chemical Holes	1-52-009	25-Feb-23	NA	NA
NYSDEC - SPDES Equivalency	TR 829	Carbon Tetrachloride System	None	Closed 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 2013	NA	NA
NYSDEC - SPDES Equivalency	OS-5	North St./North St. East Treatment System	1-52-009	26-Mar-25	NA	NA
NYSDEC - SPDES Equivalency	OS-6	Ethylene Di-Bromide Treatment System	1-52-009	26-Mar-25	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System - BGRR/WCF	1-52-009	26-Mar-25	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	26-Mar-25	NA	NA
NYSDEC - Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-21	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 Tanks (2)	1-4722-00032/00115	30-Jan-25	U-METAL	42307-08
NYSDEC - Air Quality	423	Gasoline & E85 Storage and Fuel Pumps	1-4722-00032/00115	30-Jan-25	U-FUELS	42309-10
NYSDEC - Air Quality	423	Motor Vehicle A/C Servicing	1-4722-00032/00115	30-Jan-25	U-MVACS	MVAC2
NYSDEC - Air Quality	423	Motor Vehicle A/C Servicing	1-4722-00032/00115	30-Jan-25	U-MVACS	MVAC5
NYSDEC - Air Quality	244	Paint Spray Booth	1-4722-00032/00115	30-Jan-25	U-PAINT	24402
NYSDEC - Air Quality	244	Flammable Liquid Storage Cabinet	1-4722-00032/00115	30-Jan-25	U-PAINT	244AE
NYSDEC - Air Quality	479	Metal Parts Cleaning Tank	1-4722-00032/00115	30-Jan-25	U-METAL	47908
NYSDEC - Air Quality	510	Spin Coating Operation	1-4722-00032/00115	30-Jan-25	U-INSIG	510AK
NYSDEC - Air Quality	801	Target Processing Laboratory	1-4722-00032/00115	30-Jan-25	U-INSIG	80101
NYSDEC - Air Quality	Site	Aerosol Can Processing Units	1-4722-00032/00115	30-Jan-25	U-INSIG	AEROS
NYSDEC - Air Quality	498	Aqueous Cleaning Facility	1-4722-00032/00115	30-Jan-25	U-METAL	49801
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-61007	61007
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	30-Jan-25	U-METAL	61008

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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	30-Jan-25	U-61005	6101A
NYSDEC - Air Quality	902	Epoxy Coating/Curing Exhaust	1-4722-00032/00115	30-Jan-25	U-COILS	90206
NYSDEC - Air Quality	922	Electroplating Operation	1-4722-00032/00115	30-Jan-25	U-INSIG	92204
NYSDEC - Air Quality	Site	Commercial Refrigeration Equipment	1-4722-00032/00115	30-Jan-25	U-RFRIG	COMRE
NYSDEC - Air Quality	Site	Packaged A/C Units (16)	1-4722-00032/00115	30-Jan-25	U-RFRIG	PKG01-16
NYSDEC - Air Quality	Site	Reciprocating Chillers (44)[1]	1-4722-00032/00115	30-Jan-25	U-RFRIG	REC01-651
NYSDEC - Air Quality	Site	Rotary Screw Chillers (19)	1-4722-00032/00115	30-Jan-25	U-RFRIG	ROTO1-20
NYSDEC - Air Quality	Site	Split A/C Units	1-4722-00032/00115	30-Jan-25	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal Chillers (19)[2]	1-4722-00032/00115	30-Jan-25	U-RFRIG	CEN06-292
NYSDEC - Air Quality	463	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	46301
NYSDEC - Air Quality	490	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	49006
NYSDEC - Air Quality	515	Diesel Non-Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	51501
NYSDEC - Air Quality	555	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	55503
NYSDEC - Air Quality	635	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	63501
NYSDEC - Air Quality	734	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	73401
NYSDEC - Air Quality	735	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	73501
NYSDEC - Air Quality	740	Diesel Emergency Generators (2)	1-4722-00032/00115	30-Jan-25	U-GENER	74001-02
NYSDEC - Air Quality	801	Diesel Emergency Generator	1-4722-00032/00115	30-Jan-25	U-GENER	80102
NYSDEC - Air Quality	912	Diesel Emergency Generators (3)	1-4722-00032/00115	30-Jan-25	U-GENER	912A1-A3
NYSDEC - Air Quality	30	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-SMBLR	030AB
NYSDEC - Air Quality	422	Combustion Unit	1-4722-00032/00115	30-Jan-25	U-SMBLR	422AF
NYSDEC - Air Quality	423	Combustion Unit	1-4722-00032/00115	30-Jan-25	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:
[1] Multiple reciprocating chillers in list were removed and are no longer listed in BNL's Title V Permit.
[2] Multiple centrifugal chillers in list were removed and are no longer listed in BNL's Title V Permit.
[3] Source Facility Removed and awaiting termination of NESHAPs authorization.
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

- State Pollutant Discharge Elimination System (SPDES) permits, issued by NYSDEC
- Major Petroleum Facility (MPF) license, issued by NYSDEC
- Resource Conservation and Recovery Act (RCRA) permit, issued by NYSDEC for BNL's Waste Management Facility
- Registration certificate from NYSDEC for tanks storing bulk quantities of hazardous substances (e.g., fuel oil)
- Eight radiological emission authorizations issued by the U.S. 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 12 emission units
- EPA Underground Injection Control (UIC) Area permit for the operation of 115 UIC wells (e.g., dry wells and cesspools)
- Permit for the operation of six domestic water supply wells, one irrigation well, and one fire protection 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

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

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 Laboratory has one Wetland and Wild, Scenic, and Recreational Rivers Permit that was opened in 2017. The permit is an equivalency permit for the cleanup of a small area of contamination within the Peconic River. The Laboratory completed required vegetation monitoring in August 2019 and submitted documentation to NYSDEC to request permit closure. A site visit is required and will occur mid-2020 once vegetation is in full growth.

3.3 NEPA ASSESSMENTS

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 2019, environmental evaluations were completed for 168 proposed projects at BNL. Of those, 166 were considered minor actions requiring no additional documentation. Two projects were addressed by submitting notification forms to DOE, which determined that the projects were covered by existing "Categorical Exclusions" (per 10 CFR 1021) or fell within the scope of a previous environmental assessment.

3.4 PRESERVATION LEGISLATION

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

BNL has 13 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, four 1960s-era efficiency apartments, Berkner Hall (Building 488), Chemistry (Building 555), Physics (Building 510), Computational Sciences (Building 515), Instrumentation (Building 535), the World War-II (WWII) barracks portion of Building 120, and the WWI Army training trenches associated with Camp Upton. 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 2019, 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 CSF boilers 5, 6, and 7 cannot meet the new lower NOx RACT standards effective as of July 2014, BNL uses 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 2019, there were no recorded exceedances of the NOx RACT limit by the Boiler 6 or Boiler 7 CEMS. Using the system averaging approach, actual weighted average NOx emission rates for operating boilers for the first through fourth quarters were 0.081, 0.083, 0.087, and 0.085 lbs./MMBtu, respectively, which were below the corresponding quarterly permissible weighted average emissions rate of 0.150 lbs./MMBtu each quarter.

In 2019, there were five recorded excess opacity measurements. Three were due to the start-up and shutdown of Boiler 6 in preparation for periodic emission tests conducted in January, and two Boiler 6 excess readings in December were from unknown causes. All 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 are 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 2019, 182 pounds of R-22, 2,000 pounds of R-134A, and 30 pounds of R-410A were recovered and recycled from refrigeration equipment that was serviced. Meanwhile, 292 pounds of R-22, 430 pounds of R-134A, and 73 pounds of R-410A leaked from refrigeration and air

conditioning equipment on site. These leaks were subsequently reported as emissions in the Annual Emissions Statement transmitted to NYSDEC.

Halon: Halon 1211 and 1301 are extremely efficient fire suppressants but are being phased out due to their effect on the earth's ozone layer. In 1998, the Laboratory purchased equipment to comply with the halon recovery and recycling requirements of the CAA, 40 CFR 82 Subpart H. Halon recovered from excessed systems is shipped to the Department of Defense Ozone Depleting Substances Reserve in accordance with the Class I Ozone Depleting Substances Disposition Guidelines prepared by the DOE Office of Environmental Policy and Guidance. In 2019, 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.

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.

Maximum Available Control Technology

Based on the Laboratory's periodic review of Maximum Available Control Technology (MACT) standards in 2019, 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.

3.5.2.1 Asbestos

In 2019, the Laboratory notified the EPA Region II office regarding the removal of materials containing asbestos. During the year, 17,500 pounds of non-scheduled friable asbestos from maintenance operations (e.g., pipe insulation, sheetrock, popcorn ceiling, transite board, floor tiles, water main pipes) materials were removed and disposed of according to EPA requirements.

3.5.2.2 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 2019 is provided in Chapter 4.

BNL transmitted all data pertaining to radioactive air emissions and dose calculations to EPA in fulfillment of its 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 2019 was 1.28 mrem (12.8 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 Suffolk County Department of Health Services (SCDHS) through a 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 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 96 percent in 2019.

There were five excursions of SPDES permit limits at Outfall 001 in 2019, all of which involved Tolyltriazole (TTA). The effluent limit for TTA (0.05 mg/L) at Outfall 001 was exceeded in April, May, June, July, and September of 2019. TTA is a stable corrosion inhibitor that produces a protective electrochemical film on metal surfaces to slow the rate of corrosion. It can shield multiple types of metals against corrosion, though it is most commonly used for copper and copper alloy systems. TTA is the industry standard for this type of protection and BNL uses it throughout the site to protect valuable machinery and equipment from the corrosive conditions found in harsh operating environments, such as cooling towers.

This is a unique challenge for the Laboratory due to the large number of operating cooling water systems that require water treatment chemicals like TTA to prevent corrosion and the need to maintain compliance with New York State Department of Health Legionella Disease prevention regulations. Every time Legionella bacteria is detected in a cooling tower, New York State Law requires that the Laboratory follow its water safety plan which includes additional disinfections and draining of water that has residual levels of water treatment chemicals, including TTA. As a result, a large percentage of wastewater entering the STP during the cooling season (typically between June and September) is tower blowdown from cooling towers. The Lab's Environmental Protection Division and Facilities & Operations (F&O) Directorate staff

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)	6.9	8.3	Continuous Recorder	Min 5.8, Max. 8.5	0	100
Solids, Total Dissolved (mg/L)	260	620	Monthly	1000	0	100
Total nitrogen (mg/L)	1.4	9.4	Twice Monthly	10	0	100
Total phosphorus (mg/L)	0.3	1.4	Twice Monthly	NA	0	100
Cyanide (mg/L)	< 0.002	< 0.002	Twice Monthly	0.1	0	100
Copper (mg/L)	0.005	0.07	Twice Monthly	0.15	0	100
Iron (mg/L)	0.09	0.2	Twice Monthly	0.6	0	100
Lead (mg/L)	< 0.001	0.002	Twice Monthly	0.025	0	100
Mercury (ng/L)	3	11	Twice Monthly	200	0	100
Methylene chloride (ug/L)	<2	< 2	Twice Monthly	5	0	100
Nickel (mg/L)	< 0.002	0.003	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	0.24	Twice Monthly	2	0	100
1,1,1-trichloroethane (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Max. Flow (MGD)	0.35	0.50	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.17	0.31	Continuous Recorder	NA	0	100
HEDP (mg/L)	<0.05	0.1	Monthly	0.5	0	100
Tolytriazole (mg/L)	<0.005	0.1	Monthly	0.05	5	58

Notes: Notes:
See Figure 5-2 for location of Outfall 001.
* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100
HEDP = 1-hydroxyethylidene diphosphonic acid
MGD = million gallons per day
NA = Not Applicable
SPDES = State Pollutant Discharge Elimination System
SU = standard unit

have been working closely with the DOE and NYSDEC to investigate the cause(s) of this issue and possible solutions.

Several corrective actions have been implemented including, but not limited to:

- Decreasing the control limits for the TTA-containing Water Treatment Chemical Assetguard-7286T (Assetguard) to reduce the overall amount of this chemical that is currently being used to treat onsite cooling tower systems;
- Initiating the collection of "in-house" process control samples of STP Effluent. Personnel at the STP are qualitatively measuring the TTA influent and effluent concentrations of the unit operations within the STP to study efficiency gains from changes in treatment methodologies;
- Accelerating the installation of automated chemical control systems at cooling towers where treatment chemicals are manually added in order to reduce the amount of product used;
- Conducting volume studies of all cooling tower systems to ensure systems are being effectively treated and using the minimal amount of chemical product possible.

More recently, the Laboratory identified a water treatment chemical that does not contain TTA that was approved for use by NYSDEC. This new chemical has been added to the contract with the vendor that helps manage the water treatment chemical program at BNL and work planning has been initiated for a pilot study using this new chemical at the Chilled

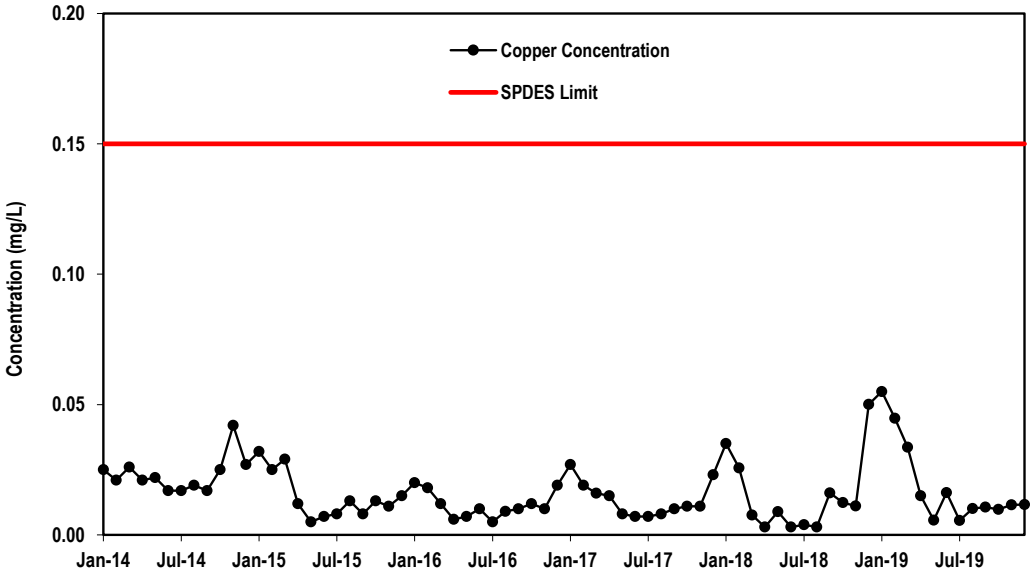

Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2014–2019.

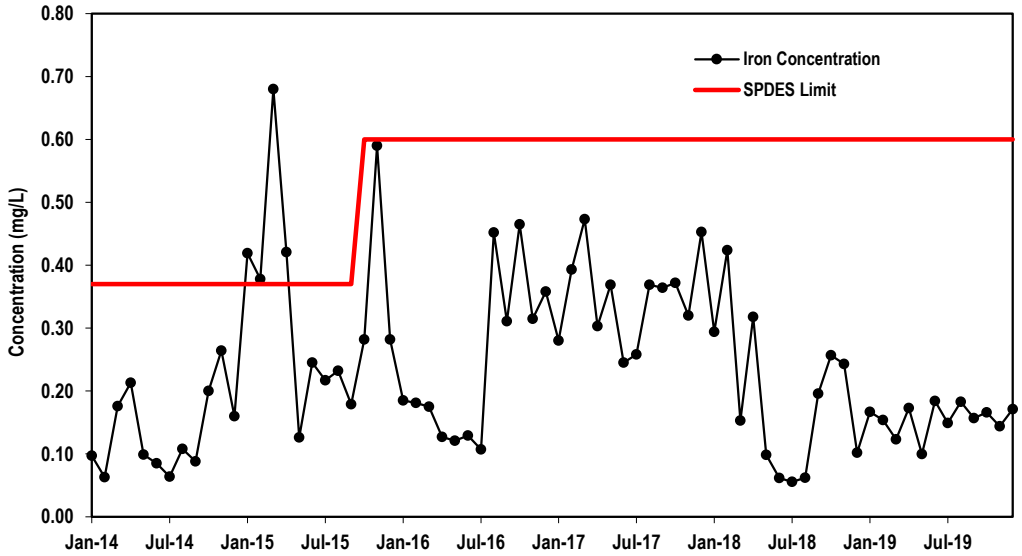

Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2014–2019.

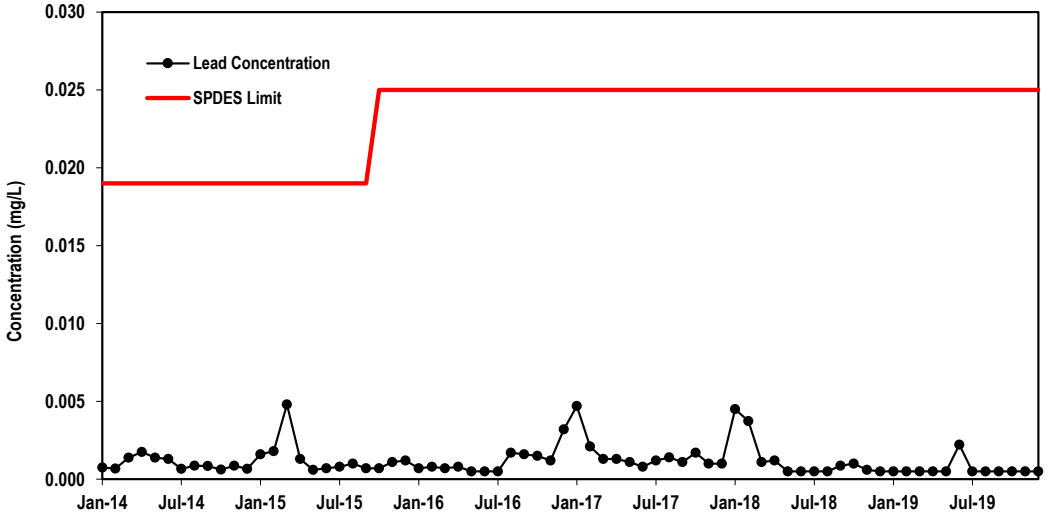

Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2014–2019.

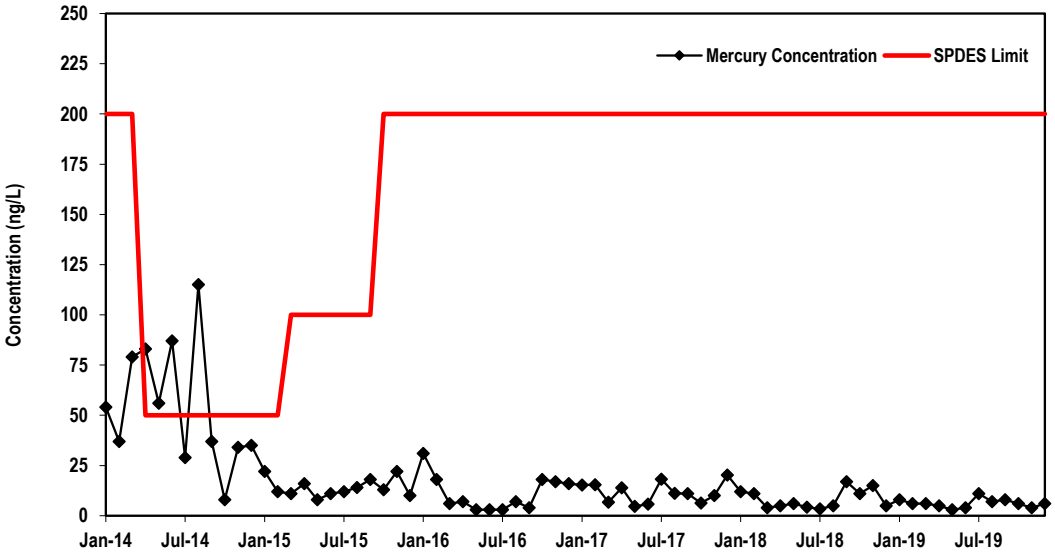

Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2014–2019.

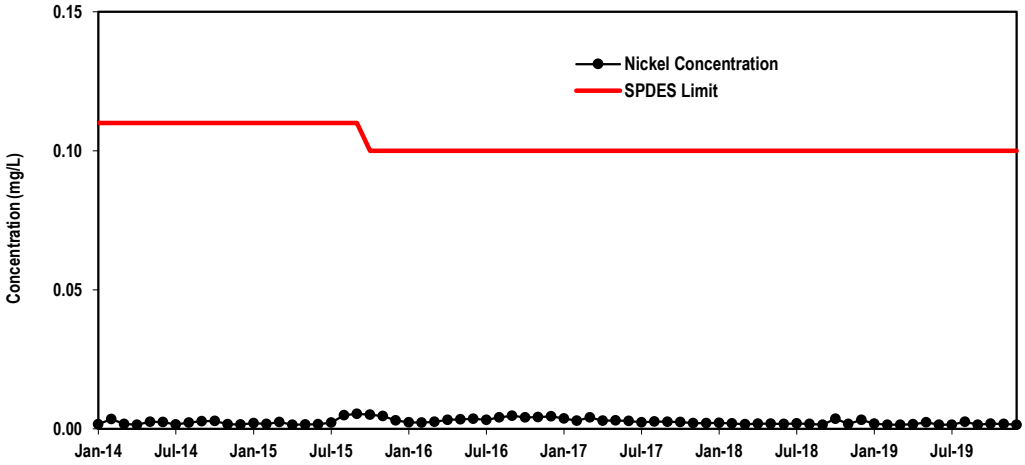

Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2014–2019.

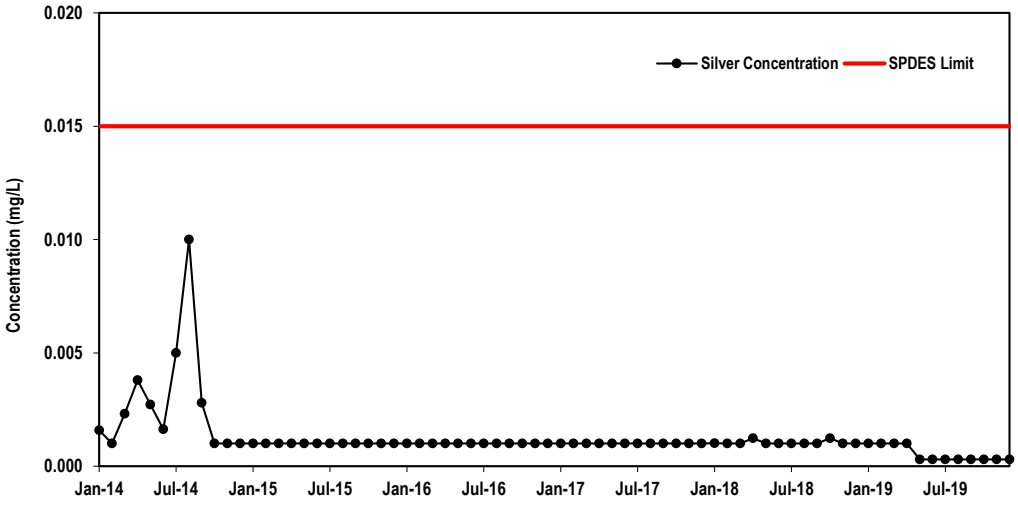

Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2014–2019.

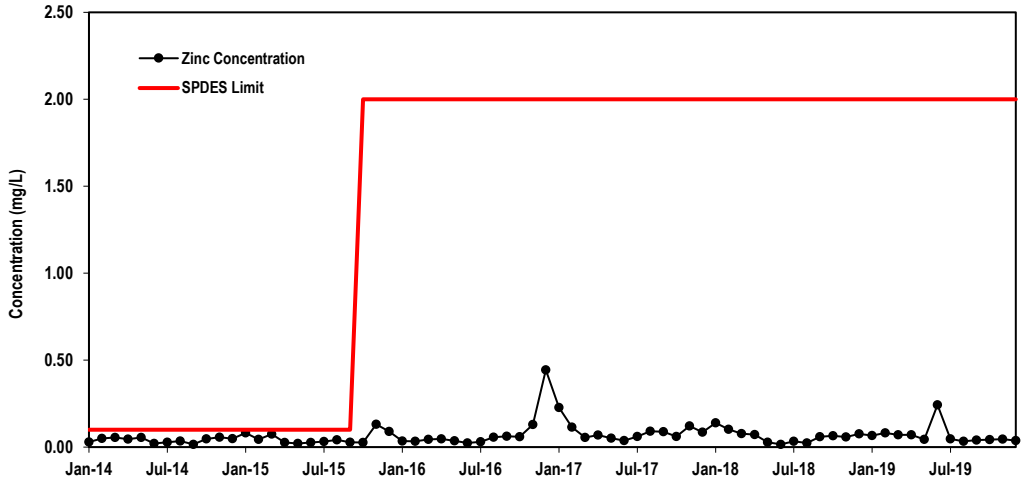

Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2014–2019.

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

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
Flow (MGD)	N	CR	CR	CR	CR	CR	CR	10	10			
	Min.	0.14	0.002	0.1	0.07	0.02	0.08	0.04	0.002	NA		
	Max.	0.63	0.13	0.61	0.18	0.07	0.16	1	0.5	NA	NA	NA
pH (SU)	Min.	6.9	6.2	6	6.9	7.1	7	7.1	7.5	NA		
	Max.	8.4	8.6	8.5	8.7	8.6	8.8	8	8.4	8.5, 9.0 (a)	0	100
Oil and Grease (mg/L)	N	12	12	12	12	12	NR	11	11			
	Min.	< 1.2	< 1.1	< 1.1	< 1.2	< 1.1	NR	< 1.1	< 1.2	NA		
	Max.	2.0	3.2	1.4	1.9	1.6	NR	2.4	1.9	15	0	100
Copper (mg/L)	N	NR	NR	4	NR	NR	NR	NR	4			
	Min.	NR	NR	0.001 (T)	NR	NR	NR	NR	0.001 (D)	NA		
	Max.	NR	NR	0.004 (T)	NR	NR	NR	NR	0.004 (D)	1.0	0	100
Aluminum (mg/L)	N	4	NR	NR	NR	NR	NR	4	4			
	Min.	< 0.07 (T)	NR	NR	NR	NR	NR	< 0.07 (D)	< 0.07 (D)	NA		
	Max.	0.07 (T)	NR	NR	NR	NR	NR	0.11 (D)	0.11 (D)	2.0	0	100
Lead, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	<0.0005	NA		
	Max.	NR	NR	NR	NR	NR	NR	NR	<0.0005	0.05	0	100
Vanadium, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4			
	Min.	NR	NR	NR	NR	NR	NR	NR	0.002	NA		
	Max.	NR	NR	NR	NR	NR	NR	NR	0.006	NPL	NA	NA
Chloroform (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	0.4	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	1.4	NR	NR	NR	NR	NR	NR	NR	7	0	100
Bromodichloromethane (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR			
	Min.	<1.0	NR	NR	NR	NR	NR	NR	NR	NA		
	Max.	2.6	NR	NR	NR	NR	NR	NR	NR	50	0	100
1,1,1-trichloroethane (µg/L)	N	4	NR	NR	NR	NR	NR	10	NR			
	Min.	< 1.0	NR	NR	NR	NR	NR	< 1.0	NR	NA		
	Max.	< 1.0	NR	NR	NR	NR	NR	< 1.0	NR	5	0	100
1,1-dicloroethane (µg/L)	N	NR	NR	NR	NR	NR	NR	10	NR			
	Min.	NR	NR	NR	NR	NR	NR	< 1.0	NR	NA		
	Max.	NR	NR	NR	NR	NR	NR	< 1.0	NR	5	0	100

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

Hydroxyethylidene-diphosphonic acid (mg/L)	N	4	NR	4	4	4	NR	NR	NR			
	Min.	<0.05	NR	<0.05	<0.05	<0.05	NR	NR	NR	NA		
	Max.	0.06	NR	<0.05	<0.05	<0.05	NR	NR	NR	0.5	0	100
Tolyltriazole (mg/L)	N	4	NR	4	4	4	NR	NR	NR			
	Min.	<0.005	NR	<0.005	<0.005	<0.005	NR	NR	NR	NA		
	Max.	0.06	NR	<0.005	<0.005	0.09	NR	NR	NR	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

Water Facility; however, it will take some time to determine if this product is effective. 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. 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 2019, no non-compliance events occurred for any of the permitted recharge basin outfalls.

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 2019) 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 2019. 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. With the exception of a violation for missing the collection of an iron sample at the Water Treatment Plant in June, BNL's drinking water and the supply and distribution system were in compliance with all

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	< 0.1	< 0.1	< 0.1	SNS
Chlorides (µg/L)	41.1	32.4	34.7	65.9	66.7	40.4	250
Color (units)	10*	75*	20*	< 5	< 5	< 5	15
Conductivity (µmhos/cm)	175	157	175	383	395	333	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)	0.13	0.069	0.19	0.53	0.56	0.2	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)	6	5.9	6	6	6	6	SNS
Sulfates (mg/L)	8.8	10.9	9.7	10.7	13	10.6	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	2.3	2.84	< 1.0	< 1.0	< 1.0	50
Barium (mg/L)	0.05	0.03	0.03	0.06	0.06	0.02	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	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.1
Copper (mg/L)	0.005	0.03	0.003	0.003	0.003	0.005	1.3
Fluoride (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2.2
Iron (mg/L)	5.1*	5.1*	2.9*	< 0.20	< 0.20	0.03	0.3
Lead (µg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
Manganese (mg/L)	0.08	0.1	0.09	< 0.010	< 0.010	< 0.010	0.3
Mercury (µg/L)	3.89**	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Nickel (mg/L)	0.002	0.415	0.0015	0.0015	0.002	<0.0005	SNS
Selenium (µg/L)	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	50
Sodium (mg/L)	15.2	20.5	21.8	45.3	44.1	25.5	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)	0.02	<0.02	0.02	0.02	0.02	<0.02	5
Radioactivity							
Gross alpha activity (pCi/L)	< 2.0	<1.95	<1.98	<1.97	<1.97	NR	15
Gross beta activity (pCi/L)	<1.77	1.99 ± 1.21	<2.16	1.58± 1.0	2.54 ± 1.0	NR	(a)
Radium-228 (pCi/L)	NS	NS	NS	NS	NS	NR	5
Strontium-90 (pCi/L)	< 0.80	< 0.79	< 0.76	< 0.79	< 0.80	NR	8
Tritium (pCi/L)	< 469	< 459	< 448	< 476	< 459	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)	6.4	8	12.3	29.9	26	62	SNS
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	< 0.20	7
Calcium (mg/L)	7	4.5	6.03	13.9	11.8	16.1	SNS
HAA5 (mg/L)	NR	NR	NR	NR	NR	0.013	0.06***
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	1.2	4
TTHM (mg/L)	NR	NR	NR	NR	NR	0.037	0.08***

Notes:
See Figure 7-1 for well locations.
Well 12 was not operational for 2019; 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.
** This detection of mercury is an anomaly and suspect. Mercury was not detected in a subsequent sample and this well was not in use during 2019.
*** 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.

applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting in 2019.

The iron violation in June 2019 was issued after a second quarter iron sample was not taken at the Laboratory's Water Treatment Facility. At the time sampling was required, the water treatment plant was down for maintenance. The error was not discovered until after the quarter was over. A sample was immediately taken, which was below the regulatory limit. Procedures have been updated and personnel trained to ensure sampling requirements are met.

In 2013, the EPA required large water providers to start testing for six common Per- and Poly-fluoroalkyl Substances (PFAS) chemicals under the third Unregulated Contaminant Monitoring Rule (UCMR 3). As a medium-size system, BNL was not required to participate in this testing program. In 2017, SCDHS began routine testing of all water supply systems for PFAS, including BNL. PFAS chemicals were detected in three of BNL's water supply wells. In these initial tests, Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) were detected at concentrations below the current EPA Health Advisory Level of 70 ng/L (ppt) that was established specifically for the combined concentration of these two chemicals. Following repeated confirmed detections of PFAS in the supply wells, the Lab started routine quarterly testing for PFAS in 2018. The results are provided in Table 3-6.

EPA's health advisories are non-enforceable and non-regulatory and provide technical information to state agencies and other public health officials on health effects, analytical methodologies, and treatment technologies associated with drinking water contamination. New York State is currently evaluating whether to establish enforceable drinking water standards for PFOS and PFOA at concentrations that may be lower than the current EPA advisory level. The other four PFAS chemicals would continue to be regulated under the current New York State limit of 50 µg/L (ppb) for unregulated contaminants.

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 *(continued).*

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	2.7	1.0	0.9	0.8	0.9	1.4	50
Bromodichloromethane	2.9	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Dibromochloromethane	2.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Bromoform	1.2	< 0.5	< 0.5	< 0.5	< 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
Metolachlor	<1	<1	<1	<1	<1	<1	50

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

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
	µg/L						
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
Freon-113	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Perfluorobutanesulfonic Acid	<0.002	<0.002	<0.002	<0.002	0.003	0.001	50
Perfluoroheptanoic Acid	<0.002	<0.002	<0.002	<0.002	0.003	0.0008	50
Perfluorohexanesulfonic Acid	<0.002	<0.002	<0.002	<0.002	0.016	0.005	50
Perfluorooctanoic Acid (ng/L)*	0.7	<2	1.2	0.7	6.6	2.9	70
Perfluorooctanesulfonic Acid (ng/L)*	1.8	<2	2.7	1.5	35.1	11.7	70

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.
* Compounds results are reported in ng/L
Well 12 was offline and remained unused during 2019.
SNS = drinking water standard not specified
NYS DWS = New York State Drinking Water Standard
WTP = Water Treatment Plant

The Laboratory continues to monitor sample results and is in the process of restoring the Granular Activated Carbon filters to remove PFAS on Well 10 and Well 11.

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 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 2019, the Laboratory inspected 254 cross-connection control devices, including

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 [ ]

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 re-tested 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 drywells, cesspools, septic tanks, and leaching pools, all of which are classified by EPA as Class V injection wells. Proper management of UIC devices is vital for protecting underground sources of drinking water. In New York State, the UIC program is implemented through EPA because NYSDEC has not adopted UIC regulatory requirements. (Note: New York State regulates the discharges of pollutants to cesspools under the SPDES program.) Under EPA's UIC program, all Class V injection wells must be included in an inventory maintained with the agency.

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

In 2019, the Laboratory closed ten permitted UICs associated with former Buildings 130 and 134. Prior to closing a UIC, an assessment is performed to ensure that past operations did not result in the deposition of contaminants in the environment. This assessment is performed in accordance with an EPA approved Closure Plan. As outlined in the Closure Plan, assessment of UICs include collection of a bottom end-point sample for subsequent chemical analysis. Analysis typically includes volatile and semi-volatile organic compounds, PCB's, pesticides, herbicides, inorganic elements, and gamma spectroscopy detectable radioisotopes. The analytical findings collected during this UIC investigation were found to be less than the clean-up guidance levels and/or are within typical background ranges. Approval to backfill the UICs was received from Suffolk County Department of Health Services (SCDHS) in May 2019.

BNL's total UIC inventory at the end of 2019 was 115.

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 (Bruno, 2016). The purpose of this plan is to provide information regarding release prevention measures, the

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

Spill No. and Date	Material/ Quantity	ORPS Report	Source/Cause and Corrective Actions
19-02 01/29/19	PCB Dielectric Oil / Unknown	No	As part of the Discovery Park Phase II Environmental Assessment, 19 soil samples were collected by P.W. Grosser Consulting on November 15, 2018 beneath the transformer pad and at four locations north-north-west of the pad to delineate the depth and lateral extent of historical PCB contamination for future remediation. This finding was reported to NYSDEC as a legacy spill for tracking purposes and to ensure area is remediated and waste properly disposed of.
19-03 01/29/19	PCB Dielectric Oil / Unknown	No	As part of the Discovery Park Phase II Environmental Assessment, 22 soil samples were collected by P.W. Grosser Consulting on November 14, 2018 at five locations south-southwest of the two transformer pads to delineate the depth and lateral extent of historical PCB contamination for future remediation. This finding was reported to NYSDEC as a legacy spill for tracking purposes and to ensure area is remediated and waste is properly disposed.
19-05 04/29/19	Transformer Oil / 2 gallons	No	During a routine inspection of a transformer adjacent to Bldg. 197, an Energy & Utilities technician noticed contaminated soil beside the transformer's concrete slab and a low-level reading on the tank gauge. A leaking gasket inside the transformer caused oil to seep beyond the transformer housing onto the concrete slab and into the soil. After the transformer was de-energized, staff removed contaminated soil around the perimeter of the slab to a depth of six to seven inches until clean, dry soil was evident. Contaminated soil and absorbent pads used to soak up soil inside the housing were transferred into three 55-gallon drums for off-site disposal as industrial waste. The transformer was replaced later during the year.
19-08 05/03/19	Hydraulic Fluid / 8 gallons	No	After cutting the lawn adjacent to Bldg. 860, the Production Division Grounds mower left tracks from a hydraulic fluid leak in the parking lot north of the building. A two-inch wide path of hydraulic fluid continued along the path taken by the mower operator including roadside grass traveling west on East Fifth Avenue to the mower's final destination in the parking lot across from Bldg. 97 where the operator first noted the hydraulic fluid leak. Vibrational wear of a metal hydraulic line against the metal bracket that holds the line in place created a hole in the line that caused it to leak. HEMO Shop personnel replaced the line and a rubber piece between the line and bracket. Grounds personnel lowered the cutting blade on another lawn mower to the grass-soil interface to skim cut the oil stained grass adjacent to East Fifth Ave where the mower had previously cut. The oil-stained clippings and disturbed soil were collected in a bag attached to the mower. Meanwhile, a HEMO Shop street sweeper followed the path on roads taken by the mower from Bldg. 860 to Bldg. 97 to sweep up oil coated road grit along the path.
19-09 07/13/19	Diesel Fuel / 0.5 gallons	No	After an employee reported a fuel oil odor in the parking lot of Bldg. 422 to Fire Rescue, personnel from the group discovered a sheen on a puddle that smelled of diesel fuel. The source of the oil sheen was a chunk of asphalt at the side of Woods Road west of the parking lot saturated with petroleum. Apparently, heavy rains the evening before washed away overburden and leached petroleum into stormwater that drained to the parking lot. Oil absorbent pads were used to soak up the sheen in the parking lot. The oil-soaked pads along with the asphalt chunk and petroleum contaminated sandy soil adjacent to Woods Road were placed in a five-gallon pail subsequently taken to the Bldg. 452 waste accumulation area.
19-15 09/03/19	Compressor Oil / 2 gallons	No	As riggers prepared to unload three boxes that contained a helium liquefier and two compressors from a flat-bed trailer near the loading dock at Bldg. 902, they noticed compressor oil leaking from one of the boxes and immediately called ext. 2222 to report the leak. When Fire Rescue responded and met up with the Magnet Division employee supervising the transfer of the boxes, they used oil absorbent pads and Speedi-dry to soak up compressor oil that had leaked in the flat-bed trailer and the pavement where oil had leaked from the trailer. The source of the leak was a broken lubricating line weld on one of the compressors. After learning that the flat-bed trailer had arrived at Bldg. 98 in the morning and waited there for several hours before it was dispatched to Bldg. 902, Fire Rescue personnel drove to Bldg. 98 and used oil absorbent pads and Speedi-Dri to absorb compressor oil that had leaked from the trailer-bed onto pavement leading to the loading dock and onto the road headed to the loading dock. They also placed oil absorbent socks within the loading dock drain to capture any oil that may have seeped into the drain. Finally, they also dug up a small patch of soil adjacent to the road stained with oil that had leaked from the trailer-bed. All materials used during the clean-up of the spilled oil at both buildings along with the contaminated soil were placed in a 55-gallon drum that was subsequently transferred to the Bldg. 452 90-day storage area.

(continued on next page)

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

Spill No. and Date	Material/ Quantity	ORPS Report	Source/Cause and Corrective Actions
19-16 09/10/19	Transformer Oil / 1 gallon	No	During a routine inspection of substations, Tower Line personnel observed stained gravel near the discharge valve of Transformer 930-534. Since the discharge valve on this transformer and other transformers in the Bldg. 930 transformer bank were defective and allowing transformer oil to be discharged, valve plugs were installed in this discharge valve and the discharge valves of the other transformers to prevent future leaks.Stained gravel around this transformer was subsequently recovered by Grounds personnel and placed in a five-gallon pail that was taken to the Bldg. 452 90-day waste area to be consolidated with similar waste for off-site disposal as non-hazardous industrial waste.
19-17 09/16/19	Transformer Oil / 1 pint	No	After a slow leak of synthetic non-PCB transformer oil from transformer 652-TRNF687 located to the east of Bldg. 817 was observed and called in to Fire Rescue, absorbent pads were used to clean impacted surfaces of the transformer cabinet and the concrete slab. About 0.3 cubic feet of contaminated soil adjacent to the pad were recovered by Grounds personnel and transferred to the Bldg. 452 90-day storage area. After Tower Line personnel made repairs to stop the leak, the transformer was inspected weekly to identify and repair leaks. The transformer is scheduled to be replaced in 2020.
19-18 09/16/19	Transformer Oil / 0.5 gallons	No	During a preventative maintenance inspection of the transformer 528-TRNF633 north of Bldg. 528, an EU Tower Line technician noted that silicone-based transformer oil was actively weeping from the transformer fuses and had leaked onto the concrete pad beneath the transformer and onto the surrounding gravel. After calling in the spill for assistance, Fire Rescue personnel responded and placed absorbent pads inside the transformer casing to capture leaking oil. Grounds personnel recovered the visibly contaminated gravel adjacent to the pad to a depth of six inches along the north edge of the pad and to a depth of nine inches along the west edge of the pad where oil had leaked. Contaminated gravel was placed in one 55-gallon drum that was taken to the Bldg. 326 90-day waste storage area. The transformer fuses were tightened to stop the leaks and the transformer has been inspected weekly to identify and repair leaks. The transformer is scheduled to be replaced in 2020.
19-22 12/12/19	Engine Oil / 0.5 gallons	No	Motor oil leaked onto an unpaved road bed adjacent to the weather tower at TR834 after a hose-fitting failed on a trailer mounted mobile emergency generator. The operator arranged for the unit to be transported back to the HEMO Shop for repairs. Grounds personnel recovered contaminated soil and placed it into five-gallon pails. The contaminated soil was subsequently transferred to a 55-gallon drum at the Bldg. 452 waste accumulation area.

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 five years. BNL remained in full compliance with SPCC requirements in 2019.

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 39 on-site chemicals (with thresholds greater than 10,000 pounds or 500 pounds for acutely toxic materials) via E-Plan, the New York State-approved computer-based submittal program. The chemicals ranged from road salt (about 1,225 tons) to Portland cement (10,656 pounds). To satisfy the requirements of the Tier III submittal, the Laboratory submitted its data via the EPA-approved TRI-ME computer-based submittal program. During 2019, BNL reported releases of lead (about 35,000 pounds), mercury (about nine pounds), polychlorinated biphenyls (PCBs) (about two pounds), benzo(g,h,i)perylene (less than one pound), polycyclic aromatic compounds (less than one pound), and friable asbestos (about 17,500 pounds). Releases of lead, PCBs, mercury, and asbestos 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 2019, 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 23 spills in 2019 and ten 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 ten 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 1.9 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 five 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, fuel, or other miscellaneous petroleum needs (e.g., motor oil, waste oil, lube oil).

There are currently 61 petroleum storage facilities listed on the License. With exception of a violation identified at the Laboratory's diesel tank farm that is further described below, BNL remained in full compliance with MPF license requirements in 2019, which include monitoring groundwater near six above-ground storage tanks at the MPF. The license also requires the Laboratory to inspect the storage facilities monthly, test the tank leak detection systems, and ensure high-level monitoring and secondary containment is functional. 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 2019, 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.

NYSDEC inspection of registered Petroleum Bulk Storage Facilities on June 25, 2019, resulted in a Notice of Violation (NOV) for the three aboveground storage tanks at the Laboratory's diesel tank farm (STO-651). The NOV was associated with the need to have both manual and solenoid valves located at the top of each tank on gravity flow lines leading to the dispenser to prevent back-siphonage in the event of a supply line leak. F&O began immediate planning for the correction of the deficiency and addressed the finding in accordance with NYSDEC directives.

Also, in 2019, the coating for the secondary containment berm for the three aboveground

diesel fuel tanks at Storage Facility/STO-651 was refurbished. This was in response to BNL staff inspections that identified delamination-loosening of the coating from the concrete base floor. This project included the complete removal of the existing coating, sealing of concrete floor cracks, and application of petroleum-compatible epoxy and fiberglass matting on the floor and walls of the berm in accordance with manufacturer's requirements. The secondary containment berm was flood tested by an independent consultant and the results of the test indicated that the coating passed the impermeability test as per NYSDEC directives.

3.8.5 Chemical Bulk Storage

Title 6 of the Official Compilation of the Codes, Rules, and Regulations of the State of New York (NYCRR) Part 597 requires that all aboveground tanks larger than 185 gallons and all underground tanks that store specific chemicals be registered with NYSDEC. The Laboratory holds a Hazardous Substance Bulk Storage Registration Certificate for six tanks that store treatment chemicals for potable water (sodium hydroxide and sodium hypochlorite). The tanks range in capacity from 200 to 1,000 gallons. In 2019, BNL renewed its Chemical Bulk Storage (CBS) Registration in accordance with NYSDEC directives and received a Hazardous Substance Bulk Storage Registration Certificate.

As part of the NYSDEC's regulatory inspection for the above petroleum tanks, the CBS-registered tanks were also inspected and there were no findings identified.

3.8.6 County Storage Requirements

Article 12 of the SCSC 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 its sole jurisdiction over petroleum storage at Major Oil Storage Facilities, SCDHS notified BNL that it 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 121 active storage facilities that are not regulated by NYSDEC that would normally fall under SCSC Article 12 jurisdiction. This includes storage of wastewater and chemicals, as well as storage facilities used to support BNL research.

To ensure that storage of chemicals and petroleum 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 SCDHS Article 12 are maintained.

3.9 RCRA REQUIREMENTS

The Resource Conservation and Recovery Act (RCRA) 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 offsite to licensed treatment and disposal facilities. As noted in Chapter 2, BNL also has several 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 March 2019, the NYSDEC performed an unannounced two-day inspection of hazardous waste activities at BNL. The inspectors visited BNL's Permitted Transportation, Storage, and Disposal Facility (Building 855), 90-Day, and Satellite Accumulation Areas and reviewed associated documentation. During the inspection the inspectors identified two labeling issues and one documentation issue, all of which were satisfactorily resolved before the conclusion of the inspection. A letter documenting the results of the inspection was received from the NYSDEC in April 2019 and indicated that no further actions were required. In September 2019, the EPA also visited BNL to perform an inspection of hazardous waste activities. The inspector was 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 2019 and disposed of 169.4 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 has subsequently been audited by a third-party (Cornell Cooperative). Pesticides are used at the Laboratory to control undesirable insects and mice and 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). Nearly all pesticides are applied by BNL-employed, New York State–certified applicators. On an infrequent basis, an outside vendor who also possesses the required NYSDEC application licenses applies pesticides.

By February 1, each BNL applicator files an annual report with NYSDEC detailing insecticide, rodenticide, algaecide, and herbicide use for the previous year. Contractors who apply pesticides and cooling tower biocides are responsible for filing their own reports.

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 several 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.

In 2019, BNL had a single wetlands equivalency permit open. This permit was associated with the final cleanup of a small area of contamination within the Peconic River. The project was completed in 2017 and the area is being restored naturally. A final restoration report was submitted to the NYSDEC with a request to confirm restoration and close the permit.

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)* 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)* is federally endangered and was historically found on Long Island. There is a very 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), peregrine falcon (E), persius duskywing (E), bracken fern (E), crested fringed orchid (E), engelman spikerush (E), dwarf huckleberry (E), whorled loose-strife (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.

Peregrine falcons are listed as endangered in New York State due to historic declines associated with DDT. Falcons were confirmed nesting on the HFBR stack in 2019. They had been seen in earlier years but had not nested. The birds utilized an abandoned raven's nest and the pair raised and fledged three chicks. For more information, read the inside cover of this report.

Banded sunfish and swamp darter have historically been 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. Due to an extended drought from 2015 through mid-2017, these two fish are not likely to be found on site. Should NYSDEC establish a recovery plan, fish may be restored to historic habitats in the future.

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. Limited habitat for

the frosted elfin and persius duskywing exists on Laboratory property and the mottled duskywing is likely to exist on site; therefore, the need to manage 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. 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 "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 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. 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, these birds are occasionally observed visiting 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 STP, National Weather Service, and the cell tower near Building 30 through much of 2019. A pair of eagles frequented the osprey nest located on the cell tower in December 2019, suggesting the potential for utilizing the nest, but ultimately the pair did not nest there. 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 2020 Rev. 11) and are consistent with the pre-approved authorized release limits set by DOE Order 458.1.

In 2019, excess materials not identified as radioactive, such as scrap metal and electronics equipment resulting from normal operations, were released to interested parties or to an offsite location. All materials were surveyed, as required, using appropriate calibrated instruments and released based on the DOE pre-approved authorized release limits. There were no releases of real property in 2019.

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 2019, BNL was inspected by federal, state, or local regulators on 11 occasions. These inspections included:

- *Air Compliance.* In August, a NYSDEC inspector performed a full compliance evaluation of regulated emission sources at BNL. 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.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the Laboratory's STP to evaluate operations and sample the effluent for SPDES compliance. No performance or operational issues were identified. NYSDEC also visited the site in January and May 2019 to perform SPDES inspections. No issues were identified.
- *RCRA.* In March, inspectors from the NYSDEC performed an unannounced RCRA Compliance inspection. The inspectors identified two labeling issues and one documentation issue, all of which were satisfactorily resolved before the conclusion of the inspection. In September, the EPA also visited BNL to perform an inspection of hazardous waste activities and did not identify any concerns or findings.
- *Petroleum and Chemical Bulk Storage.* In June, two inspectors from the NYSDEC performed a regulatory inspection of permitted petroleum and chemical bulk storage tanks. BNL received a Notice of Violation for missing solenoid and operating valves on above ground tanks associated with the Laboratory's diesel tank farm (STO 651). BNL F&O staff began immediate planning for the correction of the deficiency and addressed the finding in accordance with NYSDEC directives.

3.15.2 DOE Assessments/Inspections

The DOE Brookhaven Site Office (BHSO) performs routine inspections, assessments, and surveillances of BNL operations to ensure continual improvement and success in meeting the Laboratory's mission. In 2019, BHSO

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 2019.
No Notices of Violation/Enforcement Actions for 2019.				
None	Notice of Violation (NOV)	NYSDEC/ MOSF	06/21/19	NYSDEC inspection of Petroleum Bulk Storage Facility and Major Oil Storage Facility on June 18, 2019 resulted in a Notice of Violation (NOV) for the MOSF (STO-651) received on June 21, 2019. The NOV was associated with the need to have both manual valves and solenoid valves located at the top of each tank on gravity flow lines leading to the dispenser. BNL Facility and Operations began immediate planning for the correction of the deficiency and addressed the finding in accordance with NYSDEC directives.
None	Notice of Violation (NOV)	SCDHS	7/11/2019	A formal NOV was issued by SCDHS in July 2019 after a second quarter iron sample was not taken at the Laboratory's Water Treatment Facility. At the time sampling was required, the water treatment plant was down for maintenance. The error was not discovered until after the quarter was over. A sample was immediately taken, which was below the regulatory limit. Procedures have been updated and personnel trained to ensure sampling requirements are met.

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
MOSF = Major Oil Storage Facility
RCRA = Resource Conservation and Recovery Act
SCDHS = Suffolk County Department of Health Services

performed a surveillance of BNL's compliance with NESHAPs, specifically, 40 CFR 61 Subpart H *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* and an assessment of BNL's Packaging and Transportation Program, as required by DOE O 460.2A, Departmental Material Transportation and Packaging Management.

The surveillance was conducted in conjunction with BHSO's review of BNL's annual NESHAPs compliance report and there were no findings identified.

The assessment of the Packaging and Transportation Program at BNL was performed with assistance from the Office of Science Consolidated Service Center and was coordinated with Brookhaven Science Associates (BSA) personnel. Overall, the assessment found that BSA continues to have a strong program with no significant programmatic deficiencies being identified. There were four Level 3 Findings, five Observations, three Improvement Opportunities, four Best Practices, and one Noteworthy Practice identified during the assessment. A Level 3 Finding is defined as a singular/isolated regulatory non-compliance where there is a process in place. A causal analysis was performed for the identified findings and corrective actions were developed to minimize the risk of recurrence.

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 2019, EPD planned for and executed a programmatic self-assessment of two programs: Activated Soil Cap Inspections and Waste Management (Hazardous, Industrial, and Radiological).

The Activated Soil Cap Inspections assessment reviewed Collider-Accelerator Department's (C-AD's) implementation of measures to minimize groundwater pollution caused by soil activation. The measures include groundwater cap inspections, maintenance of information systems, and the use of removable soil samples to estimate impacts caused by accelerator beam loss. This assessment resulted in one observation and nine opportunities for improvement and concluded that overall, the C-AD is properly implementing the required activities to prevent groundwater impacts from soil activation. The observation was immediately addressed and C-AD and EPD staff are working together to address the identified opportunities for improvement.

The hazardous and industrial waste management portion of the assessment focused on sitewide compliance and conformance with the relevant sections of the Laboratory's Waste Subject Area and other associated regulatory drivers. Due to the limited number of departments/facilities at BNL that routinely generate radioactive waste, the scope of the radioactive waste portion of the assessment focused on the high-dose radioactive wastes generated by C-AD's Medical Isotope Research and Production (MIRP) group and how they are characterized, documented, and stored in accordance with the requirements.

Overall, the assessment found that waste management programs are strong and that there were no significant programmatic deficiencies identified. The hazardous and industrial waste management portion of the assessment resulted in one noteworthy practice, three opportunities for improvement, one observation, and six non-conformances. The radiological waste portion of the assessment resulted in one opportunity for improvement and two non-conformances. All non-conformances and observations identified during the assessment were addressed and communicated to the relevant, responsible staff.

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 annual assessments of generator Waste Certification Programs.

The NNSS performed a remote tabletop surveillance of the BNL Radioactive Waste program from July 9 to July 10, 2019. The assessment was conducted from the North Las Vegas offices of Navarro via teleconference. The team consisted of two members of the Radiological Waste Assistance Program (RWAP) and one DOE Nevada staff member and they concentrated on

Radiological Characterization and Waste Traceability compliance. Radiological characterization and waste traceability were 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 no observations against BNL's Waste Certification Program, enabling BNL continued access to the NNSS for radioactive waste disposal.

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 and two NOVs accessed in 2019. Existing agreements and details on the findings and corrective actions taken for the NOVs are summarized in Table 3-9.

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4 Air Quality

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

During 2019, BNL facilities released a total of 19,022 curies of short-lived radioactive gases. Oxygen-15 and Carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.9 percent of the site's radiological air emissions.

Because natural gas prices were comparatively lower than residual fuel oil prices throughout the year, BNL's Central Steam Facility used natural gas to meet 99.6 percent of the heating and cooling needs of the Laboratory's major facilities in 2019. 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; the Target Processing Laboratory (TPL), which 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 Table 8-5 in Chapter 8.

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 2019 are reported in Table 4-2. The average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were 0.0004 and 0.0073 pCi/m^3, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0007 and 0.0107 pCi/m^3, respectively.

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

High Flux Beam Reactor

In 1997, a groundwater 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 the 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 2019), 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.

4.2.1 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 2019, BLIP operated over a period of 25.14 weeks, during which 6,341 Ci of C-11 and 12,681 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, at 0.0377 Ci. Combined emissions of C-11 and O-15 were 19,022 Ci, 17.6 percent less than the combined emissions of 23,035 Ci in 2018. This decrease is primarily due to fewer days of operation at higher-than-average beam energies than in 2018, and the fact that cooling water gaps for thorium targets are up to 50 percent greater than those for rubidium chloride targets. 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	0.385
BLIP	Carbon-11	20.4 minutes	6,341
	Oxygen-15	122 seconds	12,681
	Tritium	12.3 years	0.0377
Total			**19,022**

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

4.2.2 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 multi-stage 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. Historical analytical results of TPL particulate filters show gross alpha/beta levels to be minimal. 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 analysis may be used to identify potentially emitted nuclides.

4.2.3 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 using an inventory system that allows an upper estimate of potential releases to be calculated.

Facilities that demonstrate compliance in this way include Buildings 120, 348, 463, 490, 535, 555, 740, 741, 743, 744, 745, 801, 815, 901, and 911, where research is conducted in the fields of nuclear safety, biology, chemistry, 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.

4.2.4 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 activities. Evaluations determine whether NESHAPs permitting and continuous monitoring requirements are applicable, or 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 2019.

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). There are four block-house 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 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 2019, 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 0.0011 and 0.0128 pCi/m^3, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-3. The results for this location are typical for the site and show seasonal variation in activity within a range that is representative of natural background levels. The New York State Department

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.	0.0013 ± 0.0007	0.0289 ± 0.0020
	Avg.	0.0004 ± 0.0004	0.0073 ± 0.0010
	MDL	0.0007*	0.0009*
TPL - Bldg. 801	N	52	52
	Max.	0.0019 ± 0.0008	0.0355 ± 0.0021
	Avg.	0.0007 ± 0.0005	0.0107 ± 0.0012
	MDL	0.0007*	0.0009*

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	52	52
	Max	0.0027 ± 0.0008	0.0215 ± 0.0015
	Avg.	0.0011 ± 0.0005	0.0127 ± 0.0011
	MDL	0.0005*	0.0006*
P4	N	51	51
	Max	0.0019 ± 0.0004	0.0204 ± 0.0015
	Avg.	0.0008 ± 0.0004	0.0113 ± 0.0010
	MDL	0.0005*	0.0006*
P7	N	48	48
	Max	0.0058 ± 0.0012	0.0427 ± 0.0037
	Avg.	0.0012 ± 0.0006	0.0140 ± 0.0013
	MDL	0.0006*	0.0008*
P9	N	50	50
	Max	0.0027 ± 0.0007	0.0223 ± 0.0016
	Avg.	0.0012 ± 0.0005	0.0132 ± 0.0012
	MDL	0.0006*	0.0007*
Grand Average		**0.0011 ± 0.0005**	**0.0128 ± 0.0011**

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

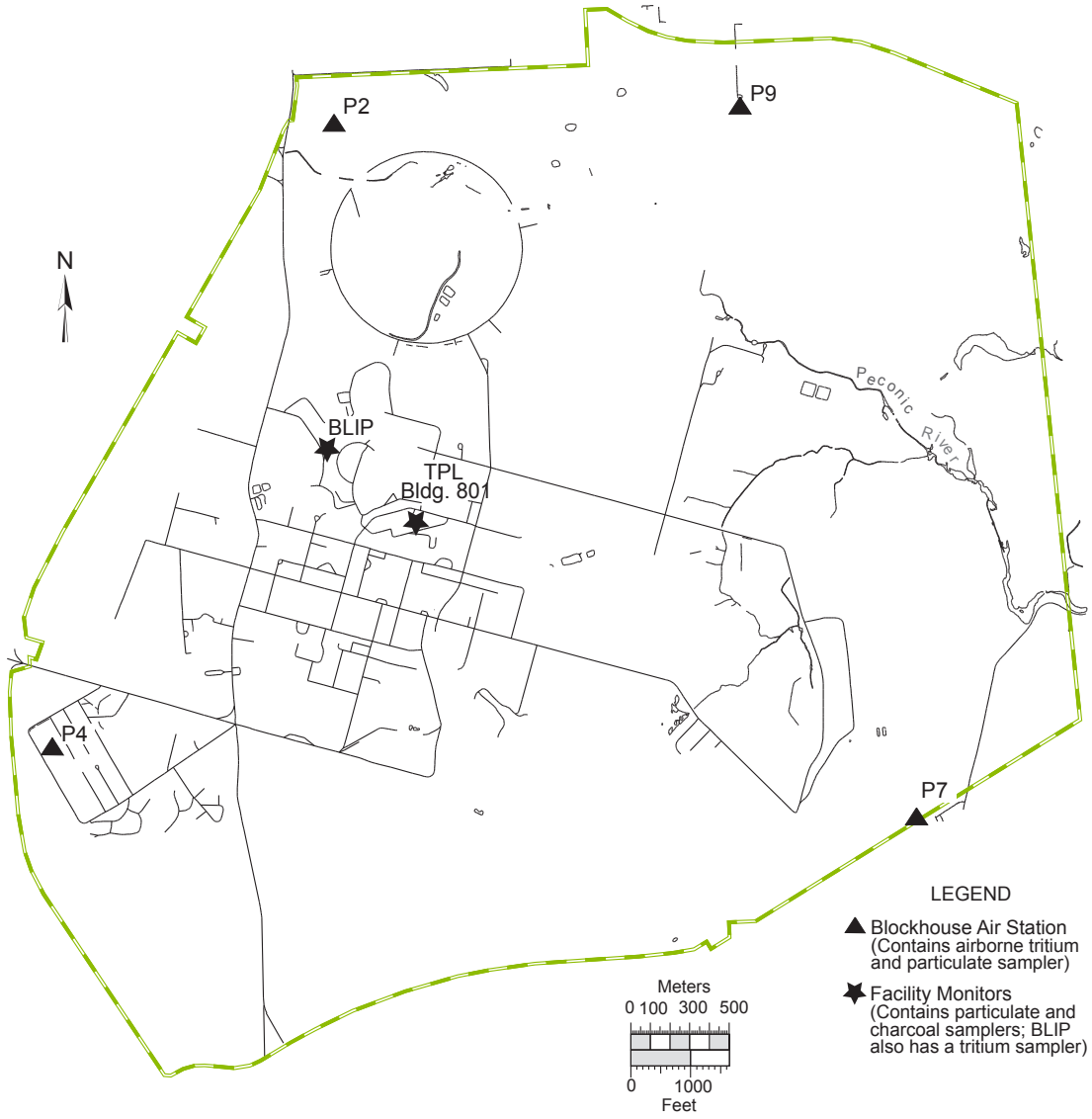


Figure 4-2. BNL On-Site Ambient Air Monitoring Stations.

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 0.0039 and 0.0162 pCi/m^3, with an average concentration of 0.0082 pCi/m^3. BNL results ranged from 0.0087 to 0.0427 pCi/m^3, with an average concentration of 0.0140 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 2019, NYSDOH reported that airborne gross beta activity at that location varied between 0.0010 and 0.0199 pCi/m^3 and had an average concentration of 0.0099 pCi/m^3. All but five of the BNL samples 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 tritiated water (HTO) is monitored throughout the BNL site. In 2019, 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 2019. The average tritium concentrations at all the sampling locations were less than the typical minimum detection limits, ranging from 4.0 to 11.0 pCi/m^3.

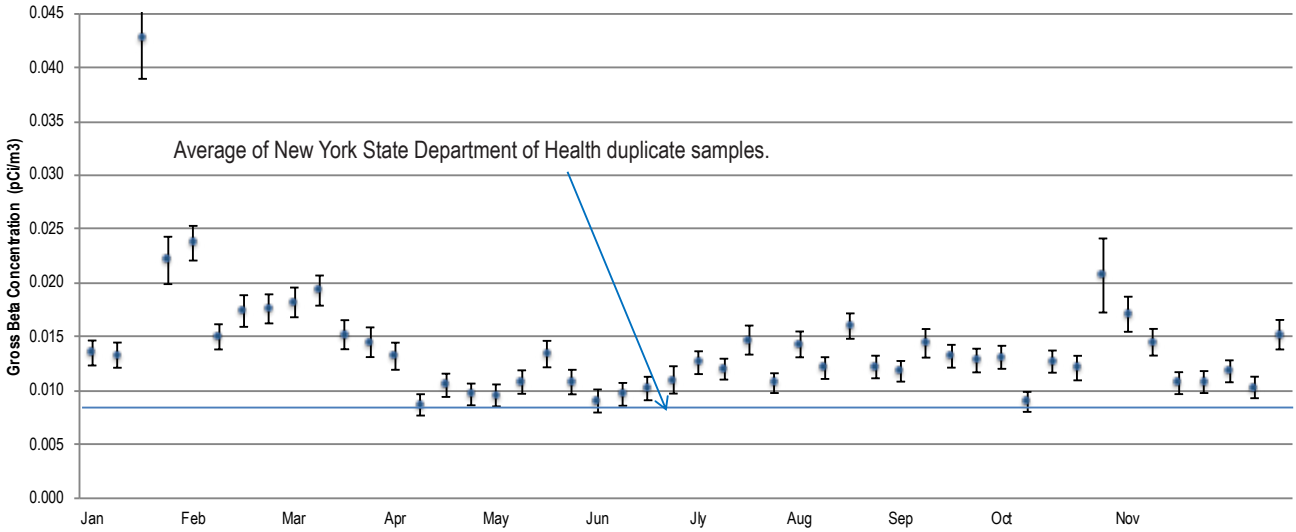
4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing non-radiological 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 non-radiological 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 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).

The Subpart 227-2 NOx RACT emission limit for the combustion of natural gas and the combustion of No. 6 oil burned in the CSF three large boilers is 0.15 lbs/MMBtu. The NOx RACT emission limit for the CSF's one mid-size boiler (Boiler 1A) is 0.20 lbs/MMBtu. From May 1 to September 15 of each year, the peak ozone period, owners and operators of 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



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

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

emissions testing. Following the end of each calendar quarter, facilities with boilers equipped with CEMS must tabulate and summarize emissions, monitoring, and operating parameter measurements recorded during the preceding three months. Measured opacity levels cannot exceed 20 percent opacity, except for one six-minute period per hour of not more than 27 percent opacity.

When No. 6 oil was burned, past emissions testing and CEMS results have shown that CSF boilers 5, 6, and 7 cannot meet the new lower NOx RACT standards; therefore, BNL uses an approved system averaging plan to demonstrate compliance in quarterly reports submitted to NYSDEC. This plan utilizes 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 Boilers 5, 6, and 7 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 0.081, 0.083, 0.087, and 0.085 lbs/MMBtu, while the corresponding permissible weighted average emissions rate for all four quarters was 0.150 lbs/MMBtu.

In 2019, there were five recorded excess opacity measurements. Three recorded readings on January 23 were due to the start-up and shutdown of Boiler 6 in preparation for periodic emissions tests conducted later that day, and two Boiler 6 excess opacity readings on December 30 were due to unknown causes. 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 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 2019. 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. To fulfill periodic testing requirements of the Laboratory's Title V operating permit, emission

Table 4-4. Ambient Airborne Tritium Measurements in 2019.

Sample Station	Wind Sector	Validated Samples	Maximum (pCi/m³)	Average (pCi/m³)
P2	NNW	24	13.3 ± 6.2	1.2 ± 3.8
P4	WSW	25	17.7 ± 9.9	2.1 ± 4.4
P7	ESE	23	11.6 ± 7.2	2.1 ± 4.0
P9	NE	24	12.0 ± 9.2	1.7 ± 6.2
Grand Average				**1.8 ± 4.6**

Notes:
See Figure 4-2 for station locations.
Wind sector is the downwind direction of the sample station from the High Flux Beam Reactor (HFBR) stack.
All values reported with a 95% confidence interval.
Typical minimum detection limit for tritium is between 4.0 and 11.0 pCi/m3.

tests of Boilers 6 and 7 originally scheduled for the first week of December 2018 were delayed until January 23, 2019.

Results of particulate matter emissions tests when the boilers burned No. 6 oil at high load conditions confirmed that Boilers 1A, 5, and 6 met the 6 NYCRR Subpart 227-1 applicable emission standard of 0.2 lbs/MMBtu, while Boiler 7 met the 40 CFR 60 Subpart Db emission standard of 0.1 lbs/MMBtu. The tests also confirmed that Boiler 1A and 5 met their respective Subpart 227-2 NOx RACT emission limits of 0.2 lbs/MMBtu for No. 6 oil and 0.15 lbs/MMBtu for natural gas. Since Boiler 5 NOx emission test results averaged 0.22 lbs/MMBtu when No. 6 oil was fired, the Laboratory will utilize its approved system averaging plan to demonstrate compliance in quarters when Boiler 5 burns No. 6 oil.

In 2019, residual fuel prices exceeded those of natural gas for most of the year. As a result, natural gas was used to supply 99.6 percent of the heating and cooling needs of BNL's major facilities. By comparison, in 2016, residual fuel satisfied 21.0 percent of the major facility heating and cooling needs. Consequently, 2019 emissions of particulates, NOx, and sulfur dioxide (SO2) were 5.1, 1.5, and 18.5 tons less than the respective totals for 2016, 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 2010.

4.5 GREENHOUSE GAS EMISSIONS

Signed in May 2018, Executive Order (EO) 13834, Efficient Federal Operations, replaced EO 13693, Planning for Federal Sustainability in the Next Decade, which established sustainability goals for federal agencies. Since implementation instructions for EO 13834 were not released until April 2019, the Laboratory continued to follow the guidance, recommendations, plans, and numerical targets set forth in EO 13693 in 2019.

One of the overarching goals of EO 13693 is for federal agencies to establish agency-wide greenhouse gas (GHG) reduction targets for their combined Scope 1 and 2 GHG emissions and for their Scope 3 GHG 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 2019). 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 was estimated 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. To date, it has exceeded the estimate every year; in 2019, the LISF provided 50.6 million kilowatt-hours of solar energy to Long Island. This equates to 33,828 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 2019, BNL consumed 118,847 megawatts of hydropower, providing a net combined GHG reduction of 97,629 $MtCO_2e$ from the LISF and

Table 4-5. Central Steam Facility Fuel Use and Emissions (2010–2019).

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)
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
2018	36.04	5,409	0.04	6	642.33	662,242	2.5	31.5	1.0	1.8
2019	15.56	2,335	0.13	17.94	588.49	649,343	2.3	28.5	0.5	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

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 2019, it provided 1,018,000 kWh and offset 1,179 $MtCO_2e$.

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, and air conditioning temperature setbacks in nine buildings.

The UESC project has been a success, with annual energy savings within three percent of the original estimates for each of the five full years since completion. In FY 2018, an investment grade audit (IGA) was initiated for potential Phase II UESC projects. In 2019, the IGA was completed and the process to issue a contract was begun. Planned energy savings projects under consideration include additional lighting and building control upgrades, free cooling, and some HVAC improvements for the Chemistry Building. BNL continues to 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 base-line of 20,136 $MtCO_2e$. Overall, Scope 3 GHG emissions increased by 4,809 $MtCO_2e$, up 32 percent from FY 2018, and two percent less than the FY 2008 baseline value of 20,136 $MtCO_2e$.

The increase from FY 2018 is mostly due to a 3,975 MT CO_2e rise in GHG emissions from business air travel, a 452 MT CO_2e increase in GHG emissions from the disposal of municipal solid waste (MSW), and a 381 MT CO_2e increase in commuting GHG emissions. The increase in air travel GHG emissions was primarily due to a 234 percent rise in long haul passenger miles traveled for flights greater than 700 miles, which accounted for more than 99

percent of the increase. The GHG emissions increase from the disposal of MSW was due to a contract change that resulted in the wastes being hauled to an offsite landfill, which produces significantly higher GHG emissions from the anaerobic digestion of MSW, than the waste-to-energy facility in Hempstead where they had been combusted in the past. Commuting GHG rose mostly due to a 4.5 percent increase in the average number of employees commuting each day from 1,969 in FY 2018 to 2,057 in FY 2019, and a four-day increase in the number of work days for the average employee. The following actions were taken in 2019 to promote ridesharing:

- During BNL's Celebration of Earth Day on April 20, a representative of New York State's 511NYRideshare program disseminated information on ridesharing and its benefits to employees.
- BNL participated in Car Free Day Long Island on September 20, 2019, an annual event to increase employee awareness and appreciation of the environmental, health, and economic benefits of sustainable means of transportation. Through various promotional efforts, employees were encouraged to make a pledge on the Car Free Day Long Island website to be car-free or car-lite on September 20 and commit to drive less by carpooling, biking, walking, or teleworking. More than 25 employees participated by making pledges to carpool, bike, walk, and telework 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 2019 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, with the exception of multiple tolytriazol exceedances, organic and inorganic parameters were within State Pollutant Discharge Elimination System (SPDES) effluent limits 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.

The Peconic River flowed the first half of 2019, then stopped flowing offsite by July as groundwater levels began subsiding. 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 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 former STP outfall, 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 its 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).

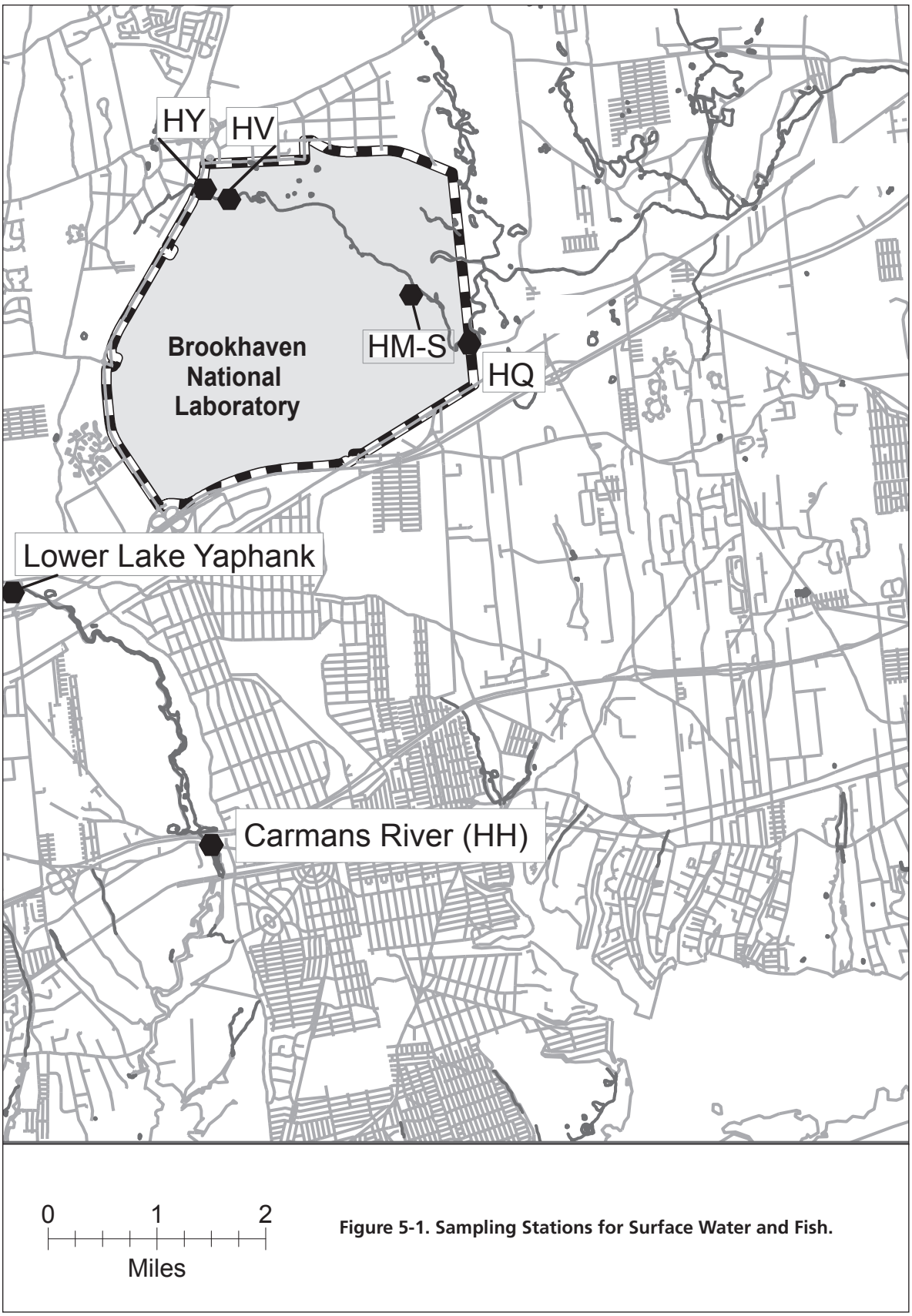

Figure 5-1. Sampling Stations for Surface Water and Fish.

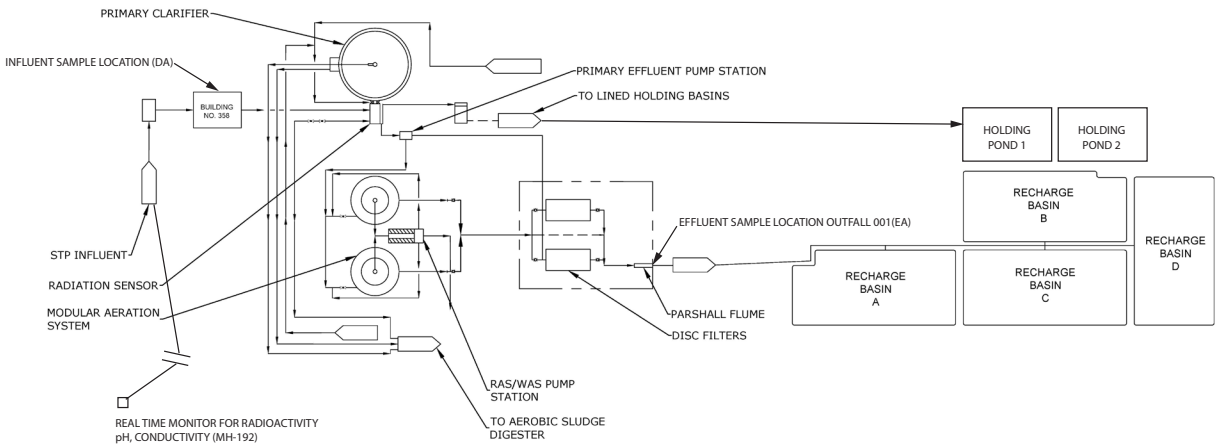

Figure 5-2. Schematic of BNL's Sewage Treatment Plant (Recharge Basin Discharge)

The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by operations at BNL and is not connected to 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 off-site flow during the first half of 2019 followed by drying conditions through the end of the year. The fluctuating cycles with periods of flow and no-flow are indicative of the combined influences of precipitation and groundwater.

Historical monitoring data indicates no significant variations in water quality throughout the Peconic River system on site, 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.

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.

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.

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*	2.38E+07	< 368	< MDL	< 3.1	0.3 ± 0.4	5.1 ± 1.4	4.3 ± 0.7
	effluent	1.60E+07	< 364	< MDL	< 2.6	0.8 ± 0.4	5.7 ± 1.4	4.2 ± 1.4
February	*influent*	2.40E+07	< 399	< MDL	< 6.2	0.9 ± 1.5	7.2 ± 2.7	4.6 ± 1.8
	effluent	2.40E+07	< 399	< MDL	< 2.5	0.3 ± 0.9	3.3 ± 1.2	2.6 ± 0.8
March	*influent*	2.33E+07	< 390	< MDL	< 3.9	0.2 ± 1.2	5.4 ± 2.1	5.0 ± 0.4
	effluent	2.79E+07	< 384	< MDL	< 3.0	0.7 ± 1.1	5.2 ± 1.5	4.0 ± 1.0
April	*influent*	2.95E+07	< 320	< MDL	< 3.6	1.1 ± 1.3	5.8 ± 1.2	5.1 ± 1.0
	effluent	3.65E+07	< 322	< MDL	< 1.8	0.0 ± 0.3	5.8 ± 1.1	4.4 ± 0.7
May	*influent*	3.07E+07	< 268	< MDL	< 2.5	0.3 ± 1.1	5.7 ± 1.3	5.1 ± 0.5
	effluent	2.94E+07	< 321	< MDL	< 1.9	0.1 ± 1.0	4.4 ± 0.9	3.9 ± 0.4
June	*influent*	3.10E+07	< 456	< MDL	< 2.6	1.5 ± 1.2	8.3 ± 1.4	7.2 ± 1.7
	effluent	2.56E+07	< 418	< MDL	< 1.8	0.3 ± 0.3	5.7 ± 1.0	4.8 ± 0.9
July	*influent*	3.13E+07	< 401	< MDL	< 5.4	1.5 ± 1.8	17.1 ± 1.7	8.2 ± 5.8
	effluent	3.39E+07	< 419	< MDL	< 2.1	0.3 ± 0.6	6.6 ± 1.6	5.6 ± 0.6
August	*influent*	2.82E+07	< 360	< MDL	< 2.1	0.4 ± 0.1	7.4 ± 4.5	5.4 ± 1.5
	effluent	2.01E+07	< 380	< MDL	< 1.2	-0.3 ± 0.6	4.7 ± 0.7	4.1 ± 1.0
September	*influent*	3.19E+07	< 389	< MDL	< 12.0	2.7 ± 3.7	15.6 ± 5.8	7.1 ± 4.6
	effluent	2.74E+07	< 393	< MDL	2.9 ± 3.0	0.7 ± 1.6	11.2 ± 3.6	6.0 ± 3.0
October	*influent*	2.51E+07	< 378	< MDL	< 10.2	-2.2 ± 1.8	9.3 ± 2.8	6.4 ± 2.6
	effluent	2.05E+07	< 345	< MDL	< 4.0	-2.4 ± 1.2	5.4 ± 1.2	4.6 ± 0.6
November	*influent*	1.82E+07	<231	< MDL	< 16.5	7.1 ± 5.0	11.6 ± 3.8	8.2 ± 4.1
	effluent	2.01E+07	<242	< MDL	< 3.5	-2.0 ± 1.0	5.8 ± 1.4	5.0 ± 1.1
December	*influent*	2.24E+07	< 411	< MDL	< 4.1	-3.7 ± 4.9	8.2 ± 2.9	5.4 ± 1.8
	effluent	2.41E+07	< 326	< MDL	< 4.1	-1.0 ± 1.8	4.9 ± 1.3	3.8 ± 0.5
Annual Avg.	*influent*			< MDL		1.8 ± 2.2		6.0 ± 0.8
	effluent			< MDL		-0.2 ± 0.4		4.5 ± 0.4
Total Release		**3.06E+08**		**8.8 mCi (a)**		**0.1 mCi**		**1.3 mCi**
Average MDL (pCi/L)				**363.3**		**2.9**		**1.5**
SDWA Limit (pCi/L)				**20000**		**15**		**50 (b)**

Notes:
All values above MDL are reported with a 95% confidence interval.
To convert values from pCi to Bq, divide by 27.03.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
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.

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. 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 2019, there were no instances where influent water quality required diversion of wastewater to the hold-up ponds.

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 more stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of

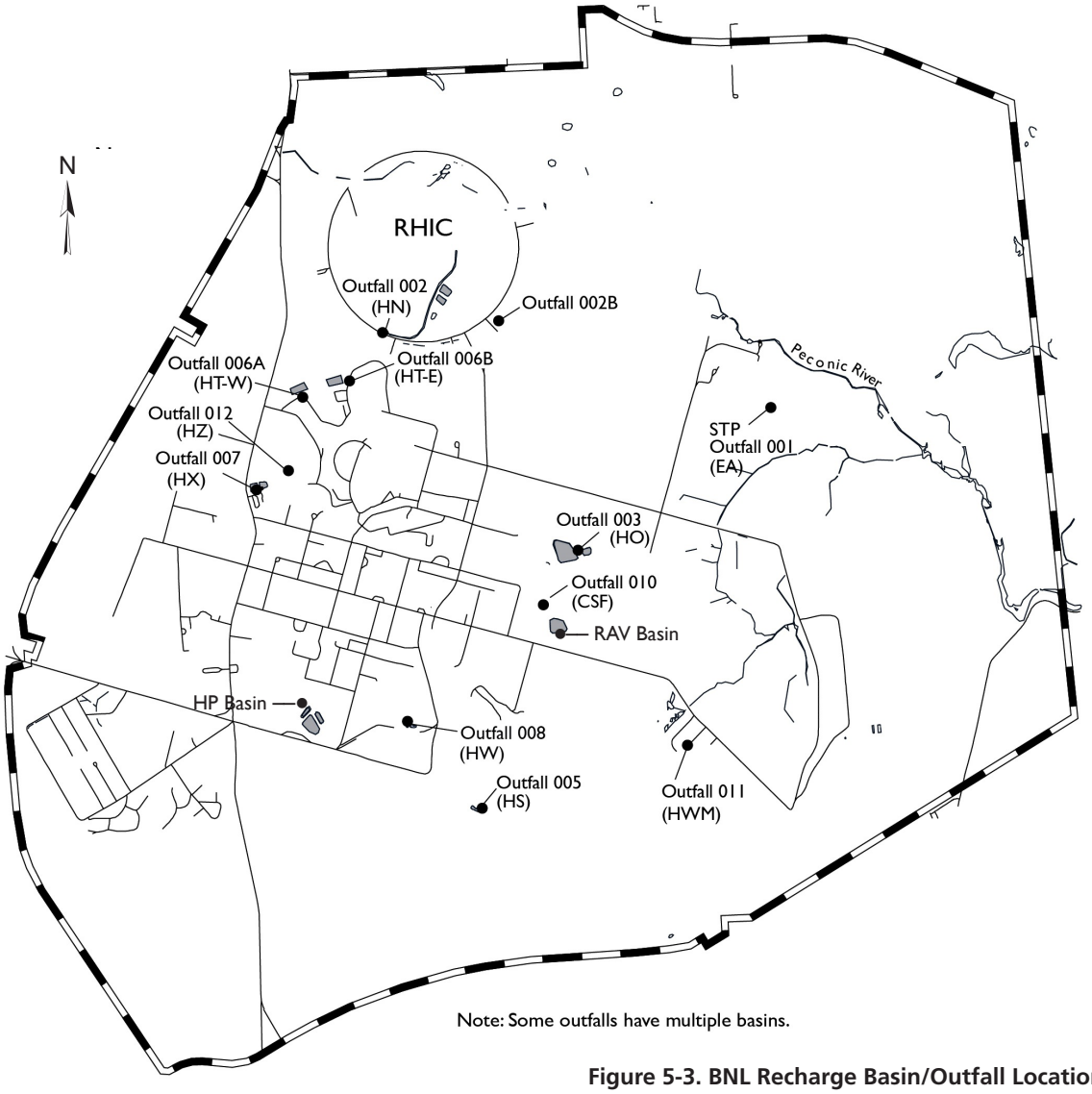

Figure 5-3. BNL Recharge Basin/Outfall Locations.

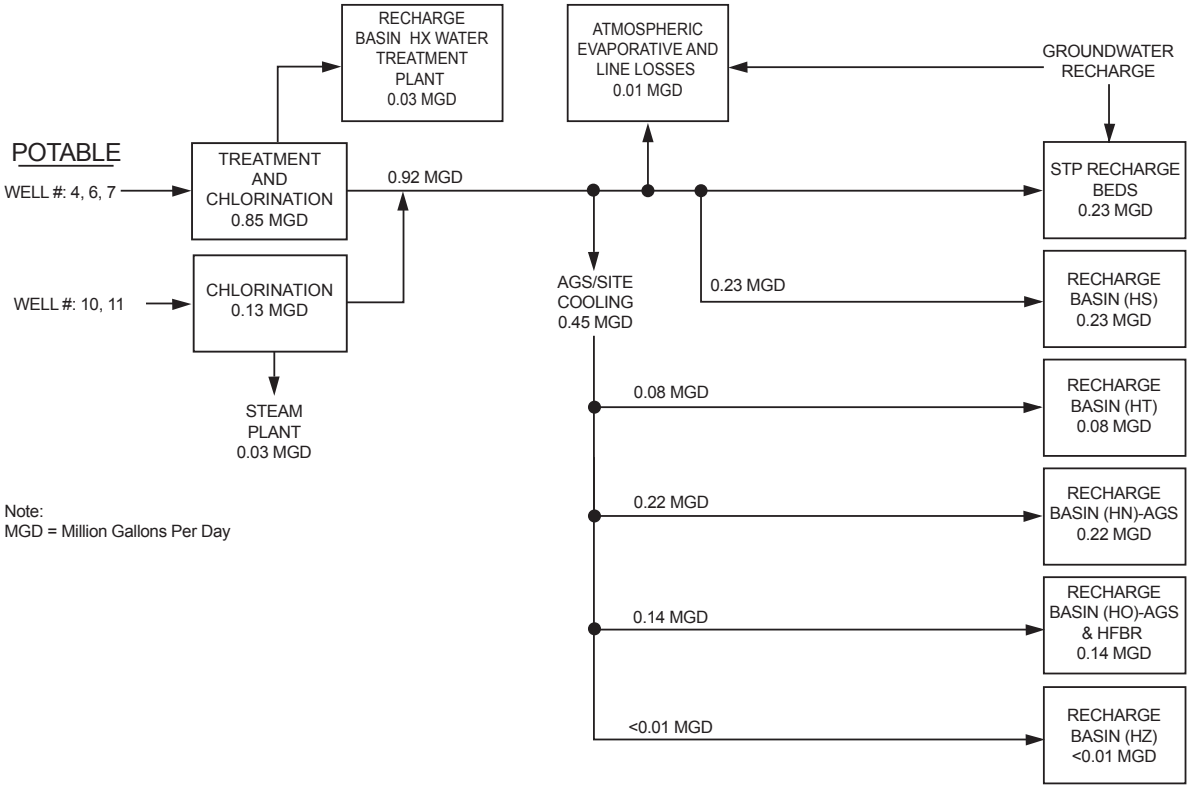

Figure 5-4. Schematic of Potable Water Use and Flow at BNL.

Department of Energy wastewater criteria. Under the SDWA, water standards are based on a 4 mrem (40 µSv) dose limit. The SDWA specifies that no individual may receive an annual dose greater than 4 mrem from radionuclides that are beta or photon emitters, which includes up to 168 individual radioisotopes. BNL performs radionuclide-specific gamma analysis to ensure compliance with this standard. The SDWA annual average gross alpha activity limit is 15 pCi/L, including radium-226 (Ra-226: half-life, 1,600 years), but excluding radon and uranium. Other SDWA-specified drinking water limits are 20,000 pCi/L for tritium (H-3: half-life, 12.3 years), 8 pCi/L for Sr-90, 5 pCi/L for Ra-226 and radium-228 (Ra-228: half-life, 5.75 years), and 30 µg/L for uranium. Gross alpha and beta activity measurements are used as a screening tool for detecting the presence of radioactivity.

Table 5-1 shows the monthly gross alpha and beta activity data and tritium concentrations for the STP influent and effluent during 2019. Annual average gross alpha and beta activity levels in the STP effluent were -0.2 ± 0.4 pCi/L and 4.5 ± 0.4 pCi/L, respectively. The gross alpha average concentrations were lower than those measured at the Carman's River control location (HH) while the gross beta was higher than the control location reported in Table 5-5; however, they were well below the SDWA standards that are used for comparison purposes. Tritium was not detected above MDL in the discharge of the STP (EA, Outfall 001) for the entire year. In 2019, there were no gamma-emitting nuclides detected in the STP effluent.

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 2020).

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 2019, 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 2020). 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 On-Site Recharge Basins.

Basin		Gross Alpha	Gross Beta	Tritium
		(pCi/L)		
No. of samples		2	2	2
HN	*max.*	< 1.97	2.37 ± 0.92	< 312
	avg.	0.53 ± 0.08	2.3 ± 0.15	< MDL
HO	*max.*	< 1.94	< 1.34	< 318
	avg.	0 ± 0.48	0.92 ± 0.14	< MDL
HS	*max.*	2.09 ± 1.46	4.14 ± 1.12	< 317
	avg.	1.32 ± 1.52	3.61 ± 1.04	< MDL
HT-E	*max.*	< 1.87	3.29 ± 1.22	< 320
	avg.	0.39 ± 0.61	2.46 ± 1.64	< MDL
HT-W	*max.*	< 1.76	1.43 ± 0.8	< 312
	avg.	-0.04 ± 0.02	1.27 ± 0.31	< MDL
HW	*max.*	< 1.93	1.58 ± 1	< 305
	avg.	1.01 ± 1.2	1.18 ± 0.78	< MDL
HZ	*max.*	< 1.97	1.32 ± 0.74	< 380
	avg.	0.16 ± 0.53	0.54 ± 1.53	< MDL
SDWA Limit		**15**	**(a)**	**20,000**

Notes:
See Figure 5-3 for recharge basin/outfall locations.
All values above MDL 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-

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

ANALYTE		Recharge Basin HN (RHIC)	HO (AGS)	HS (s)	HT-W (Linac)	HT-E (AGS)	HW (s)	CSF (s)	HZ (s)	NYSDEC Effluent Standard	Typical MDL
No. of samples		2	2	2	2	2	2	2	2		
pH (SU)	*min.*	7.6	7.4	7.5	7.6	7.4	7.5	7.5	7.5	6.5 - 8.5	NA
	max.	7.7	7.7	7.9	7.9	7.8	7.6	8.4	7.5		
Conductivity (µS/cm)	*min.*	526	236	314	229	345	31	86	216	SNS	NA
	max.	566	245	587	282	1049	317	259	235		
	avg.	546	240.5	450.5	255.5	697	174	172.5	225.5		
Temperature (°C)	*min.*	9.9	14.8	8.1	9.9	10.4	9.4	10.3	13.0	SNS	NA
	max.	25.7	23.7	23.7	24.5	25.1	23.5	23.6	21.8		
	avg.	17.8	19.2	15.9	17.2	17.8	16.4	17.0	17.4		
Dissolved oxygen (mg/L)	*min.*	8.1	9.0	9.9	8.9	9.0	8.8	8.4	9.4	SNS	NA
	max.	11.5	10.5	12.1	11.7	11.9	11.7	11.2	11.0		
	avg.	9.8	9.8	11.0	10.3	10.4	10.2	9.8	10.2		
Chlorides (mg/L)	*min.*	92.5	39.2	61.9	41.3	51.8	2.6	5.8	33.4	500	2.1
	max.	99.1	42.6	144.0	42.2	196.0	80.0	61.0	38.5		
	avg.	95.8	40.9	103.0	41.8	123.9	41.3	33.4	36.0		
Sulfates (mg/L)	*min.*	12.5	9.2	3.9	9.9	8.8	1.1	0.9	8.5	500	0.6
	max.	18.7	9.9	10.6	10.4	11.5	1.1	2.3	10.0		
	avg.	15.6	9.5	7.3	10.2	10.1	1.1	1.6	9.2		
Nitrate as nitrogen (mg/L)	*min.*	0.21	0.22	0.34	0.24	0.24	0.12	0.12	0.23	10	0.05
	max.	0.31	0.26	0.57	0.25	0.28	0.05	0.05	0.27		
	avg.	0.26	0.24	0.45	0.24	0.26	0.09	0.08	0.25		

Notes:
See Figure 5-3 for recharge basin/outfall locations.
NA = not applicable
(s) = stormwater
NYSDEC = New York State Department of Environmental Conservation
AGS = Alternating Gradient Synchrotron
RHIC = Relativistic Heavy Ion Collider
Linac = Linear Accelerator
SNS = effluent standard not specified

through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS), LINAC 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 Computational Science Initiative 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.

Each of the recharge basins is a permitted point-source discharge under the Laboratory's

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

METAL		Recharge Basin HO (AGS/HFBR)		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.*	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	50	1
	max.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
	avg.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Al Aluminum (µg/L)	*min.*	< 68.0	< 68.0	< 68.0	< 68.0	< 68.0	< 68.0	< 68.0	< 68.0	2000	68
	max.	< 68.0	< 68.0	< 68.0	< 68.0	101	< 68.0	< 68.0	< 68.0		
	avg.	< 68.0	< 68.0	< 68.0	< 68.0	84.5	< 68.0	< 68.0	< 68.0		
As Arsenic (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	50	2
	max.	2.3	2.1	< 2.0	< 2.0	< 2.0	< 2.0	2.3	2.2		
	avg.	2.1	2.0	< 2.0	< 2.0	< 2.0	< 2.0	2.1	2.1		
Ba Barium (µg/L)	*min.*	21.3	19.8	26.7	26.3	21.1	20.8	18.3	17.0	2000	1
	max.	24.6	23.2	27.1	27.8	23.7	22.0	20.0	20.1		
	avg.	23.0	21.5	26.9	27.1	22.4	21.4	19.2	18.6		
Be Beryllium (µg/L)	*min.*	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	SNS	1
	max.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
	avg.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Cd Cadmium (µg/L)	*min.*	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	10	1
	max.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
	avg.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Co Cobalt (µg/L)	*min.*	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	1
	max.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
	avg.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Cr Chromium (µg/L)	*min.*	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	100	1
	max.	1.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
	avg.	1.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Cu Copper (µg/L)	*min.*	3.0	2.9	3.0	3.0	11.0	3.9	3.4	3.7	1000	2
	max.	1.6	3.0	6.0	4.9	13.1	10.9	39.3	33.7		
	avg.	2.3	2.9	4.5	4.0	12.1	7.4	21.3	18.7		
Fe Iron (mg/L)	*min.*	0.06	0.04	0.09	0.05	0.03	< 0.03	0.03	< 0.03	0.6	0.03
	max.	0.11	0.07	0.14	0.06	0.26	0.05	0.07	0.05		
	avg.	0.08	0.05	0.12	0.05	0.14	0.04	0.05	0.04		
Hg Mercury (µg/L)	*min.*	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.4	0.1
	max.	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1		
	avg.	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1		
Mn Manganese (µg/L)	*min.*	3.0	2.0	4.1	2.3	1.7	< 2.0	< 2.0	< 2.0	600	2
	max.	5.3	2.2	8.9	6.3	13.7	3.7	4.2	3.9		
	avg.	4.1	2.1	6.5	4.3	7.7	2.4	3.1	3.0		

(continued on next page)

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

METAL		Recharge Basin HO (AGS/HFBR)		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.*	25.5	25.4	37.3	38.6	28.4	28.0	20.6	21.0	SNS	0.1
	max.	26.5	25.6	130.0	127.0	29.6	29.7	25.3	24.7		
	avg.	26.0	25.5	83.7	82.8	29.0	28.9	23.0	22.9		
Ni Nickel (µg/L)	*min.*	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	200	1.5
	max.	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5		
	avg.	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5		
Pb Lead (µg/L)	*min.*	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50	0.5
	max.	< 0.5	< 0.5	< 0.5	< 0.5	1.7	< 0.5	11.2	8.6		
	avg.	< 0.5	< 0.5	< 0.5	< 0.5	1.1	< 0.5	5.9	4.6		
Sb Antimony (µg/L)	*min.*	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	6	3.5
	max.	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5		
	avg.	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5		
Se Selenium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	20	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		
Tl Thallium (µg/L)	*min.*	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	SNS	0.6
	max.	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6		
	avg.	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6		
V Vanadium (µg/L)	*min.*	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	SNS	1
	max.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
	avg.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		
Zn Zinc (µg/L)	*min.*	3.3	3.7	16.3	14.0	18.0	15.6	19.7	23.1	5000	3.3
	max.	6.9	5.5	25.3	21.8	42.0	22.0	38.8	37.7		
	avg.	5.1	4.6	20.8	17.9	30.0	18.8	29.3	30.4		

Notes:
See Figure 5-3 for recharge basin/outfall locations.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards
Linac = Linear Accelerator
HFBR = High Flux Beam Reactor
SNS = effluent standard not specified
MDL = Method Detection Limit

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 2019, 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 (due to absence of 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.

Sampling Station		Gross Alpha	Gross Beta	Tritium	Strontium-90
		(pCi/L)			
HY (headwaters) on site, west of the RHIC ring	*N*	2	2	2	2
	max	< 1.52	11.4 ± 1.72	< 393	< 0.27
	avg	0.13 ± 0.41	6.46 ± 9.69	<MDL	0.11 ± 0.14
HV (headwaters) on site, inside the RHIC ring	*N*	2	2	2	NS
	max	< 2.36	3.47 ± 0.94	< 395	
	avg	2 ± 0.68	2.86 ± 1.21	<MDL	
HM-S tributary, on-site	*N*	1	1	1	1
	max	< 1.82	< 1.62	< 397	< 0.7
	avg	NA	NA	NA	NA
HQ BNL site boundary	*N*	3	3	3	3
	max	< 1.96	39.9 ± 2.17	< 319	< 0.83
	avg	0.64 ± 0.85	15.15 ± 24.27	<MDL	0.44 ± 0.1
Carmans River HH control location, off site	*N*	1	1	2	2
	max	< 1.76	< 1.11	< 375	0.24 ± 0.15
	avg	NA	NA	<MDL	0.13 ± 0.23
SDWA Limit (pCi/L)		**15**	**(a)**	**20,000**	**8**

Notes:
See Figure 5-1 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 2.09 ± 1.46 pCi/L and gross beta activity ranged from non-detect to 4.14 ± 1.12 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. All tritium values were below the method detection levels and were well below the 20,000 pCi/L drinking water standard.

5.4.2 Recharge Basins – Nonradiological Analyses

During 2019, discharge samples were collected semi-annually for water quality parameters, metals, and VOCs. Field-measured parameters (e.g, 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 break down to bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Concentrations were above the 1 ug/L method detection limit at Basins HO, HT-E, HT-W, and

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

Analyte		Peconic River Station Locations HY	HM-S	HQ	Carmans River HH (Control)	NYSDEC Effluent Standard	Typical MDL
No. of samples		2	1	3	2		
pH (SU)	*min.*	5.7	-	4.8	6.7	6.5 - 8.5	NA
	max.	6.8	4.1	6.5	6.7		
Conductivity (µS/cm)	*min.*	78	-	181	156	SNS	NA
	max.	123	35	560	247		
	avg.	101	-	311	202		
Temperature (°C)	*min.*	7.0	-	2.1	9.3	SNS	NA
	max.	17.7	7.5	24.4	16.6		
	avg.	12.4	-	14.3	13.0		
Dissolved oxygen (mg/L)	*min.*	8.1	-	1.3	9.4	SNS	NA
	max.	10.4	9.3	11.5	11.0		
	avg.	9.3	-	5.2	10.2		
Chlorides (mg/L)	*min.*	16.0	-	12.0	46.0	250 (a)	2.3
	max.	50.0	4.5	29.7	47.0		
	avg.	33.0	-	19.3	46.5		
Sulfate (mg/L)	*min.*	1.8	-	3.4	11.0	250 (a)	1
	max.	3.1	5.4	12.2	12.0		
	avg.	2.5	-	6.8	11.5		
Nitrate as nitrogen (mg/L)	*min.*	0.02	-	0.02	2.50	10 (a)	0.01
	max.	0.34	0.05	0.10	2.50		
	avg.	0.18	-	0.04	2.50		

Notes:
See Figure 5-1 for monitoring locations.
HY = Peconic River headwaters, on site, east of Wm Floyd Pkwy.
HQ = Peconic River on site at east boundary
HM-S = Peconic River tributary at east firebreak
HH = Carmans River control location, off site
NYSDEC = New York State Department of Environmental Conservation
SNS = effluent standard not specified
(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.

HN for all disinfection byproducts, the highest values all being under 9.26 ug/L, which was the highest value recorded for bromoform. The only other VOC detected above method detection limits was methylene chloride, which was detected in Basin HN during July 2019 at a concentration of 2.23 ug/L, just above the method detection limit of 2 ug/L and likely attributed to cross-contamination within the contract laboratory.

The analytical data presented in Table 5-3 show that, for 2019, the concentrations of all analytes were within effluent standards, including chlorides. Historically, chlorides are found to be higher in samples collected during the winter and are attributed to road salt used to control snow and ice buildup. The mild conditions during winter months in 2019 resulted in lower salt use. The data in Table 5-4 show that all parameters complied with the respective water quality or groundwater discharge standards.

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

METAL		Peconic River Locations								NYSDEC AWQS (a)	Typical MDL
		HY		HM-S		HQ		HH(Control)			
Total (T) or Dissolved (D)		T	D	T	D	T	D	T	D		
No. of samples		2	2	1	1	3	3	2	2		
Ag (I) Silver (µg/L)	*min.*	< 2.0	< 2.0	-	-	< 2.0	< 2.0	< 2.0	< 2.0	0.1	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		
Al (I) Aluminum (µg/L)	*min.*	250	290	-	-	< 68	< 68	25	50	100	50
	max.	610	430	780	770	260	300	91	70		
	avg.	430	360	-	-	187	193	58	60		
As (D) Arsenic (µg/L)	*min.*	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0	150	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	< 20	< 20	-	-	< 20	< 20	36	43	SNS	20
	max.	< 20	< 20	< 20	< 20	< 20	< 20	46	48		
	avg.	< 20	< 20	-	-	< 20	< 20	41	46		
Be (AS) Beryllium (µg/L)	*min.*	< 2.0	< 2.0	-	-	< 2.0	< 2.0	< 2.0	< 2.0	11	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	-	-	< 2.0	< 2.0	< 2.0	< 2.0		
Cd (D) Cadmium (µg/L)	*min.*	< 2.0	< 2.0	-	-	< 2.0	< 2.0	< 2.0	< 2.0	1.1	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		
Co (AS) Cobalt (µg/L)	*min.*	< 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		
Cr (I) Chromium (µg/L)	*min.*	< 10.0	< 10.0	-	-	< 10.0	< 10.0	< 10.0	< 10.0	34	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	-	-	< 10.0	< 10.0	< 10.0	< 10.0		
Cu (D) Copper (µg/L)	*min.*	25	27	-	-	< 10.0	< 10.0	19	< 10.0	4	10
	max.	25	100	22	< 10.0	< 10.0	< 10.0	89	24		
	avg.	25	64	-	-	< 10.0	< 10.0	54	17		
Fe (AS) Iron (mg/L)	*min.*	0.62	0.40	-	-	0.43	0.33	0.24	0.06	0.3	0.05
	max.	1.40	3.50	0.31	0.30	1.15	0.72	0.32	0.14		
	avg.	1.01	1.95	-	-	0.71	0.53	0.28	0.99		
Hg (D) Mercury (µg/L)	*min.*	< 0.2	< 0.2	-	-	< 0.2	< 0.2	< 0.2	< 0.2	0.2	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	-	-	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	29	24	-	-	12	12	62	58	SNS	4
	max.	41	32	13	13	161	111	95	120		
	avg.	35	28	-	-	66	51	78.5	89		
Na Sodium (mg/L)	*min.*	12	54	-	-	7.5	9.4	2.5	29	SNS	0.25
	max.	38	13	2.9	2.8	21.2	20.9	2.9	32		
	avg.	25	33.5	-	-	13.5	14.0	2.7	30.5		

(continued on next page)

Table 5-7: Metals Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers *(concluded).*

METAL		Peconic River Locations								NYSDEC AWQS (a)	Typical MDL
		HY		HM-S		HQ		HH(Control)			
Total (T) or Dissolved (D)		T	D	T	D	T	D	T	D		
No. of samples		2	2	1	1	3	3	2	2		
Ni (D) Nickel (µg/L)	*min.*	< 10.0	< 10.0	-	-	< 10.0	< 10.0	< 10.0	< 10.0	23	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		
Pb (D) Lead (µg/L)	*min.*	< 3.0	3.4	-	-	< 3.0	< 3.0	< 3.0	< 3.0	0.1	3
	max.	4.2	9.7	< 3.0	< 3.0	< 3.0	< 3.0	5.1	< 3.0		
	avg.	3.3	6.6	-	-	< 3.0	< 3.0	3.3	< 3.0		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	7.5	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	5.3	< 5.0	< 5.0	< 5.0		
Se (D) Selenium (µg/L)	*min.*	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0	4.6	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0		
Tl (AS) Thallium (µg/L)	*min.*	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0	8	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		
V (AS) Vanadium (µg/L)	*min.*	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0	14	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	< 5.0	< 5.0	< 5.0	< 5.0		
Zn (D) Zinc (µg/L)	*min.*	32	34	-	-	< 20.0	< 20.0	< 20.0	< 20.0	37	20
	max.	38	150	25	< 20.0	< 20.0	< 20.0	62	21		
	avg.	35	92	-	-	< 20.0	< 20.0	39	< 20.0		

Notes:
See Figure 5-1 sampling station locations.
AWQS = Ambient Water Quality Standards
AS = Acid Soluble
SNS = effluent standard not specified for these elements in Class C surface waters
(a) NYS AWQS for Class C surface waters

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.

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 and 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 comply with regulatory requirements. Basin sediments were last sampled in 2017 and data were presented in Chapter 6 of the 2017 SER. 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, four stations (two upstream and two downstream of the former STP discharge) were sampled in 2019. 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 William Floyd Parkway
- HV, on site, just east of the 10 o'clock experimental hall in the RHIC Ring, radiological only

Downstream sampling stations:
- HM-S, on site, at east firebreak south of mainstem of Peconic
- HQ, on site, at east boundary of BNL

Control location:
- HH, Carmans River

5.5.1 Peconic River – Radiological Analyses

During 2019, radionuclide analyses were performed on surface water samples collected from the four Peconic River sampling locations and the Carmans River control location. HM-N, located at the east firebreak, was removed from sampling as HY and HV allow for radiological assessment of potential RHIC impacts and no other contributions from potential BNL operations enter the river until the tributary monitoring at HM-S. HQ sampling station is the final monitoring location before the river flows off site. The majority of the Peconic River on site held water for at least part of 2019. 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 nor Sr-90 was detected above method detection limits in any of the Peconic River samples. Sr-90 was detected at a maximum concentration of 0.24 ± 0.15 pCi/L and was just above the detection limit and well below the drinking water standard of 8 pCi/L. This value is consistent with background levels, and can be attributed to worldwide fallout.

5.5.2 Peconic River – Nonradiological Analyses

River water samples collected in 2019 were analyzed for water quality parameters (e.g. pH, temperature, conductivity, and dissolved oxygen), anions (e.g. 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 2019.

Water quality parameters measured in the three Peconic River locations and the Carmans River control location (HH) show that pH, temperature, conductivity, and dissolved oxygen levels were all 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 2019, 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 are found in high concentrations in native Long Island soil and, for iron, at high levels in groundwater. Levels of copper greater than the NYS AWQS were found at all locations except station HQ. Lead at concentrations greater than the NYS AWQS were found in samples collected at station HY on the Peconic River and HH on the Carmans River, while zinc was found at station HY, HM-S on the Peconic River, and HH on the Carmans River. Filtration of the samples reduced concentrations for some metals but not all, suggesting that suspended sediment was responsible for some metals in the samples.

REFERENCES AND BIBLIOGRAPHY

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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 2019, deer, vegetation, and soil sampling results were consistent with previous years' results.

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. In 2019, six additional buildings were determined to be eligible for listing on the National Register of Historic Places.

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 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.

Mapping associated with tracking impacts from the operation of the Long Island Solar Farm (LISF) at BNL continues to use GPS and GIS as tools to analyze changes to wildlife populations and vegetation. In 2019, natural resource personnel and interns continued to look at use of the LISF site by pollinators, changes in bird use, and changes in vegetation.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the BNL site. Through implementation of the NRMP, endangered and threatened species, as well as 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). New York State endangered animal species confirmed as currently

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

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
Rusty patched bumble bee	*Bombus affinis*	FE	Unlikely
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	*Setophaga discolor*	SGCN	Confirmed
Horned lark	*Eremophila alpestris*	SC	Confirmed
Perigrine Falcon	*Falco peregrinus*	E	Confirmed
Bald Eagle	*Haliaeetus leucocephalus*	T	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

continued on next page

inhabiting Laboratory property include the eastern tiger salamander *(Ambystoma t. tigrinum)* and the peregrine falcon *(Falco peregrinus)*. 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)*. Five other New York State endangered species have been identified at BNL in the past or are possibly present including: Persius duskywing *(Erynnis p. persius)*, crested fringed orchid *(Plantathera cristata)*, prostate knotweed *(Polygonum aviculare ssp. buxiforme)*, bracken fern *(Pteridium alquilinum var. pseudocaudatum)*, and possum haw *(Viburnum nudum var. nudum)*. Eight 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])*; three plants (stiff-leaved goldenrod *[Oligoneuron rigida]*, stargrass *[Aletris farinosa]*, and eastern showy aster *[Eurybia spectabilis])*; the northern harrier *(Circus cyaneus)* is periodically seen in the fall; and the bald eagle *(Haliaeetus leucocephalus)* is routinely seen visiting the site. Insects listed as threatened include the Pine Barrens bluet *(Enallagma recurvatum)*, a damselfly which was confirmed at one of the many coastal plain ponds located on site. Two other damselflies, the little bluet *(Enallagma minisculum)* and the

Table 6-1. Federal and New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL *(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**
Mammals			
Northern long-eared bat	*Myotis septentrionalis*	FT	Confirmed
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
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:
information based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data.
E = endangered
FE=federally endangered
FT = federally threatened
R = rate
SC = species of special concern
SGCN = species of greatest conservation need
T = threatened
V = exploitably vulnerable

scarlet bluet *(Enallagma pictum)*, are likely to be present at one or more of the ponds on site. The frosted elfin *(Callophrys irus)*, a butterfly, has been historically present on site due to its preferred habitat and host plant, wild lupine *(Lupinus perennis)*.

A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically.

BNL has one federally threatened species, the northern long-eared bat *(Myotis septentrionalis)* that is found within the forests of the Lab; and the federally endangered rusty-patch bumble bee *(Bombus affinis)* was likely to have been in the area historically. A single bee tentatively identified as *B. affinis* was identified in 2016, but no photo or specimen was kept. Subsequent searches in 2017 and 2018 did not yield evidence for its presence suggesting that the bee is not likely to be present.

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 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.

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 2019, surveys confirmed the presence of salamanders in three of the 26 ponds.

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. Drought conditions that lasted from 2015 through early 2017 likely resulted in the extirpation of the banded sunfish from the BNL site. The single known habitat held water throughout 2018 and 2019 could likely sustain sunfish. However, a short survey by NYSDEC personnel did not find sunfish in the pond. Regionally, NYSDEC determined that only a few populations of banded sunfish survived the drought and continues to evaluate the need for restoration efforts.

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 2019, monthly surveys were conducted starting at the end of April and extending through the end of August. These surveys identified 73 bird species, compared to the 67 species identified in 2018 and 72 species in 2017. A total of 134 bird species have been identified in surveys in the past 20 years; 59 of these species were present in each of the past 20 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 on-site are by the LISF and the Peconic River and the eastern edge of the BNL property. The transects passing through the various forest types on site (e.g., 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. Little data on the effects of a large, utility-scale solar array such as the LISF are present 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 Solar Farm transects is important. The LISF vegetation and the way it is managed may play a key role as habitat for migratory birds.

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. The LISF

created nearly 200 acres of suitable habitat for the eastern blue bird. Forty boxes were installed around the northern most portions of the LISF and are routinely used by bluebirds, house wrens, and tree swallows. Bluebirds have also benefited from natural nesting habitat resulting from the 2012 wildland fire that resulted in significant tree mortality.

In 2019, a pair of peregrine falcons *(Falco peregrinus)* successfully nested on the stack of the former High Flux Beam Reactor. The pair took over a common raven's nest and successfully raised two chicks. While the nesting is a great success, the nesting must be discouraged in 2020 to allow the demolition of the stack which is required under the Record of Decision for the Decontamination and Dismantlement of the High Flux Beam Reactor (HFBR).

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. To control the goose population, the Laboratory manages nesting through egg oiling under an annual permit from the U.S. Fish & Wildlife Service. In 2019, 44 nests were treated to reduce the number of goslings. Several pairs of geese were successful at hiding their nests, resulting in more than three dozen goslings being produced and the increase of the estimated goose population to between 130 and 150 birds.

6.1.2.4 Bald Eagle

The bald eagle *(Haliaeetus leucocephalus)* has been increasing in population locally on Long Island with at least eight known nest sites on the island. Bald eagles were sighted numerous times in the area of the Sewage Treatment Plant (STP) and near the National Weather Service offices throughout the fall of 2019, and a pair of adult eagles was routinely observed in late-December visiting an osprey nest. 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 on the BNL site are building demolitions and prescribed fires. Inspections for the presence of bats may be conducted through either acoustic or visual surveys prior to demolition. Regardless of the outcome of acoustic monitoring (when conducted), 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 may be done within the burn unit to determine if there is bat activity. If positive results occur, 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 2019, two buildings were demolished, and there was no impact to bats. No prescribed fires were conducted in 2019.

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 2019, the on-site population continued to range between 350 and 500 birds due to successful nesting. Each year, NYSDEC manages a hunting period during the week of Thanksgiving, and a youth-only hunt in May for several areas across Long Island, which typically results in approximately 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.

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 (e.g., songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (e.g., collision damage to autos and browsing damage to ornamental plantings). Deer-related collisions on site decreased in 2019 compared to 2018, potentially an indication of decreased population from the 2019 deer harvest.

4 poster™ tick management system

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 (aka deer harvests), hunting, or sterilization programs. 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. BNL has been implementing deer management since 2015 and conducting herd reductions every other year. The herd was estimated at between 350 and 450 animals at the end of 2018 and a harvest was conducted in April 2019 during which 250 animals were taken, effectively bringing the population to approximately 200 animals. With reproduction at approximately 60 percent, the population at the end of 2019 was estimated at 300 to 350 deer. Efforts were underway in December 2019 to establish an inter-agency agreement between the Department of Energy (DOE) and the U.S. Department of Agriculture - Wildlife Services that would establish a mechanism for annual population management to more effectively maintain a lower deer population.

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (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 2019.

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 which also coordinates research projects that occur within the reserve and the larger Pine Barrens. After successfully establishing a Memorandum of Understanding (MOU) with the State University of New York's School of Environmental Science and Forestry (SUNY-ESF), efforts to revisit the 2005-2006 forest health monitoring program resulted in the first year of monitoring during summer 2019 (see education programs below). The MOU with SUNY-ESF will allow for greater levels of research within the Central Pine Barrens and the Upton Reserve.

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. 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 from above ground nuclear bomb testing 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 tables in this chapter listing Cs-137 also list analytical results for potassium-40 (K-40), a naturally occurring radioisotope of potassium that is commonly found in flora and fauna. Studies indicate that Cs-137 out-competes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables 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 2019, a total of 11 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 between 2015 and 2019. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas historically 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 two decades 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 2019,

three deer were obtained on site, five from off-site locations within one mile of the Laboratory, and three from greater than one mile from the BNL boundary, all from car/deer accidents. The analytical results of deer sampling are shown in Table 6-2. Additionally, BNL conducted a population reduction of the local deer herd and conducted batch sampling of the deer in order to determine the safe release of meat for consumption. Table 6-3 provides results of batch sampling.

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 above-ground plant matter via root uptake, where it then becomes available to browsing and grazing animals or is consumed directly with soil while the animal is grazing. Remediation of contaminated soil areas on site occurred under the Laboratory's Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) program, with all major areas of contaminated soil being remediated by September 2005.

In 2019, Cs-137 concentrations in deer meat samples were obtained from three deer on site with a range of values from 0.07 pCi/g, wet weight to 0.28 pCi/g, wet weight, and an arithmetic average of 0.20 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 2019 (0.28 pCi/g, wet weight) was about eight times lower than the highest on-site sample reported in 2018 (2.19 pCi/g, wet weight) and 42 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 (five samples) and samples taken farther away (three samples), as shown in Table 6-2. Concentrations in meat samples taken within one mile ranged from 0.05 pCi/g, wet weight to 0.98 pCi/g, wet weight, with an arithmetic average of 0.42 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 2019, this was 0.34 pCi/g, wet weight. The three deer sampled from greater than one mile from BNL had Cs-137 concentrations ranging between 0.01 pCi/g, wet weight, to 0.08 pCi/g, wet weight, with an arithmetic average of 0.05 pCi/g, wet weight. Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2019 from four different location groupings. The off-site location group within one mile of the site was higher than the onsite average. The last time this occurred was in 2013. 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 nine of the 11 meat samples taken both on and off site were below 0.3 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 2019 average is approximately 75 percent lower than the 2011 average and is 25 percent 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 2009 to 2019 and the ten-year average being 0.71 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 cleanup, while the on-site and near off-site values were shown to

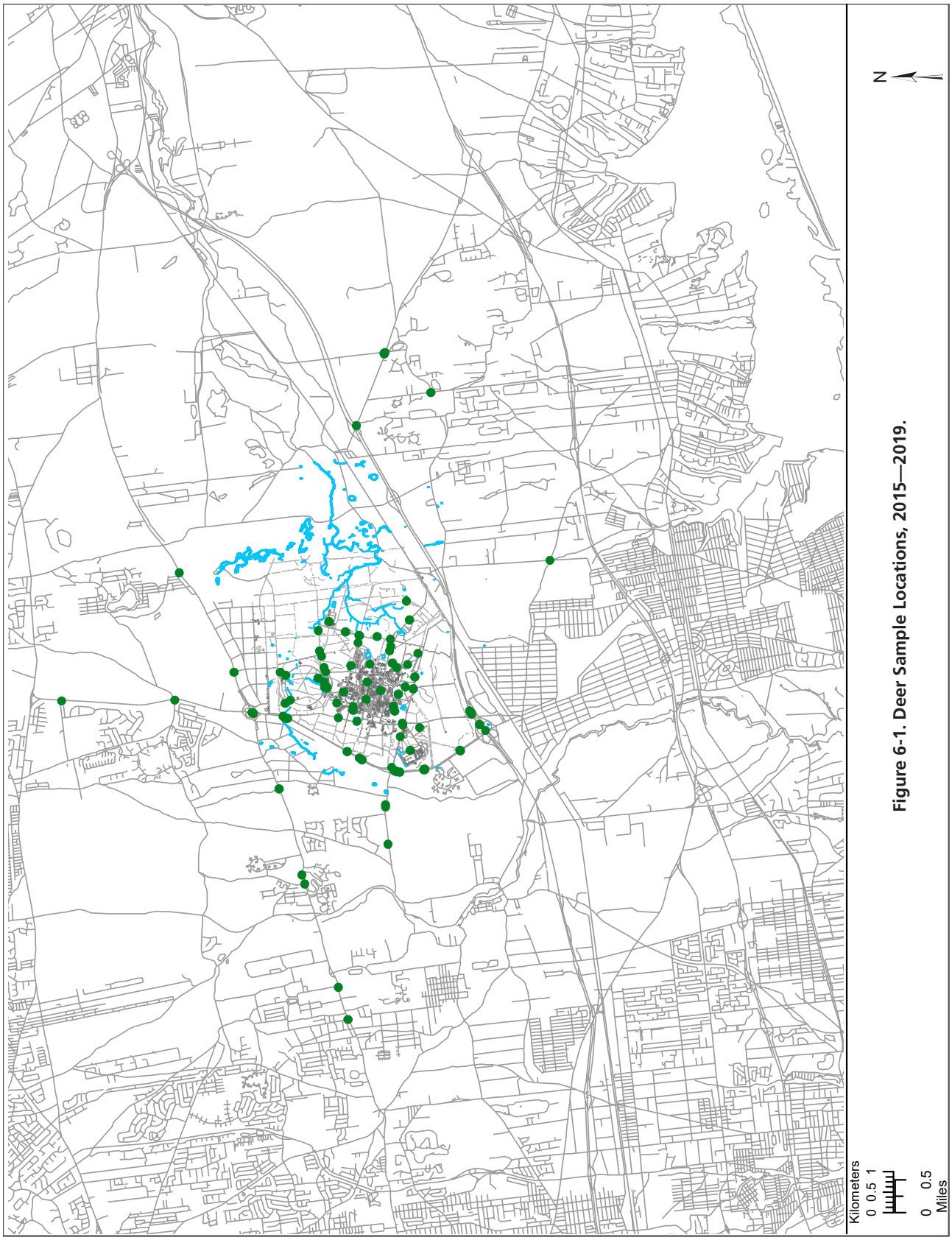


Figure 6-1. Deer Sample Locations, 2015—2019.

Table 6-2. Radiological Analyses of Deer Tissue (2019).

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL				
Bldg. 750, West Side	2/1/219	Flesh	3.22±0.11	0.28±0.01
		Liver	3.08±0.10	0.09±0.01
Outer RHIC Ring Road, North Gate	3/16/19	Flesh	3.24±0.15	0.24±0.01
		Liver	2.40±0.23	0.07±0.01
Inner RHIC Ring Road, 1005S	5/21/19	Flesh	3.25±0.14	0.07±0.01
		Liver	2.37±0.12	0.02±0.01
< 1 Mile from BNL				
William Floyd Parkway (WFPKWY) and Main Gate	1/13/19	Flesh	3.37±0.12	0.23±0.01
		Liver	1.97±0.18	0.04±0.01
WFPKWY and North Gate	10/26/19	Flesh	3.05±0.20	0.98±0.03
		Liver	2.53±0.21	0.31±0.02
WFPKWY 1/2 mile North of Main Gate	11/11/19	Flesh	3.74±0.23	0.05±0.01
		Liver	2.64±0.18	0.02±0.00
Long Island Expressway Service Road and South Gate	11/12/19	Flesh	3.17±0.20	0.59±0.02
		Liver	2.55±0.18	0.27±0.02
WFPKWY 3/4 mile North of Main Gate	11/13/19	Flesh	2.60±0.19	0.25±0.01
> 1 Mile from BNL				
Rte. 111 Manorville and Halsey Manor Road	5/25/19	Flesh	3.13±0.24	0.07±0.01
		Liver	2.34±0.17	0.04±0.01
Rte. 25 and Church Ln., Middle Island	9/3/19	Flesh	3.62±0.21	0.08±0.01
		Liver	2.32±0.32	0.05±0.02
Rte. 25 Artist Lake, Middle Island, NY*	11/22/19	Flesh	3.55±0.21	0.01±0.01
		Liver	2.86±0.22	ND
Averages by Tissue				
Flesh Averages				
All Samples (11)			3.27±0.62	0.26±0.05
BNL Average (3)			3.24±0.24	0.20±0.02
< 1 Mile Average (5)			3.19±0.43	0.42±0.04
BNL + < 1 Mile Average (8)			3.21±0.49	0.34±0.04
> 1 Mile Average (3)			3.43±0.38	0.05±0.02
Liver Averages				
All Samples (10)			2.51±0.63	0.09±0.04
BNL Average (3)			2.62±0.28	0.06±0.01
< 1 Mile Average (4)			2.42±0.37	0.16±0.03
BNL + < 1 Mile Average (7)			2.51±0.47	0.12±0.03
> 1 Mile Average (3)			2.51±0.42	0.03±0.02

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.
* = Denotes an estimated value for Cs-137 based on laboratory qualifiers.
ND = not detected

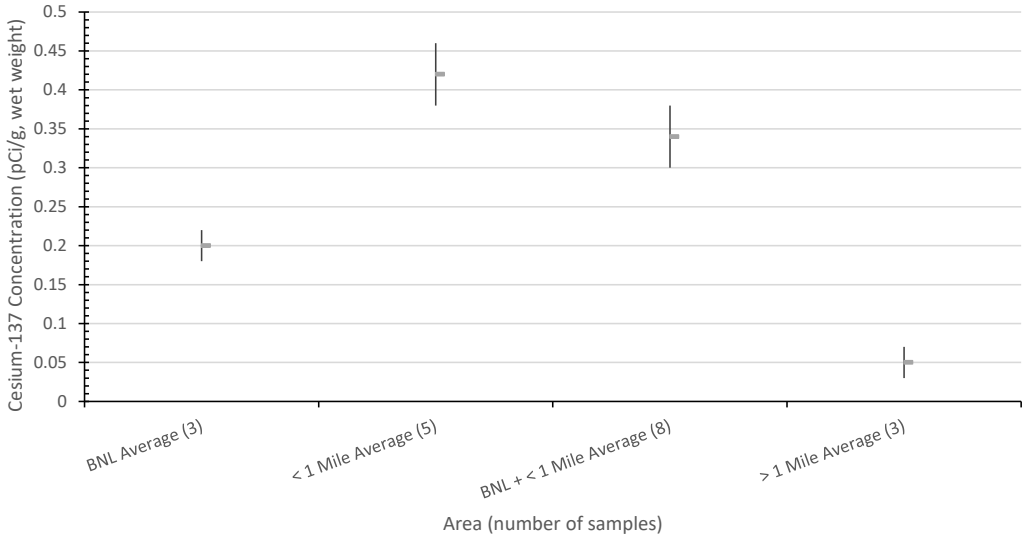
Table 6-3. Radiological Analysis of Batch Samples From Deer Cull Released for Donation (2019)

Batch Number	Collection Date	K-40 pCi/g±95% C.I.	Cs-137 pCi/g±95% C.I.
Day 1 Batch Sampling			
Batch #1	4/6/19	2.80±0.18	0.04±0.01
Batch #2		3.18±0.32	0.07±0.02
Batch #3		3.15±0.20	0.05±0.01
Batch #4		2.96±0.29	0.20±0.02
Batch #5		2.91±0.28	0.05±0.02
Day 2 Batch Sampling			
Batch #6	4/7/19	2.93±0.16	0.08±0.01
Batch #7		2.83±0.22	0.07±0.01
Batch #8		3.15±0.27	0.05±0.01
Batch #9		3.33±0.30	0.02±0.01
Batch #10		3.01±0.21	0.07±0.01
Batch #11		3.01±0.30	0.07±0.02
Batch #12		3.11±0.27	0.03±0.01
Batch #13		2.71±0.29	0.03±0.01
Batch #14		2.70±0.45	0.11±0.03
Batch #15		3.02±0.27	0.03±0.01
Batch #16		2.91±0.31	0.03±0.02
Batch #17		3.14±0.25	0.05±0.02
Day 3 Batch Sampling			
Batch #18	4/8/19	2.74±0.33	0.05±0.02
Batch #19		3.23±0.28	0.13±0.02
Batch #20		3.05±0.28	0.03±0.01
Batch #21		3.18±0.32	0.06±0.02
Batch #22		2.88±0.32	0.06±0.02
Batch #23		2.96±0.27	0.08±0.01
Batch #24		2.78±0.20	0.04±0.01
Batch #25		2.98±0.17	0.05±0.01
Batch #26		3.16±0.26	0.07±0.01
Day 4 Batch Sampling			
Batch #27	4/9/19	2.93±0.20	0.04±0.01
Batch #28		2.90±0.23	0.05±0.01
Batch #29		2.83±0.24	0.02±0.01
Batch #30		2.80±0.26	0.02±0.01
Batch #31		3.13±0.31	0.06±0.02
Batch #32		3.10±0.27	0.03±0.02
Batch #33		3.14±0.31	0.02±0.01
Day 5 Batch Sampling			
Batch #34	4/10/19	3.04±0.32	0.03±0.01
Batch #35		2.98±0.30	0.10±0.02
Batch #36		3.20±0.28	0.06±0.01
Batch #37		1.99±0.34	0.05±0.03
Batch #38		3.28±0.28	0.19±0.02
Batch #39		2.80±0.26	0.18±0.02
Batch #40		3.35±0.28	0.08±0.01
Batch #41		2.99±0.32	0.07±0.02
Day 6 Batch Sampling			
Batch #42	4/11/19	3.16±0.32	0.09±0.02
Batch #43		3.11±0.28	0.07±0.02
Batch #44		2.95±0.36	0.13±0.02
Batch #45		3.11±0.28	0.06±0.01
Batch #46		3.21±0.24	0.08±0.01
Day 7 Batch Sampling			
Batch #47	4/12/19	3.07±0.26	0.06±0.02
Batch #48		3.28±0.30	0.03±0.01
Batch #49		3.05±0.27	0.04±0.01
Batch #50		2.89±0.41	0.07±0.03
Average Concentration		3.00±2.00	0.06±0.12

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.

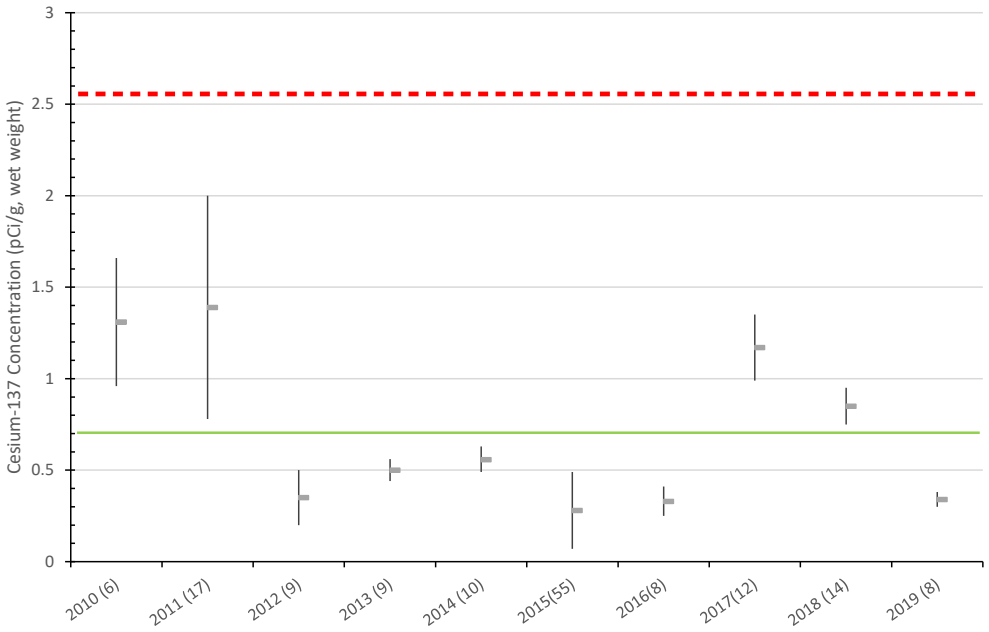
decline. In 2017, while preparing for monitoring associated with the reduction of the deer population, the ten-year average for on-site deer samples was calculated to be 1.0 pCi/g, wet weight, and this value was used to establish an administrative release criterion for deer meat made available for donation.

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 2019, Cs-137 concentrations ranged from 0.02 pCi/g, wet weight to 0.09 pCi/g, wet weight, with an average of 0.06 pCi/g, wet weight. The near off-site Cs-137 concentration in liver ranged from 0.02 pCi/g, wet weight to 0.31 pCi/g, wet weight, with an arithmetic average for off-site liver samples within one mile of 0.16 pCi/g, wet weight. Liver samples from deer taken greater than one mile from BNL ranged from non-detect to 0.05 pCi/g, wet weight with the arithmetic average being 0.03 pCi/g, wet



Notes: Ten year average of onsite and near offsite deer flesh samples is 0.71 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) 0.71 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.

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 from deer removed from the Laboratory and donated for consumption. A total of 250 deer were taken during population reductions in 2019. Meat samples were obtained from all deer and composited samples were sent for analysis. Composite samples consisted of comingled samples taken from five deer per sample, resulting in a total of 50 samples. Table 6-3 provides results of all meat samples taken during the population reduction. Results ranged from 0.02 pCi/g, wet weight to 0.20 pCi/g, wet weight with the arithmetic average being 0.06 pCi/g, wet weight. Since all samples were well below the 1.0 pCi/g, wet weight administrative limit, all 5,467 pounds of meat was donated to local food pantries.

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g, wet weight, reported in 1996) would carry a total amount of approximately 0.2 μCi. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only 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 2019.

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 lack of flow off site, 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 enough 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 has discontinued fish monitoring under the CERCLA program. However, when conditions allow, fish sampling will be conducted under the surveillance program for radionuclide content supporting dose to biota and dose to the maximally exposed off site individual. Due to lack of water and fish within the on-site portions of the Peconic River, no fish were sampled in 2019.

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 resulted in the on-site portions of the Peconic River being totally dry through July 2018 when groundwater levels began to rise. By the end of 2018, water levels were sufficiently high, resulting in off-site flow at station HQ on the east boundary of the Laboratory. In 2019, water levels began to recede, resulting in water being retained only in deeper open water areas.

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 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. In order to determine if enough fish are present to support sampling, population assessments are conducted. In 2019, a population assessment was conducted at the end of May and resulted in the capture of 16 chain pickerel and one pumpkinseed from the onsite portions. The largest fish had a length of 85 mm or a little over three inches.

6.3.4 Vegetation Sampling

6.3.4.1 Grassy Plants and Soil

During 2019, grassy vegetation samples were collected from ten 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 0.07 pCi/g, wet weight at a single location. Soil samples had Cs-137 levels ranging from non-detect to 0.84 pCi/g, dry weight. All values were consistent with historic monitoring and knowledge of cleanup areas. Monitoring results for grassy vegetation and soils were utilized for the annual dose to biota analysis reported in Chapter 8.

6.4 PRECIPITATION MONITORING

6.4.1 Mercury Monitoring of Precipitation

During 2019, 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 6-5) using low-level mercury analysis. 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 the precipitation samples collected at both sampling stations. Mercury ranged from 3.55 ng/L at station P4 in October to 13.1 ng/L at station S5 in July. The 13.1 ng/L concentration is 3.4 times lower than the highest value of 45.1 ng/L, recorded in 2017.

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 the 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 2019, BNL hosted 16 student interns, a graduate student, and two faculty members within the Natural Resources program throughout the year. One intern conducted statistical analysis of bird survey data during the spring, and a second worked on statistics of the 4-Poster™ tick management program in the fall. During summer 2019, 14 interns participated in programs looking at forest health of the Long Island Pine Barrens, pollinator use of

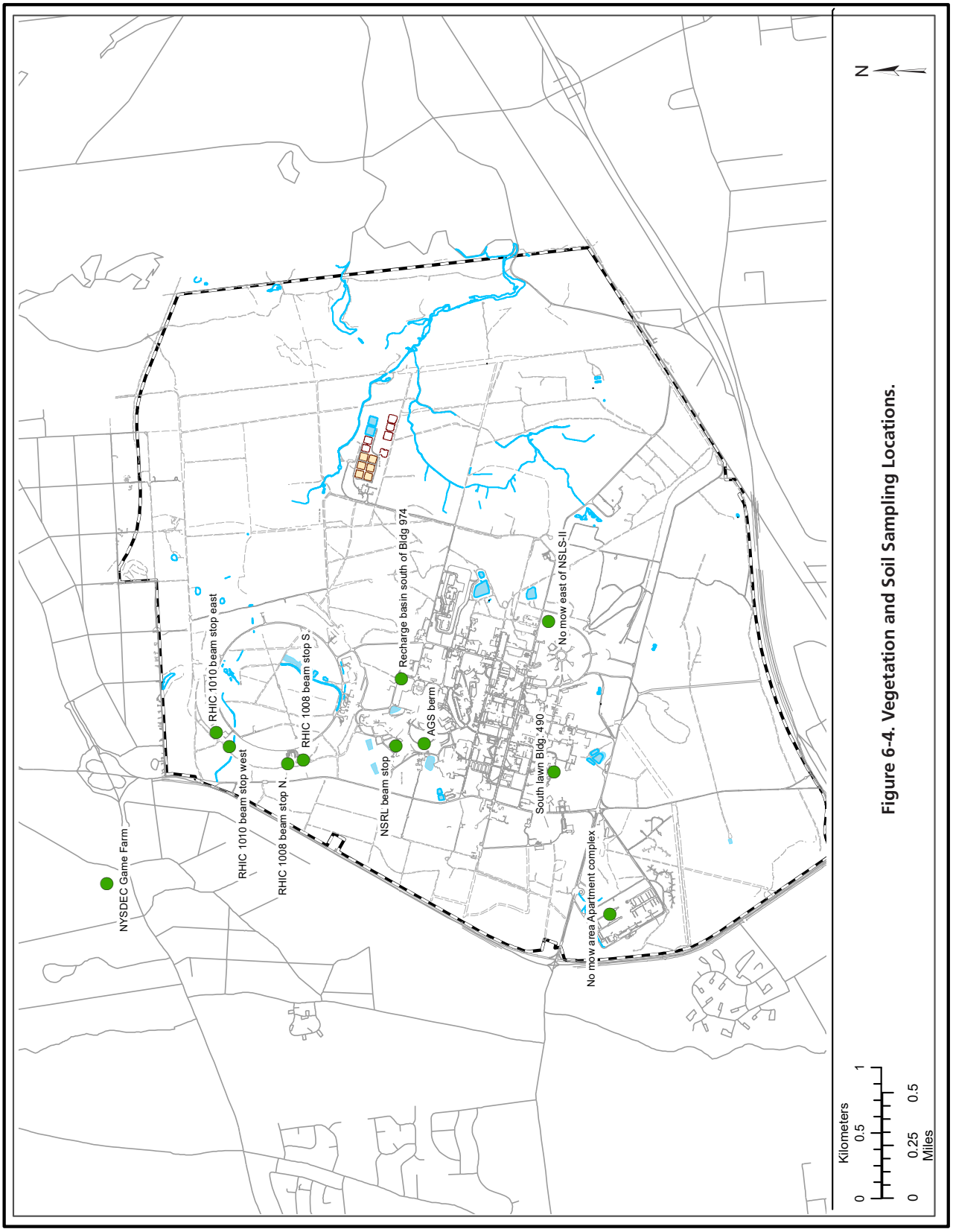


Figure 6-4. Vegetation and Soil Sampling Locations.

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.
RHIC 1010 Beam Stop West		
Vegetation	2.07±0.61	ND
Soil*	5.90±1.03	0.17±0.07
RHIC 1010 Beam Stop East		
Vegetation	1.67±0.87	ND
Soil*	5.04±0.97	0.12±0.05
RHIC 1008 Beam Stop South		
Vegetation	2.05±0.91	ND
Soil*	4.38±0.81	ND
RHIC 1008 Beam Stop North		
Vegetation	5.91±1.38	ND
Soil*	9.88±1.40	0.10±0.05
NSRL Beam Stop		
Vegetation	5.31±1.07	0.07±0.07
Soil*	6.76±1.16	0.14±0.07
AGS Berm		
Vegetation	5.08±1.02	ND
Soil*	3.58±0.83	0.10±0.07
Recharge Basin S. of Bldg. 974		
Vegetation	5.59±1.04	ND
Soil	2.14±0.64	ND
South Lawn Bldg. 490		
Vegetation	10.2±1.88	ND
Soil	4.83±0.97	0.84±0.12
No Mow East of NSLS-II		
Vegetation	5.32±1.37	ND
Soil*	7.66±1.87	0.18±0.10
No Mow Area Apartment Complex		
Vegetation	3.51±0.99	ND
Soil	5.83±1.25	0.34±0.08
NYSDEC Game Farm (Control)		
Vegetation	1.84±0.84	ND
Soil*	4.72±0.90	0.14±0.08

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.

Table 6-5 Precipitation Monitoring (Mercury).

Location/Period	Mercury ng/L
P4	
1/7/19	4.52
4/16/19	5.13
7/12/19	12.2
10/9/19	3.55
S5	
1/7/19	4.04
4/16/19	5.26
7/12/19	13.1
10/9/19	5.01

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.

the Long Island Solar Farm, modified feeding effects on effectiveness of the 4-Poster™ tick management devices, and mapping valves and other infrastructure associated with the Laboratory's potable water system. More details are provided below.

- A spring intern worked specifically on developing statistical analysis of bird survey data looking at changes in avian communities using occupancy modelling which provided the intern with experience in coding and statistical analysis.
- A team led by Dr. Murty S. Kambhampati from Southern University at New Orleans worked on two projects, both continuation of projects from previous summers. The first continued work on assessing pollinator use of flowering plants in the LISF. The other continued assessing effectiveness of the 4-Poster™ tick management devices under altered feeding regimes. Both projects are expected to result in published papers once additional data are acquired in 2020. These efforts provided experience to four interns in plant and pollinator identification, data management, and statistics.
- A team led by Joanna Lumbsden-Pinto, a

doctoral candidate, and Dr. Martin Dovciak, both from SUNY-ESF conducted the first summer of monitoring of forest health across the Central Pine Barrens. This effort is re-visiting the forest health monitoring conducted from 2005 to 2006 and will compare results to determine the trajectory of forest health. This effort provided field experience for eight interns in plant identification, statistics, and data management.

- To better understand the potable water distribution system and other pieces of the utilities infrastructure on site, an intern worked with both Environmental Protection and the Facilities & Operations Divisions to identify and map all shut-off valves to the water system and all manholes associated with underground utilities resulting in updated maps. The effort provided experience with utilities engineering and GIS software.
- A fall intern continued work associated with the 4-Poster™ tick management devices. The study calls for the analysis of photos taken at each device to record deer activity over the seven months that they are deployed. This required sorting over 800,000 photos for presence of deer and conducting statistical analysis on the variation of use between treatments. The effort provided experience working with large data sets, statistical analysis, and presentation skills.

As mentioned above, the MOU with SUNY-ESF initiated the implementation of the second round of forest health monitoring of the Central Pine Barrens of Long Island. It has also resulted in an MOU being established between SUNY-ESF and the Central Pine Barrens Joint Planning and Policy Commission, allowing for greater collaboration between the three entities. Besides the forest health monitoring, an ESF class on Environmental Planning carried out research on some of the research needs associated with management of the Pine Barrens, and a teacher workshop on phyto-remediation was held at BNL.

In 2019, BNL continued to participate in several events in support of ecological education programs including: hosting the Long Island Natural History Conference; participation in the Tenth Annual Pine Barrens Discovery Day held at the Wertheim National Wildlife Refuge; and assisting the Central Pine Barrens Commission with "A Day in the Life of the Rivers," which allowed students from multiple school districts to acquire environmental and biological data about 11 different rivers on Long Island. On separate days, over 70 partner organizations and agencies, over 50 schools, and approximately 2,100 students collected scientific information for analysis to be used to portray the status of the rivers and estuary systems of Long Island. These events provided students hands-on experience with field techniques in catching fish, invertebrate sampling, biodiversity inventory, and water chemistry.

2019 Forest Health Monitoring Team

In 2019, BNL entered its 15th year of the Open Space Stewardship Program (OSSP) and worked with 30 schools and nearly 2,500 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. Due to the need for a MOU with the NYSDEC, no prescribed fires were conducted in 2019.

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 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 local and national history and culture are documented and available for interpretation.

In 2019, the Laboratory contracted with Hartgen Archeological Associates to conduct historical architectural reviews of buildings that had recently reached 50 years of age. Several reports were required under the contract and the first report was provided in late 2019, resulting in the increase in number of National Register Eligible buildings. As of the end of 2019, the Laboratory had ten structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the HFBR complex, the 1960s-era efficiency apartments, Berkner Hall, the Chemistry Building, Physics Building, Building 515, Building 535, the World War II (WWII) barracks part of Building 120, and the WWI training trenches associated with Camp Upton. The trenches are examples of the few surviving WWI earthworks in the United States. Berkner Hall is eligible due to its construction and design by architect Max O. Urbhan. The Chemistry Building is eligible due to its architecture, association with key scientific discoveries, and design by Marcel Breuer. Buildings 510 (Physics), 515 (Information Technology), and 535 (Instrumentation) were all designed by the Max O. Urbhan architectural group and are associated with significant scientific events. Building 120 is National Register-eligible due to its integrity representing WWII barracks buildings. An interesting outcome of the review was the determination that Building 30 (Brookhaven Center) is not eligible for listing. It was long thought that this building would be eligible for its association with the Civilian Conservation Corps and WWII (Officers Club), and BNL would make it eligible for listing. However, the significant modifications that have taken place at each stage of historic transition have resulted in loss of integrity.

Berkner Hall

Chemistry Building

BNL continued to work on issues associated with the 1960s-era apartments, which will be negatively impacted from the development of Discovery Park, and the HFBR Stack which is scheduled for demolition in 2020 and was added to the MOU for the BGRR. Both require compilation of materials documenting aspects of their history for submission to the New York State Historic Preservation Officer. These and other efforts will continue in 2020 as additional reports are received from architectural reviews.

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7 Groundwater Protection

Brookhaven National Laboratory (BNL) implements aggressive pollution prevention measures to protect groundwater resources, and uses an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. During 2019, BNL collected groundwater samples from 625 permanent monitoring wells and 32 temporary wells during 1,704 individual sampling events. Seven groundwater remediation systems removed 61 pounds of volatile organic compounds (VOCs) and returned approximately 750 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 7,650 pounds of VOCs by treating over 28 billion gallons of groundwater. Also, one groundwater treatment system removed approximately 0.8 millicurie of strontium-90 (Sr-90) while remediating approximately 14 million gallons of groundwater. Since 2003, BNL has removed approximately 33.6 millicuries of Sr-90 from the groundwater while remediating approximately 245 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have occurred in several 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; Department of Energy (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 remediating existing contaminated groundwater.

7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented several 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 the Environmental Protection Agency (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. Several 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 2018) 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 30 years and continues to make progress in achieving its goal of preventing new impacts to groundwater quality and remediating 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 Poly-fluoroalkyl Substances (PFAS) were detected in water samples collected from three BNL water supply wells. In response to these detections, BNL conducted a search of available records to determine a source of PFAS

in 2018. As a result, BNL identified eight areas where firefighting foam had been used for firefighter training or fire suppression system maintenance from 1966 until 2008. Groundwater characterization confirmed the presence of PFAS in each of the eight areas, with the highest concentrations detected near BNL's former firehouse (in operation from 1947-1985) and near the current firehouse (1986-present). In both areas, the combined concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) significantly exceeded the current U.S. EPA Health Advisory Level (HAL) of 70 ng/L. At the former firehouse area, the maximum combined PFOS and PFOA concentration was 5,371 ng/L, whereas the maximum combined concentrations at the current firehouse area was 12,440 ng/L. In addition to PFAS, BNL has been characterizing the extent of 1,4-dioxane, which was used as a chemical stabilizer for the solvent 1,1,1-trichloroethane (TCA). BNL has confirmed the presence of 1,4-dioxane in several on-site and off-site areas that have been impacted by TCA contamination.

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 regulatory 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 170 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 625 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: 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 and remediated 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 2019, the Facility Monitoring program monitored 91 permanent wells during

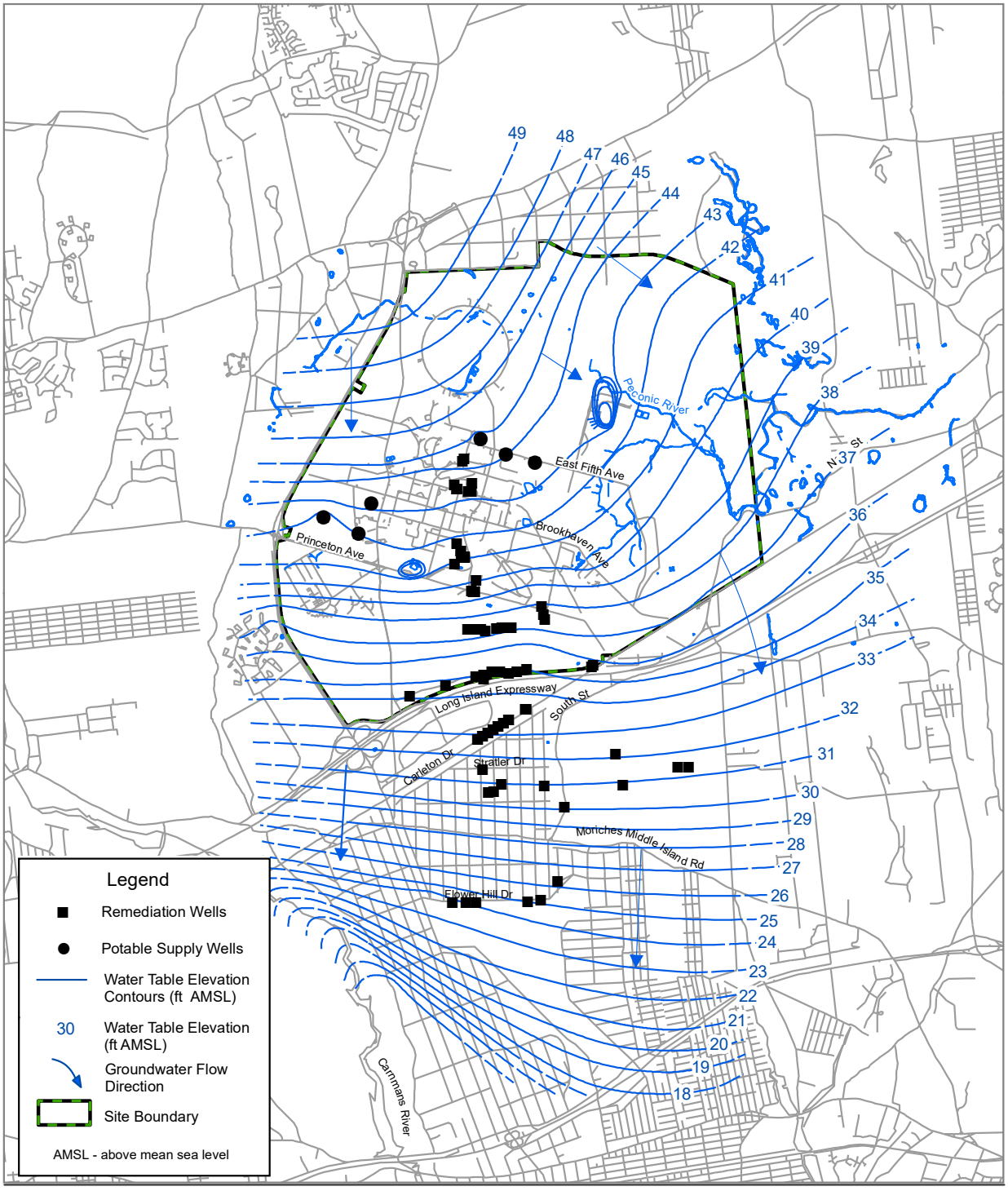

Figure 7-1. Groundwater Flow and Water Table Elevation (January 2020) with Supply and Remediation Wells Shown.

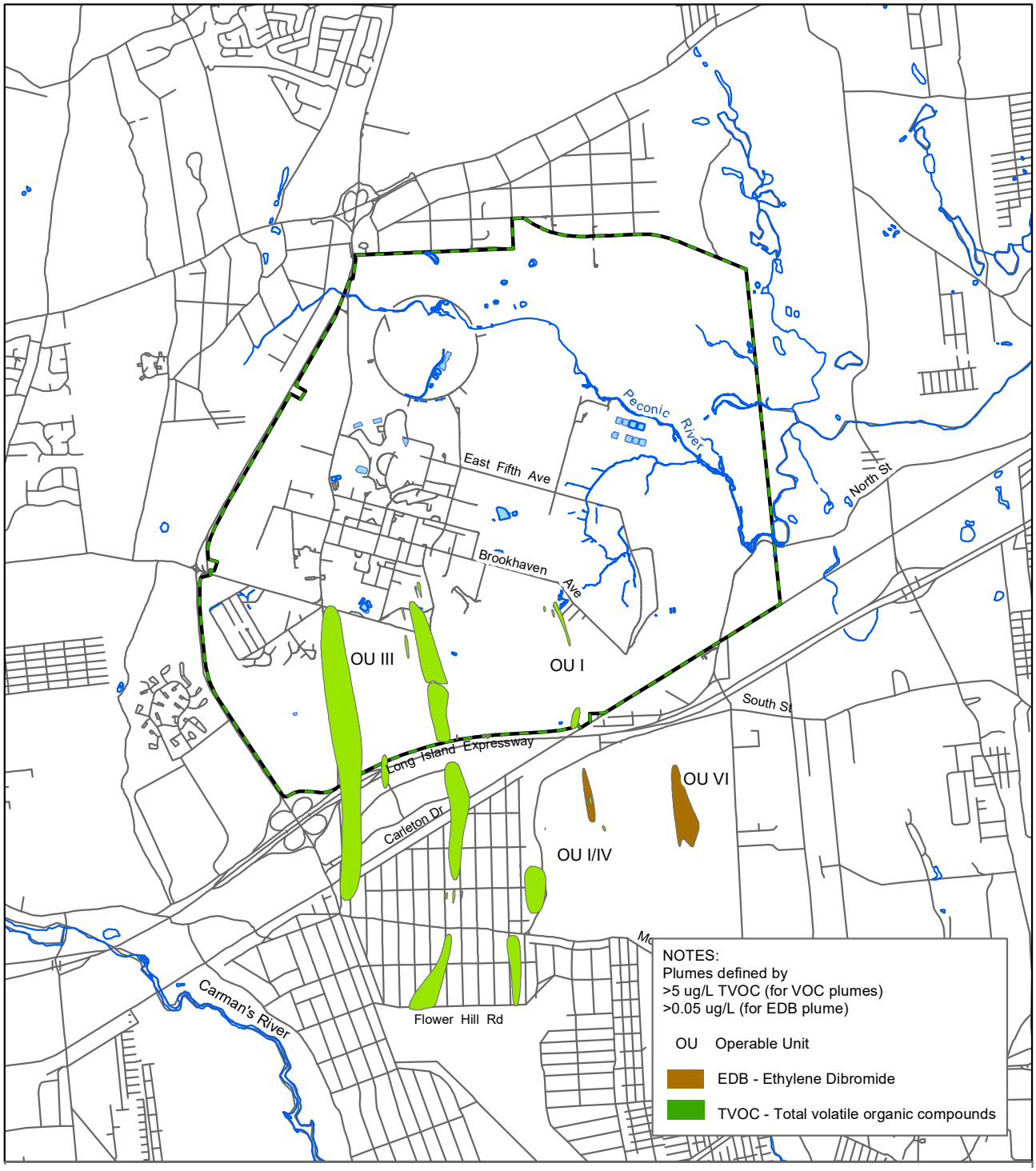

Figure 7-2. Extent of VOC Plumes.

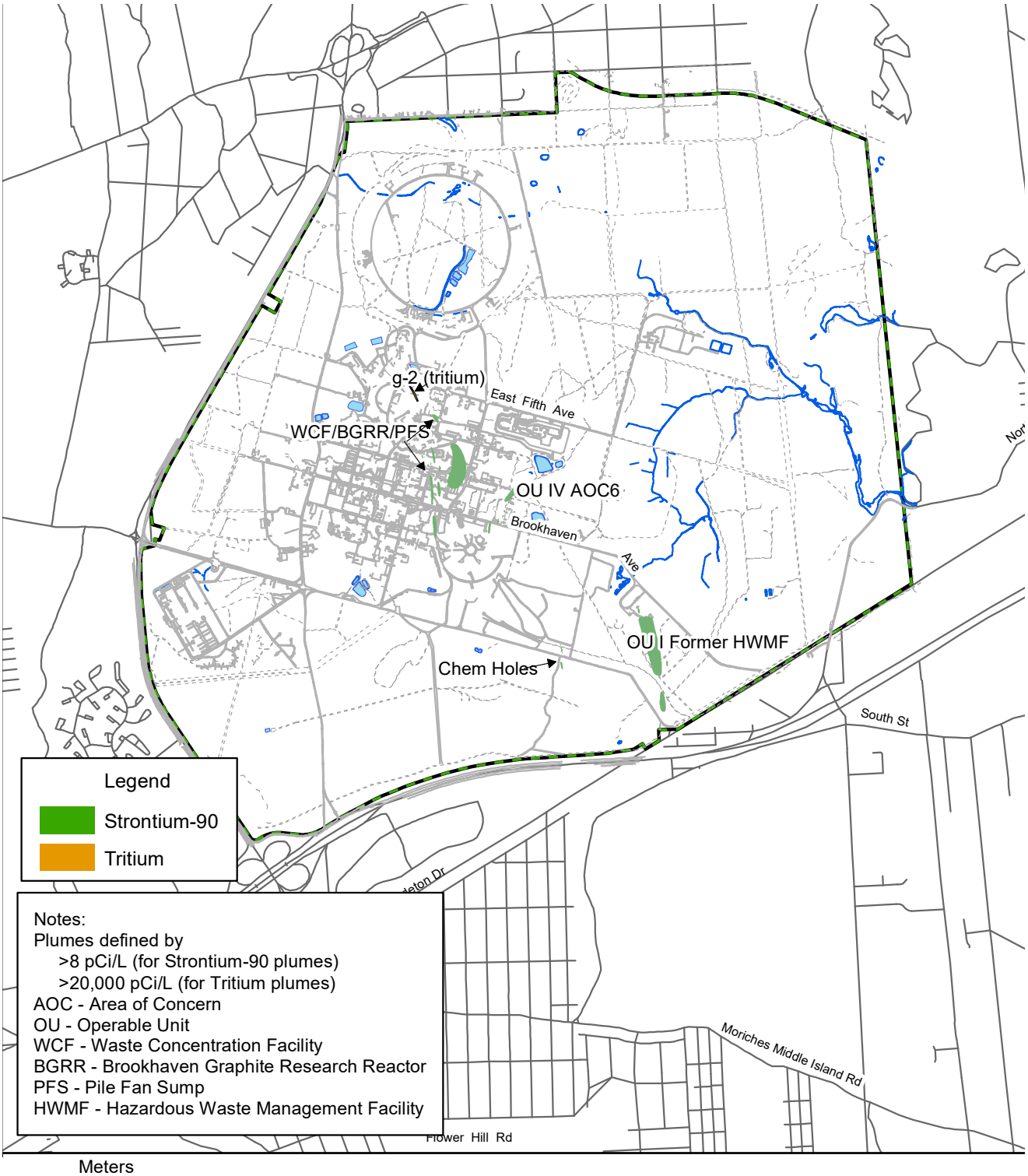

Figure 7-3. Extent of Radionuclide Plumes.

121 individual sampling events. The CERCLA groundwater monitoring program monitored 534 permanent wells during 1,583 individual groundwater sampling events. Thirty-two 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 2019 include:

- Monitoring conducted at BNL's major research facilities (e.g., AGS, RHIC, NSLS-II, and BLIP) and support facilities (e.g., STP, WMF, MPF, and vehicle maintenance facilities) did not identify any new impacts to groundwater quality resulting from current operations.
- During 2016-2018, BNL characterized a plume of deeper than previously defined VOC contamination in the Western South Boundary area. Four new extraction wells were installed to remediate the deeper contamination and allow for achievement of the cleanup goal of meeting Maximum Contaminant Levels (MCLs) in the Upper Glacial aquifer by 2030. The new extraction wells began full-time operation in March 2019.
- Due to the detection of ethylene dibromide (EDB) in the North Street East area at concentrations above the 0.05 µg/L DWS since 2015, in 2019 BNL began making modifications to the treatment system that will allow the EDB plume to be remediated within the OU III ROD-specified 2030 cleanup timeframe for the Upper Glacial aquifer. The modified treatment system is expected to be fully operational by mid-2020.
- After meeting its cleanup objectives, in 2019 BNL submitted Petitions for Closure for the HFBR pump and recharge system, the Building 452 Freon-11 groundwater treatment system, and the OU I South Boundary groundwater treatment system. The regulatory agencies approved these petitions in March, August, and September 2020, respectively. Furthermore, because the North Street treatment system has also met its cleanup objectives, BNL will submit a petition for its closure in early 2020. These treatment systems, and their associated monitoring wells, will be maintained for potential future use in addressing the emerging contaminants of concern, PFAS, and 1,4-dioxane.
- Continued monitoring of the HFBR facility is now conducted using a network of monitoring wells located immediately downgradient of the facility. During 2019, tritium was detected above the 20,000 pCi/L DWS, with a maximum concentration of 35,900 pCi/L.
- During 2019, a significant increase in Sr-90 concentrations were observed in BGRR facility monitoring wells, increasing from less than 1 pCi/L DWS in 2018 to 1,170 pCi/L in October 2019. This increase appears to have resulted from the rising water table leaching residual Sr-90 from contaminated soils beneath the building and adjacent below ground duct area.
- In early 2019, BNL continued its effort to characterize the extent of PFAS by sampling 33 permanent wells and installing 11 temporary wells along the southern site boundary. PFAS were detected in several south boundary area wells, with a maximum combined concentration of PFOS and PFOA of 69.2 ng/L, slightly below the current 70 ng/L HAL. For 2020, BNL is planning on conducting a comprehensive sampling of approximately 350 on-site and off-site monitoring wells for PFAS and 1,4-dioxane, as well as conducting detailed characterization of the PFAS plumes originating from the former and current firehouse facilities.

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:

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2019.

Remediation System	Start Date	1997-2018		2019	
		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	Shutdown	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	Shutdown	0
OU III South Boundary	06/1997	5,112,151,000	3,048	87,000,000	6
OU III Industrial Park	09/1999	2,547,662,000	1,076	30,000,000	1
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	495,697,000	143	31,000,000	2
OU III Middle Road	10/2001	3,448,547,000	1,261	164,000,000	25
OU III Western South Boundary	09/2002	1,769,555,000	143	143,000,000	13
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	Shutdown	0
OU III North Street East (h)	06/2004	1,009,798,000	44	Shutdown	0
OU III LIPA/Airport	08/2004	3,324,145,000	455	204,000,000	14
OU III Building 452 Freon-11 (i)	03/2012	124,997,400	106	Shutdown	0
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	2,269,057,000	(g)	91,000,000	(g)
Total		**27,192,549,000**	**7,589**	**750,000,000**	**61**

Remediation System	Start Date	2003–2018		2019	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	65,663,000	4.94	Shutdown	0
OU III BGRR/WCF Sr-90	06/2005	164,803,000	27.9	14,000,000	0.8
Total		**230,466,000**	**32.84**	**14,000,000**	**0.8**

Notes:
(a) System placed in standy mode in 2013. Approved for closure in 2019.
(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 2014.
(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 2017. Approved for closure in 2019.
(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

- 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 Holes in the Upper Glacial aquifer by 2040.

During 2019, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of eight groundwater treatment systems currently in

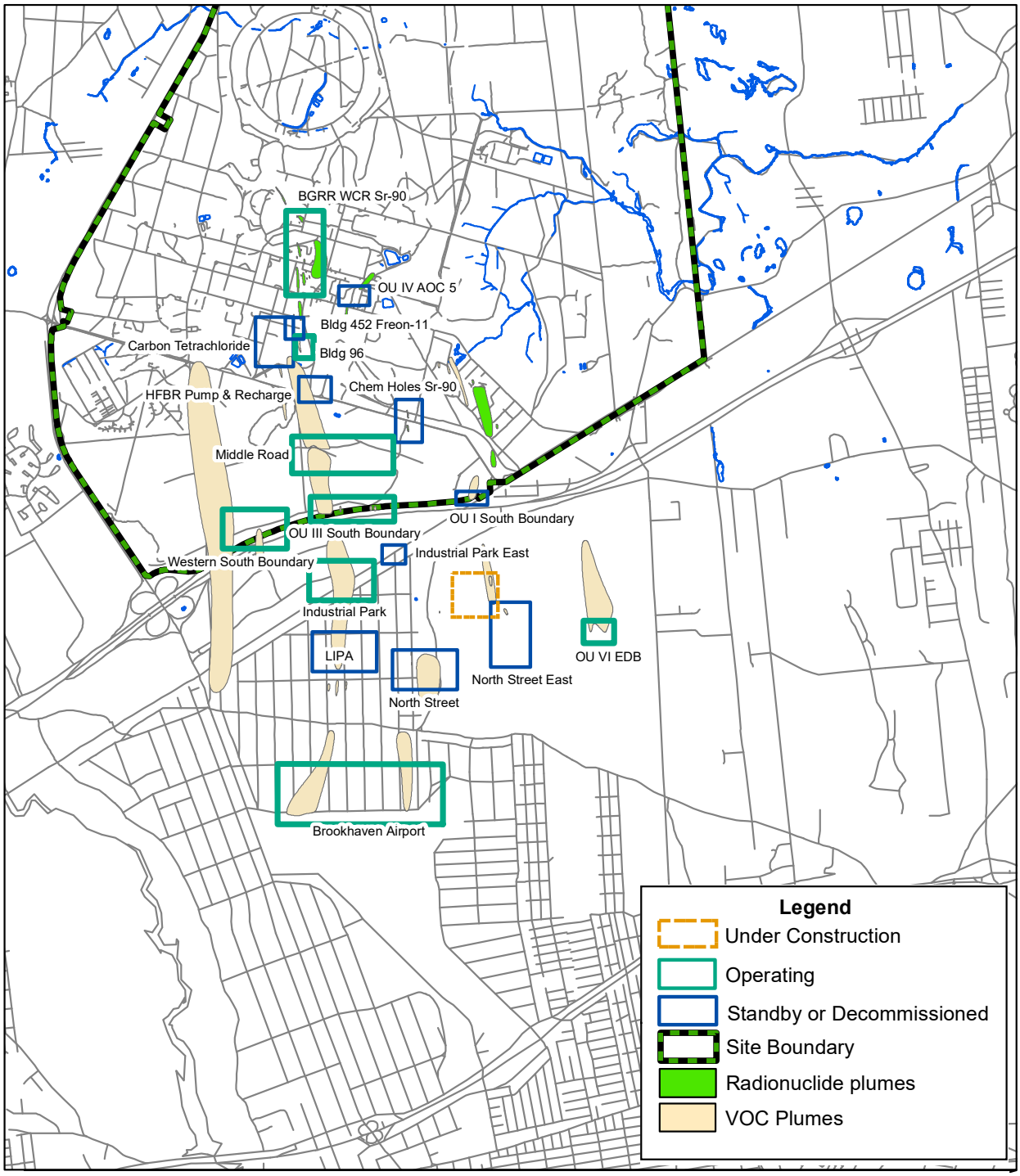

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

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 2019, approximately 61 pounds of VOCs and 0.8 mCi of Sr-90 were removed from the groundwater and nearly 820 million gallons of treated groundwater were returned to the aquifer. To date, 7,650 pounds of VOCs have been removed from the aquifer and noticeable improvements in groundwater quality are evident in several on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 34 mCi of Sr-90.

During 2019, the North Street Treatment System, North Street East Treatment System, OU I South Boundary Treatment System, OU III Building 452 Freon-11 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. 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 where models indicate a site-emission source could result in the maximum dose to 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 dose from direct and indirect dose pathways via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat. In 2019, the total effective dose (TED) to the MEOSI of 2.8 mrem (28 μSv) from Laboratory operations was well below the dose limit of 100 mrem in a year required by DOE Order 458.1, as well as all other U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) regulatory dose limits for the public, workers, and the environment.

Beginning with this edition of the Annual Site Environmental Report (2019), five years of measurement data are shown in the data tables to present and describe trends in measured ambient radiation dose at BNL. In general, the radiological footprint at BNL continues to slowly grow, with a recent peak in 2018, as testing for Ac-225 production occurred. The ambient dose decreased slightly in 2019 as readiness reviews took place in preparation for ramping up production testing for the same process.

The dose estimates for 2019 were calculated using the latest version of the dose modeling software promulgated by the EPA. All data in this chapter are reported with uncertainties at the 95 percent (2-sigma) confidence level. As such, the effective dose equivalent (EDE) from air emissions in 2019 was estimated at 1.28 mrem (12.8 μSv) to the MEOSI. This BNL dose level from the inhalation pathway was less than 13 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 1.4 mrem (14 μSv) from the consumption of deer meat and 0.09 mrem (0.90 μSv) from the consumption of fish caught near the Laboratory. In summary, the total annual dose to the MEOSI from all pathways was estimated at 2.8 mrem (28 μSv), which is less than 3.0 percent of DOE's 100-mrem limit. The aggregate population dose was 1.81 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 per person.

Dose to the maximally exposed individual (MEI) on site and outside of controlled areas, calculated from thermo-luminescent dosimeter (TLD) monitoring records, was 25 mrem above natural background radiation levels, also well below the 100-mrem DOE limit on dose. The average annual external dose from ambient sources on site was 62 ± 12 mrem (620 ± 120 μSv), while the dose from off-site ambient sources was 59 ± 11 mrem (590 ± 110 μSv). 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 50 on-site TLDs and 17 off-site TLDs showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level. Additional TLDs were used to measure on-site areas known to receive 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 2019 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 with potential for 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, the dose risk from these facilities was trivial in 2019. 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 levels with contributions from cosmic and terrestrial sources, and with no contributions from Laboratory operations.

On- and off-site external dose measurements are averaged separately 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 (See Photo 8-1).

Photo 8-1. TLD at P-4 Perimeter Station

In 2019, a total of 60 environmental TLDs were deployed on site, ten of which were placed in known radiation areas. A total of 17 environmental TLDs were deployed at off-site locations (see Figures 8-1 and 8-2). In 2019, all 16 wind sectors around the Laboratory had TLD locations. An additional 30 TLDs were stored in a lead-shielded container for use as reference and

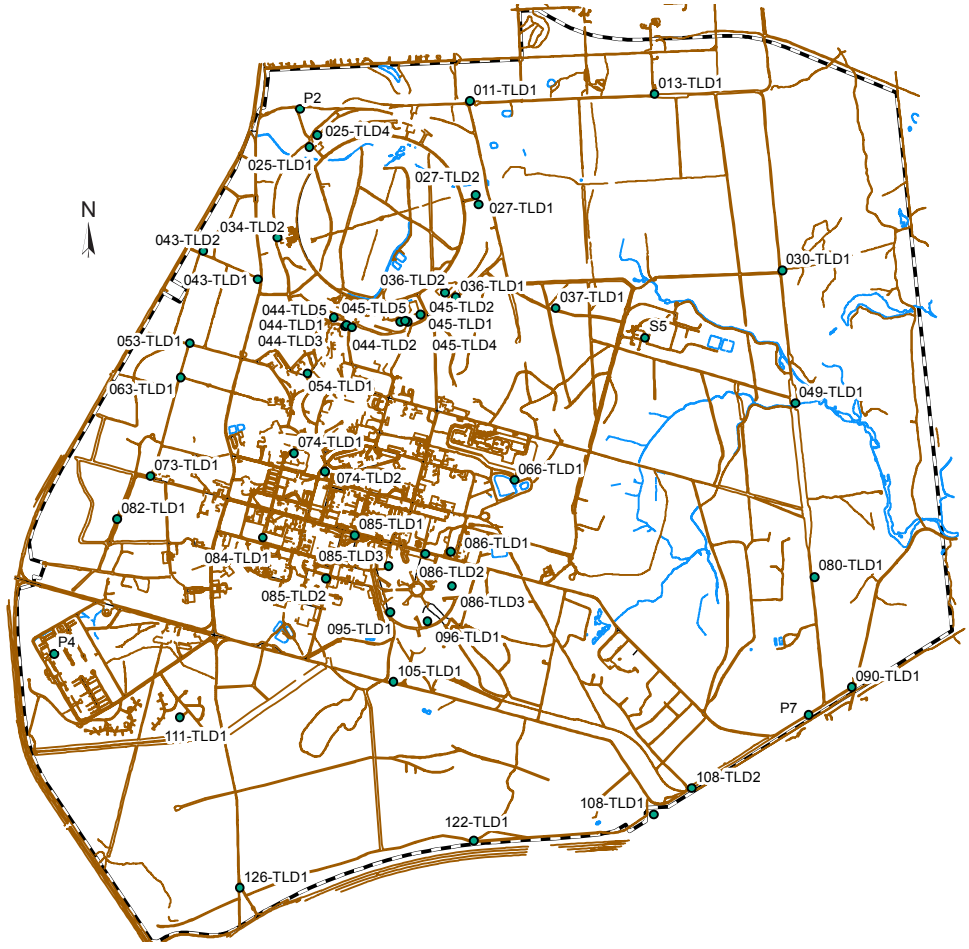

Figure 8-1. On-Site TLD Locations.

control TLDs for comparison purposes. The total of the control TLD dose values for 2019, reported as 075-TLD4 in Tables 8-1 and 8-2, was 27 ± 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 annual total external radiation dose measured. Table 8-1 shows the annual on-site radiation dose measurements for 2015 to 2019. For 2019, the on-site external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 62 ± 12 mrem (620 ± 120 μSv). The onsite measurements in this table generally exhibit year-to-year variation within 10 percent or less of the average. The same can be said about the offsite measured doses in Table 8-2, which shows the annual off-site radiation dose measurements for 2015 to 2019. The off-site ambient dose in 2019 from all potential environmental sources, including cosmic and terrestrial radiation sources, was 59 ± 11 mrem (590 ± 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

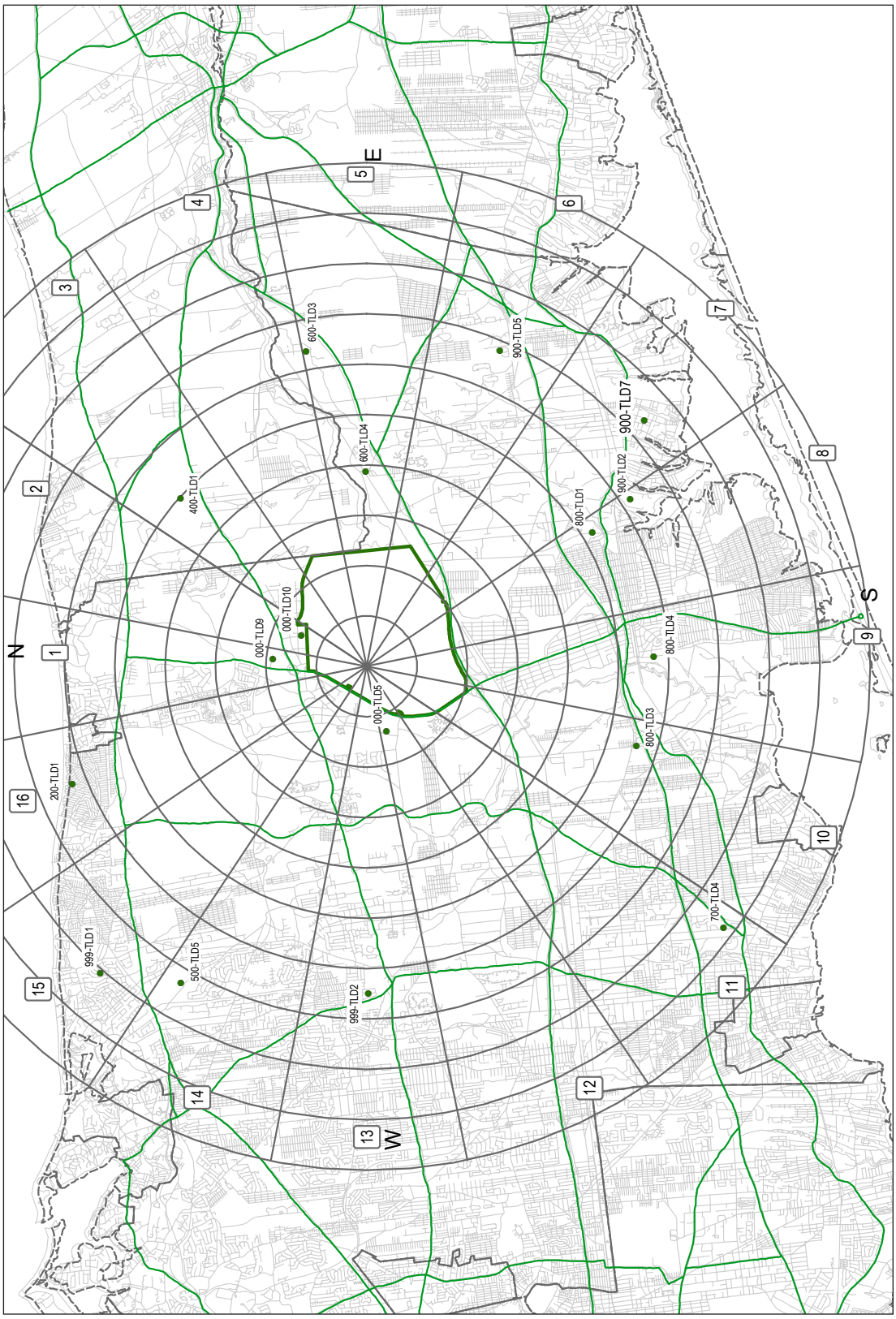

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Figure 8-2. Off-Site TLD Locations.

Table 8-1. Five-Year Annual On-Site Direct Ambient Radiation Measurements (2015-2019).

		Annual Total Dose, mrem (±2σ, 95% conf. interval)				
TLD#	**Location**	**2015**	**2016**	**2017**	**2018**	**2019**
011-TLD1	North Firebreak	54±9	53±3	56±12	58±8	55±13
013-TLD1	North Firebreak	61±7	59±6	61±8	61±11	62±12
025-TLD1	Bldg. 1010, Beam Stop 1	59±9	63±9	61±12	63±7	58±14
025-TLD4	Bldg. 1010, Beam Stop 4	63±8	63±10	67±22	62±10	59±9
027-TLD1	Bldg. 1002A South	55±9	58±10	58±9	60±9	58±14
027-TLD2	Bldg. 1002D East	56±9	59±12	58±12	62±18	55±13
030-TLD1	Northeast Firebreak	61±6	62±3	64±11	64±11	59±7
034-TLD1	Bldg. 1008, Collimator 2	62±7	64±7	NLP	NLP	NLP
034-TLD2	Bldg. 1008, Collimator 4	62±4	66±11	66±9	67±12	65±11
036-TLD1	Bldg. 1004B, East	61±14	57±8	58±14	57±9	58±12
036-TLD2	Bldg. 1004, East	64±9	61±9	61±12	62±10	58±11
037-TLD1	S-13	64±18	59±6	60±11	59±7	58±12
043-TLD1	North Access Road	67±2	68±8	66±6	69±11	68±14
043-TLD2	North of Meteorology Tower	64±4	66±5	67±11	66±10	65±15
044-TLD1	Bldg. 1006	63±10	65±10	67±11	69±13	61±10
044-TLD2	South of Bldg. 1000E	63±4	67±11	67±8	67±11	64±6
044-TLD3	South of Bldg. 1000P	61±9	62±15	65±10	66±20	60±10
044-TLD4	Northeast of Bldg. 1000P	67±11	68±14	NLP	NLP	NLP
044-TLD5	North of Bldg. 1000P	63±10	68±14	67±18	67±14	59±9
045-TLD1	Bldg. 1005S	60±11	59±9	62±10	63±14	62±9
045-TLD2	East of Bldg. 1005S	63±7	62±5	62±10	67±10	59±10
045-TLD3	Southeast of Bldg. 1005S	64±11	65±7	NLP	NLP	NLP
045-TLD4	Southwest of Bldg. 1005S	62±11	65±13	64±13	69±21	61±13
045-TLD5	West-Southwest of Bldg. 1005S	63±10	63±8	60±11	66±14	64±12
049-TLD1	East Firebreak	63±3	64±6	65±11	70±11	62±10
053-TLD1	West Firebreak	68±11	69±6	66±7	71±11	71±22
063-TLD1	West Firebreak	69±3	69±8	70±13	72±6	68±14
066-TLD1	Waste Management Facility	56±6	54±6	57±12	60±9	52±11
073-TLD1	Meteorology Tower	66±5	66±6	66±12	66±11	63±6
074-TLD1	Bldg. 560	68±3	69±8	72±21	73±15	67±13
074-TLD2	Bldg. 907	62±16	63±9	63±10	66±14	61±19
080-TLD1	East Firebreak	69±10	73±6	70±10	72±6	70±18
082-TLD1	West Firebreak	73±8	73±10	71±13	73±7	71±13
084-TLD1	Tennis courts	63±8	65±4	63±7	72±19	63±12
085-TLD1	Bldg. 735	64±5	64±8	66±16	68±11	65±15
085-TLD2	Upton Gas Station	64±11	65±7	67±7	66±9	66±17
085-TLD3	NSLS-II LOB 745	NYP	NYP	64±4	71±13	68±20
086-TLD1	Baseball Fields	65±11	62±7	64±7	66±8	61±11
086-TLD2	NSLS-II LOB 741	NYP	NYP	59±3	64±14	56±11
086-TLD3	NSLS-II LOB 742	NYP	NYP	55±4	59±11	60±16
090-TLD1	North St. Gate	62±10	66±8	66±7	64±9	62±11

(continued on next page)

Table 8-1. Five-Year Annual On-Site Direct Ambient Radiation Measurements (2015-2019). *(concluded).*

		Annual Total Dose, mrem (±2σ, 95% conf. interval)				
TLD#	**Location**	**2015**	**2016**	**2017**	**2018**	**2019**
095-TLD1	NSLS-II LOB 744	NYP	NYP	68±2	70±8	68±19
096-TLD1	NSLS-II LOB 743	NYP	NYP	58±3	62±10	59±12
105-TLD1	South Firebreak	67±8	70±7	70±8	68±14	73±24
108-TLD1	Water Tower	66±6	65±5	73±25	65±11	62±12
108-TLD2	Tritium Pole	77±5	79±4	77±14	82±16	82±9
111-TLD1	Trailer Park	66±5	66±1	65±7	72±6	69±10
122-TLD1	South Firebreak	63±4	65±13	64±16	62±11	60±12
126-TLD1	South Gate	70±7	72±4	72±16	75±17	68±9
P2	NW Corner Site Perimeter Station	56±6	57±8	56±9	58±8	55±10
P4	SW Corner Site Perimeter Station	59±8	62±5	64±16	64±11	60±12
P7	SE Corner Site Perimeter Station	63±9	63±9	66±12	66±9	64±10
S5	Sewage Treatment Plant	61±10	60±3	58±11	61±11	57±13
On-Site Average		**64±9**	**64±8**	**65±11**	**66±11**	**62±12**
Std. Dev. (2σ)		**59±6**	**60±8**	**61±11**	**64±10**	**59±11**
075-TLD4: Control TLD Average		**32±1.4**	**27±3**	**29±3**	**30±2**	**27±3**

Notes :
See Fig. 8-1 for TLD Locations
Note: Beginning with the 2017 calendar year, a handful of stable-dose-level TLDs were moved from other locations onsite to the NSLS-II locations.
NLP = No Longer Posted. TLDs were removed from these locations to be posted at NSLS-II.
NYP = The NSLS-II locations had not yet been posted with EM TLDs in 2015 and 2016.

doses was conducted. The test showed no significant difference between the off-site dose (59 ± 11 mrem) and on-site dose (62 ± 12 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- or off-site locations from Laboratory operations in 2019.

8.1.2 Facility Area Monitoring

Ten on-site TLDs are designated as facility area monitors (FAMs) because they are posted in known radiation areas (i.e., near facilities). Table 8-3 shows the external doses measured with the FAM TLDs from 2015 to 2019. Environmental TLDs 088-TLD1 through 088-TLD4 are posted at and near the S-6 blockhouse location on the fence of the Former Waste Management Facility (FWMF). Except for the doses at S6 and 088-TLD4, which were 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. As shown in Table 8-3, overall dose levels near the FWMF have been fairly consistent. Access to the FWMF is controlled by fencing.

Two TLDs (075-TLD3 and 075-TLD5) near Building 356 showed a higher annual dose of 100 ± 17 mrem (1000 ± 170 μSv) for 075-TLD3 and 109 ± 20 mrem (1090 ± 200 μSv) for 075-TLD5. These direct doses are higher than the on-site annual average because Building 356 houses a Co-60 source which is used to irradiate materials, parts, and printed circuit boards, and higher doses are to be expected as the source collimators were removed last year to allow for objects to be placed closer to the source due to declining dose rates as a result of

Table 8-2. Five-Year Annual Off-Site Direct Ambient Radiation Measurements (2015-2019).

TLD#	Location	Annual Total, mrem (±2σ, 95% Conf. Interval)				
		2015	2016	2017	2018	2019
000-TLD4	Private property	56±0	NLP	NLP	NLP	NLP
000-TLD5	Longwood Estate	56±7	55±3	58±8	59±11	58±15
000-TLD7	Mid-Island Game Farm	60±3	NLP	NLP	NLP	NLP
000-TLD8	Private property	48±0	52±30	NLP	NLP	NLP
000-TLD9	Private property	55±6	60±11	56±7	58±9	53±10
000-TLD10	Private property	NYP	63±6	65±7	66±10	62±8
004-TLD1	Private property**	63±5	NLP	NLP	NLP	NLP
200-TLD1	Private property	NYP	NYP	NYP	71±14	66±12
200-TLD5	Private property	NYP	NYP	NYP	78±10	74±21
400-TLD1	Calverton Nat. Cemetery	69±7	69±5	68±14	71±10	61±9
500-TLD4	Private property	62±19	63±9	58±2	NLP	NLP
600-TLD3	Private property	58±14	64±14	62±8	68±12	59±2
600-TLD4	Maples B&G	61±5	59±2	57±9	59±7	57±11
700-TLD3	Private property	56±4	58±7	58±12	NLP	NLP
700-TLD4	Private property	60±2	60±5	60±7	61±10	57±6
800-TLD1	Private property	59±3	62±5	65±21	65±14	56±9
800-TLD3	Suffolk County CD	63±6	64±2	62±5	62±8	61±16
800-TLD4	LI Nat'l Wildlife Refuge	60±0	64±6	58±12	63±4	56±12
900-TLD2	Private property	56±14	57±0	62±26	62±18	57±15
900-TLD4	Private property	67±14	60±13	72±26	NLP	NLP
900-TLD5	Private property	54±0	56±7	54±5	59±7	50±3
900-TLD6	Private property	58±0	54±10	NLP	NLP	NLP
900-TLD7	Private property	NYP	NYP	NYP	67±8	61±13
999-TLD1	Private property	59±18	61±10	61±7	64±7	58±12
999-TLD2	Private property	NYP	NYP	NYP	73±2	52±12
Off-site average		**59±6**	**60±8**	**61±11**	**64±10**	**59±11**
075-TLD4 : Control TLD Average		**32±1**	**27±3**	**29±3**	**30±4**	**27±3**

Notes:
See Fig. 8-2 for TLD Locations
Note: TLDs are placed by volunteers or other entities.
Year-to-year, willingness to participate varies among owners at these locations.
NLP = No Longer Posted. TLDs were removed from these locations.
NYP = Not Yet Posted with TLDs.
**TLD designator 004-TLD1 was changed to 000-TLD10 to align its designator with the naming convention.

Table 8-3. Five-Year Annual Facility Area Monitoring Results (2015-2019).

TLD#	Location	Annual Total, mrem (±2σ, 95% Conf. Interval)				
		2015	2016	2017	2018	2019
054-TLD1	Bldg. 914	72±22	82±34	83±44	91±48	75±33
054-TLD2	NE of Bldg. 913B	82±34	89±45	85±53	86±49	76±30
054-TLD3	NW of Bldg. 913B	77±28	77±32	76±43	81±47	72±24
S6	FWMF blockhouse	70±7	71±2	70±13	71±11	69±17
088-TLD1	FWMF, 50' East of S6	82±7	79±2	82±5	84±12	77±12
088-TLD2	FWMF, 50' West of S6	74±7	73±5	73±11	74±12	72±13
088-TLD3	FWMF, 100' West of S6	75±5	76±5	77±12	75±7	74±8
088-TLD4	FWMF, 150' West of S6	65±5	66±6	65±7	67±8	69±13
075-TLD3	Building 356	81±15	80±9	85±22	80±18	100±17
075-TLD5	North Corner of Bldg. 356	76±10	79±14	86±24	80±22	109±20

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

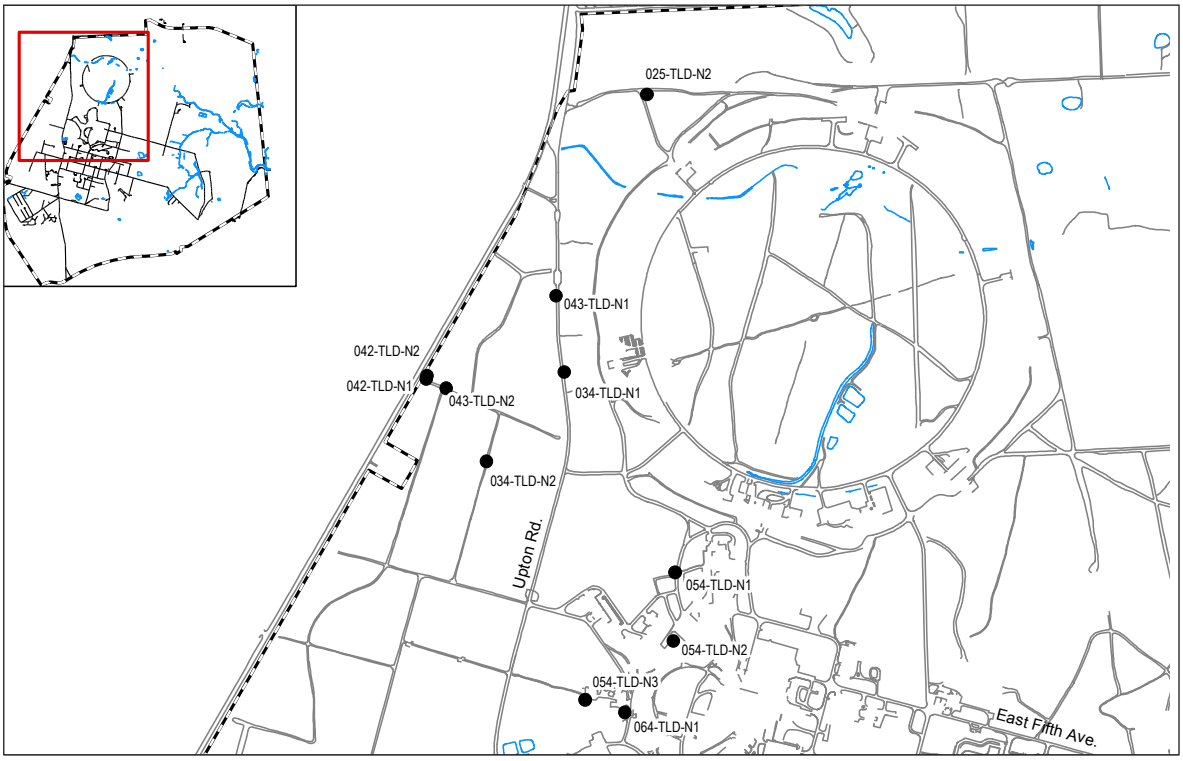

Figure 8-3. On-Site Neutron TLD Locations.

source decay. In addition, the source is left up for longer periods, sometimes overnight, and generates "sky-shine." Finally, this building also contains several Californium-252 (Cf-252) neutron sources in a cask near the corner of the building where 075-TLD5 is located. Although it is conceivable that individuals who use the parking lot adjacent to Building 356 could receive a dose from these sources, the dose would be small due to the low occupancy factor.

Three FAM TLDs near Building 914 and placed on fence sections northeast and northwest of Building 913B (the AGS tunnel access) showed slightly elevated ambient external dose. The full-year dose at these sites was measured at 75 mrem for 054-TLD1, 76 mrem for 054-TLD2, and 72 mrem for 054- TLD3 (compared to the on-site dose of 62 ± 12 mrem and off-site dose of 59 ± 11 mrem). The slightly higher levels of the first and second quarters (not shown) are expected because the operating period for the AGS is typically in the first half of the calendar year.

8.1.2.1 Neutron Monitoring

The AGS accelerates protons to energies up to 30 GeV and heavy ions up to 15 GeV/amu. 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 for ions. Under these high-energy conditions, such accelerated particles have the potential to generate high-energy neutrons when the particles leave the walls of the accelerator and produce nuclear fragments along their path or as they collide with matter. In 2019, 11 pairs of neutron monitoring TLDs (Harshaw Badge 8814) were posted at strategic locations to measure the dose contribution from the high-energy neutrons (see Figure 8-3 for locations).

The placement of neutron TLDs is based on facility 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 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 and reflected back out, where they are detected. These are mounted in pairs, for three reasons: The dose registered on these TLDs is low, so a matching number on the second TLD adds confidence to the dose measured by the first one; two neutron TLDs side-by-side decreases the potential dependence of measured dose on mounting orientation; and the reflected neutron could strike either neutron TLD and be counted (see Photo 8-2).

Photo 8-2. Neutron TLDs in Monitored Area

Table 8-4 shows measured ambient neutron doses recorded for 2015 to 2019. In 2019, four neutron TLD locations showed 1 mrem and a fifth showed 2, for a total of six mrem. 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 FOR AIRBORNE RADIONUCLIDES

The EPA regulates radiological emissions from DOE facilities under the requirements set forth in 40 CFR 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPs). This regulation specifies the compliance and monitoring requirements for reporting radiation doses received by members of the public from airborne radionuclides. The regulation mandates that no member of the public shall receive a dose greater than 10 mrem (100 μSv) in a year from airborne emissions.

The emission monitoring requirements 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 periodic confirmatory measurements for all other release

Table 8-4. Five-Year Annual Neutron Monitoring Results (2015-2019).

Neutron TLD #	Location ID No.	Annual Total, mrem neutron				
		2015	2016	2017	2018	2019
TK275	025-TLD-N1	0	0	0	NLP	NLP
TK276	"	0	0	0	NLP	NLP
TK277	025-TLD-N2	0	0	0	0	0
TK278	"	0	0	2	2	0
TK279	034-TLD-N1	0	0	1	0	1
TK280	"	0	1	0	1	0
TK281	034-TLD-N2	0	0	0	0	0
TK282	"	1	0	1	1	0
TK283	043-TLD-N1	0	0	0	0	0
TK284	"	0	0	1	0	0
TK285	043-TLD-N2	0	0	0	0	0
TK286	"	2	0	0	1	2
TK287	042-TLD-N1	1	0	0	0	1
TK288	"	4	1	0	0	1
TK289	042-TLD-N2	0	3	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	5	0	1	0	0
TK294	"	4	0	2	0	0
TK295	054-TLD-N3	0	1	0	0	0
TK296	"	0	0	0	0	1
TK297	064-TLD-N1	0	2	1	0	0
TK298	"	0	0	0	1	0
PM-bkg		2	1	1	1	1

NLP = No Longer Posted. TLDs were removed from these locations to be posted at NSLS-II.

points. The regulations also require DOE facilities to submit an annual NESHAPs report to the EPA that describes the major and minor emission sources, their releases, and their resultant dose to the Maximally Exposed Off Site Individual (MEOSI). The dose estimates from various facilities are given in Table 8-5, and the actual air emissions for 2019 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

Table 8-5. Maximally Exposed Off-site Individual (MEOSI) Effective Dose Equivalent From Facilities or Routine Processes, 2019.

Building No.	Facility or Process	Construction Permit No.	MEOSI Dose (mrem) (a)	Notes
120	Instrumentation & Calibration	None	2.21E-09	(b)
348	Instrumentation & Calibration	None	2.59E-08	(b)
463	Biology	None	2.85E-08	(b)
480	Condensed Matter Physics	None	ND	(f)
490	Nonproliferation & National Security	None	2.29E-11	(b)
510	Physics	None	7.83E-14	(b)
535	Instrumentation	None	ND	(f)
555	Chemistry Facility **	None	9.21E-04	(b)
734	Interdisciplinary Science Building	None	ND	(f)
735	Center for Functional Nanomaterials	None	ND	(f)
740	Nuclear Science & Technology	None	ND	(f)
741	Nuclear Science & Technology	None	ND	(f)
743	Nuclear Science & Technology	None	ND	(f)
744	NSLS-II	None	ND	(f)
745	NSLS-II	None	3.89E-06	(b)
750	HFBR	None	8.52E-05	(c)
750	Nonproliferation & National Security	None	ND	(g)
801	Target Processing Lab	None	9.19E-03	(c)
815	Nonproliferation & National Security	None	2.06E-08	(b)
820	Accelerator Test Facility	BNL-589-01	ND	(d)
830	Environmental Science Department	None	ND	(f)
860	Waste Managerment Facility	None	ND	(d)
901	Condensed Matter Physics & Mat'ls Sci.	None	7.00E-18	(b)
902	Superconducting Magnet Division	None	ND	(f)
906	Imaging Lab	None	ND	(f)
911	Collider Accelerator	None	1.41E-10	(b)
925	RF Systems	None	ND	(f)
931	BLIP	BNL-2009-01	1.27E+00	(c)
942	AGS Booster	BNL-188-01	ND	(e)
---	RHIC	BNL-389-01	ND	(d)
Total Potential Dose from BNL Operations			**1.28E+00**	
EPA Limit (Air Emissions)			**10**	

Notes:
MEOSI = Maximally Exposed Offsite 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 2019.
(e) Booster ventilation system prevents air release through continuous air recirculation.
(f) No radiological dispersible material inventory in 2019.
(g) Sealed sources were excluded from this inventory - no emission
** Both the CO and MO departments are housed in 555, so their MEOSI doses are combined here.

contributions from short-term projects and area sources. For that reason, modeling results are conservative.

8.2.1 Dose Modeling Program

Compliance with NESHAPs regulations is demonstrated using EPA dose-modeling software and the Clean Air Act Assessment Package 1988 (CAP88-PC). This computer program uses a Gaussian plume model to characterize the average dispersion of airborne radionuclides released from elevated stacks or diffuse sources. CAP88-PC then calculates the effective dose equivalent (EDE) to the MEOSI from low levels of radioactive materials released into the environment. 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. CAP88-PC calculated the EDE at the MEOSI location from the immersion, inhalation, and ingestion pathways. CAP88 also calculated the collective population dose within a 50-mile radius of the emission source.

As stated above, these dose and risk calculations to the MEOSI are based on low emissions and chronic intakes. In most cases, the CAP88-PC model provides conservative dose estimates. For the purpose of modeling their dose to the MEOSI, all emissions are treated as having been released from 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 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). Solar radiation effects are also accounted for. A population of six million people, based on the Geographical Information System design population survey performed by Oak Ridge National Laboratory for BNL, was used in the model.

The 2019 effective dose equivalents were estimated using Version 4.0.1.17 of CAP88-PC. The following approaches and assumptions were used in determining 2019 dose estimates for this annual report:

- A conservative approach is used for agricultural data input to the CAP88 modeling program, with 92 percent of vegetables, 100 percent of milk, and 99 percent of meat assumed 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 2019 was 517cfm, or 0.244 m3/sec. With an exit diameter of 0.1 m, the exit velocity was 31.06 m/sec, up slightly from last year's 31.04 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 located beyond the BNL site boundary such that no other member of the public could receive a higher dose. 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). 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 onsite maximally exposed individual (MEI) who could

receive any dose outside of BNL's controlled areas was determined by TLD measurements (see Table 8-7). The dose to the MEI on site and outside of controlled areas (near Building 356) was measured at 25 mrem in 2019. The increase in MEI dose in 2019 was due to nearly continuous research irradiations conducted with a Co-60 source in Building 356 during the year, as discussed in section 8.1.2. The 25-mrem dose to the on-site MEI is less than the dose received from seven round-trip flights from Los Angeles, California to New York, New York, and equal to eight percent of the average annual natural background in the U.S. of 311 mrem.

8.2.2.2 Dose Calculation: Fish Ingestion

To calculate the EDE from fish consumption, the annual intake is estimated first, which is defined as the average weight of fish consumed in a year by a Reference Person engaged in recreational fishing on the Peconic River. Based on a New York State Department of Health (NYSDOH) study, the annual 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 for a Reference Person, as listed in DOE-STD-1196-2011, Table A-1, was used for each radionuclide to convert the activity concentration to the EDE. The dose was calculated as: dose in (rem/yr) = intake (kg/yr) × activity in flesh (μCi/kg) × dose conversion factor (rem/μCi). For BNL's case, the committed dose equivalent conversion factor for Cesium-137 (Cs-137) is 4.92E-02 rem/μCi.

8.2.2.3 Dose Calculation: Deer Meat Ingestion

The dose calculation for deer meat ingestion is like that for fish consumption. The same Cs-137 dose conversion factor was used to estimate dose. No other radionuclides associated with Laboratory operations have been detected in deer meat. The total quantity of deer meat ingested during a year has been estimated by the NYSDOH 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 radionuclides 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.

8.3.1 Remediation Work

In 2019, remediation work was not performed on the BNL site.

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 1.0μSv). The BLIP facility is considered a major emission source in accordance with the ANSI N13.1-1999 standard's graded approach, specifically 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 continuously record and display 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 which is then analyzed at an off-site

Table 8-6. Five-Year Site Dose Summary, 2019.

	2015	2016	2017	2018	2019
Pathway	**Annual Maximally Exposed Off-Site Individual Dose, mrem**				
Inhalation					
Air	0.28	0.62	0.72	1.63	1.28
Ingestion					
Drinking Water	None	None	None	None	None
Fish[1]	0.088	0.088	0.088	0.088	0.088
Deer	2.78	2.45	4.8	3.32	1.4
All Pathways	**3.15**	**3.16**	**5.61**	**5.04**	**2.77**

Pathway	**Percent of DOE 100-mrem/yr Dose Limit, %**				
Inhalation					
Air	<1.0	<1.0	<1.0	<2.0	<1.5
Ingestion					
Drinking Water	None	None	None	None	None
Fish[1]	<0.1	<0.1	<0.1	<0.1	<0.1
Deer	<3.0	<3.0	<5.0	<4.0	<1.5
All Pathways	**<4.0**	**<4.0**	**<6.0**	**<6.0**	**<3.0**

Pathway	**Estimated Population Dose Per Year, person-rem**				
Inhalation					
Air	0.42	0.94	1.16	2.55	1.81
Ingestion					
Drinking Water	None	None	None	None	None
Fish[1]	Not Tracked	Not Tracked	Not Tracked	Not Tracked	Not Tracked
Deer	Not Tracked	Not Tracked	Not Tracked	Not Tracked	Not Tracked
All Pathways	**0.42**	**0.94**	**1.16**	**2.55**	**1.81**

Note:
1 - Source River remained dried up in 2019, so 2015 fish data was used to represent magnitude since sampling was not possible in 2019.

contract analytical laboratory on a weekly basis.

In 2019, the BLIP facility operated over a period of 25.14 weeks. During the year, 6,341Ci of C-11 (half life: 20.4 minutes) and 12,681 Ci of O-15 (half life: 122 seconds) were released from the BLIP facility. A small quantity (3.77E-02 Ci) of tritiated water vapor from activation of the targets' cooling water was also released. The EDE to the MEOSI from BLIP operations was calculated to be 1.27 mrem (13 μSv) in a year.

8.4.2 Target Processing Laboratory

In 2019, there were no detectable levels of emissions from the Target Processing Laboratory.

8.4.3 High Flux Beam Reactor

In 2019, the residual tritium emissions from the HFBR facility were measured at 0.385 Ci, and the estimated dose attributed was 8.5E-5 mrem (0.85 μSv) in a year.

8.4.4 Brookhaven Medical Research Reactor

In 2019, 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 2019.

Table 8-7. Five-Year Annual Maximally Exposed Onsite Individual Dose (2015-2019).

TLD #	Location	Annual Total, mrem				
		2015	2016	2017	2018	2019
TK154	2nd Floor, B120	10	5	8	14	25
TK155	1st Floor, B120	4	3	2	5	20

8.4.5 Brookhaven Graphite Research Reactor

In 2019, long-term surveillance of the BGRR continued, as well as the maintenance and periodic refurbishment of structures, systems, and components. This status will continue throughout the period of radioactive decay. There were no radionuclides released to the environment from the complex in 2019.

8.4.6 Waste Management Facility

In 2019, there were no detectable levels of emissions from the Waste Management Facility.

8.4.7 Unplanned Releases

In 2019, 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 near the BNL boundary were used to assess the potential dose impact to the MEOSI. The maximum tissue concentration in the deer meat 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 unrelated to BNL operations.

In 2019, BNL collected samples from 261 deer remains, 250 of those from a managed cull, and analyzed them 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. From Table 6-2, the average K-40 concentrations in non-culled deer tissue samples (All Samples) were 3.27 ± 0.62 pCi/g (wet weight) in the flesh and 2.51 ± 0.63 pCi/g (wet weight) in the liver. From Table 6-3, the average K-40 flesh concentration in culled deer tissue samples (Managed Cull) was 3.00 ± 2.00 pCi/g (wet weight). Liver samples were not taken from culled deer. The maximum Cs-137 flesh concentration in all samples on site (non-culled and culled) was 0.28 ± 0.01 pCi/g (wet weight). The average Cs-137 flesh concentration from all non-culled deer sampled was 0.26 ± 0.05 pCi/g. However, the maximum Cs-137 flesh concentration of 0.98 ± 0.03 pCi/g, taken 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 1.40 mrem (14.0 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 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 (i.e., a "gaining" stream) and completely drying up during dry periods (i.e., a "losing" stream). In 2019, the Peconic River did not have sufficient flow to support fish populations, therefore no fish samples were taken to analyze for radioactivity.

Therefore, as a representative estimate of dose due to fish consumption from local freshwater bodies for 2019, 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 0.09 mrem (0.9 µSv)—well below the NYSDOH health advisory limit of 10 mrem.

8.6 DOSE TO AQUATIC AND TERRESTRIAL BIOTA

DOE-STD-1153-2019, 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 2019, the terrestrial animal and plant doses were evaluated based on 0.84 pCi/g of Cs-137 (see Table 6-4) found in soil from the South lawn of Building 490, and a Strontium-90 (Sr-90) concentration of 0.44 pCi/L (see Table 5-5) in the surface water collected at the HQ station at the site boundary. The resultant dose to terrestrial animals was calculated to be 40.4 μGy/day and to plants as 3.80 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 in 2019, the surface water Sr-90 concentration mentioned above, 0.44 pCi/L, was used along with the estimated Cs-137 concentration in vegetation at the NSRL beam stop, which was 0.07 pCi/g. Using these concentrations, the calculated estimate of dose to aquatic animals was 0.10 μGy/day, and the dose to riparian animals was 1.60 μGy/day. Therefore, the dose to aquatic animals was well below the limit of 10 mGy/day, and the dose to riparian animals was also well below the 1 mGy/day limit specified by the order.

8.7 DOSE FROM ALL PATHWAYS

Table 8-6 summarizes the estimated dose to the MEOSI from the inhalation, immersion, and ingestion pathways, the percentage of the 100-mrem annual allowable dose limit posed by the estimated MEOSI dose, by pathway, and the potential cumulative dose to the surrounding population via the inhalation pathway from the BNL site, for the years 2015 through 2019. The total dose to the MEOSI from the air and ingestion pathways was estimated to be 2.8 mrem (28 mSv). In comparison, the DOE limit on dose from all pathways is 100 mrem (1 mSv). Furthermore, the EPA regulatory limit for the air pathway is 10 mrem (0.10 mSv). The cumulative population dose from airborne emissions was 1.81 person-rem (1.81E-2 person-Sv) in 2019.

In conclusion, the effective dose from all pathways due to BNL operations in 2019 was well below the DOE and EPA regulatory limits, and the ambient offsite TLD dose was within limits of 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 in the United States 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 70 mrem (0.7 mSv) to an individual. Therefore, a dose of 2.80 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 for analytical laboratories is maintained through daily instrument calibration, efficiency, 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 2019 Site Environmental Report are reliable and of acceptable quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by Department of Energy (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, 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 QA Program is to implement QA 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 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 Environmental Protection Agency (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

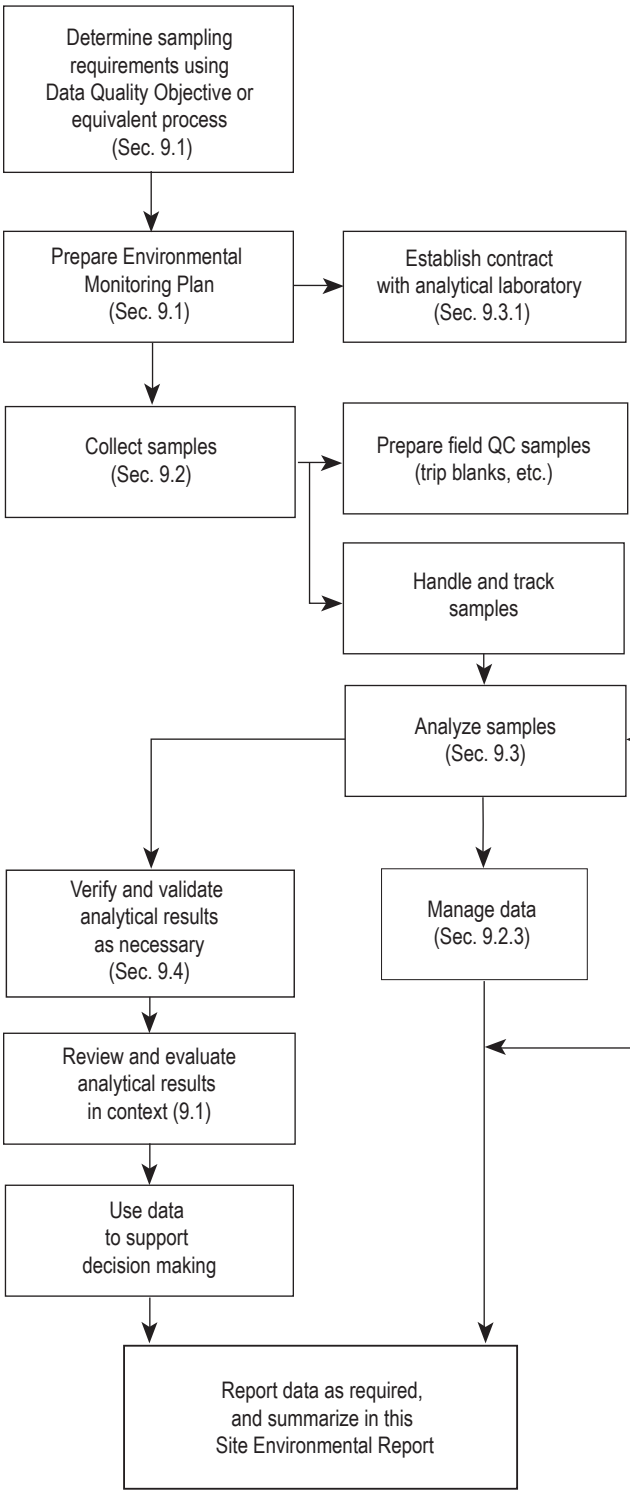


Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

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, the data is 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.). This data is used to support decision making, reported as required, and summarized in this annual report.

9.2 SAMPLE COLLECTION AND HANDLING

In 2019, environmental monitoring samples were collected, as specified, by EM-SOPs, the BNL Environmental Monitoring Plan Update (BNL 2019), 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 2019. 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 2019), 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 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 of receipt, but for weekend deliveries, the notification may occur on the following Monday. If a sample arrives with an incorrect pH, the lab is 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, are 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.

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.

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 2019.

An equipment blank is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool after decontamination. The rinse water is collected and tested to verify that the sampling tool is not contaminated. Equipment blank samples are collected, as needed, to verify the effectiveness of the decontamination procedures on non-dedicated or reusable sampling equipment.

A trip blank is provided with each shipping container of samples to be analyzed for volatile

organic compounds (VOC). 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 2019.

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 Data Quality Objectives (DQOs).

In 2019, the most common contaminant detected in the trip, field, and equipment blanks was trace to low levels of methylene chloride.. This is believed to be a laboratory contaminant due to its widespread use in commercial laboratories. This compound is commonly detected in blanks and does not pose significant problems with the reliability of the analytical results. Several other compounds were also detected, such as chloroform and methyl chloride 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 2019 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 2019, a total of 76 duplicate samples were collected for non-radiological analyses and 107 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 3,368 parameters analyzed, no parameter was above 50 percent Relative Percent Difference and only 17 (0.5 percent) of the non-radiologic analyses failed to meet a tighter 20 percent QA criteria. For the radiologic parameters, seven of the 412 parameters (1.7 percent) failed to meet QA criteria. These results are indicative of consistency with the laboratory and sampling team that is 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 2019 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 DOE Brookhaven Site Office staff using a web-based data query tool.

9.3 SAMPLE ANALYSIS

In 2019, environmental samples were analyzed by five contract analytical laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available. In addition, field sampling technicians performed field monitoring for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity.

9.3.1 Qualifications

BNL used the following five contract analytical laboratories for analysis of environmental samples in 2019:

1. American Radiation Services (ARS) in Port Allen, Louisiana, for radiological analytes;
2. Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes;
3. General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes;
4. PACE Lab in Melville, New York, for nonradiological analytes; and
5. 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 (PE) tests,
2. Their contract with the DOE Integrated Contract Procurement Team,
3. Pre-selection bidding, and
4. Their adherence to their own QA/QC programs, which must be documented and provided to BNL.

Routine QC procedures that laboratories must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. Three of the five laboratories contracted by BNL in 2019 were certified by the New York State Department of Health (NYSDOH) for the relevant analytes, where such certification existed. NYSDOH does not currently certify for the specific analytes tested by Chemtex Lab, which has Texas National Environmental Laboratory Accreditation Program (NELAP) accreditation. ARS did not have NYSDOH accreditation during 2019, however received NYSDOH accreditation at the start of 2020. ARS did have Louisiana NELAP accreditation during 2019. 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 was not initiated, or the sample was not extracted, within the time frame required by EPA or by the contract. In 2019, due to a laboratory login error, a sample for chloride was not analyzed within the technical holding time of 28 days, and four samples for volatiles were not analyzed due to the laboratory transporting samples between testing facilities. These analyses were canceled based on the usability of data that would have been obtained outside holding times. Also, due to a laboratory login error, four samples for mercury were analyzed outside the 28-day technical holding times.
- *Incorrect test method* – The analysis was

Table 9-1. Summary of Detections in Trip and Field Blank Samples.

Constituent	Number of Analyses	Number of Detects	Minimum	Maximum	Typical Reporting Limit	Units
Trip Blank Results						
Methylene chloride	92	44	0.24	15	0.5	µg/L
Chlorobenzene	92	32	0.16	0.59	0.5	µg/L
Bromodichloromethane	92	12	0.12	0.12	0.5	µg/L
Chlorobenzene	92	6	0.27	0.27	0.5	µg/L
Carbon tetrachloride	92	2	1.4	1.4	0.5	µg/L
Dibromochloromethane	92	2	0.11	0.11	0.5	µg/L
Methyl chloride	92	2	0.21	0.21	0.5	µg/L
Styrene	92	1	0.25	0.25	0.5	µg/L
Field Blank Results						
Organic Compounds						
Bromodichloromethane	39	1	0.47	0.47	0.5	µg/L
Chlorobenzene	39	1	0.17	0.17	0.5	µg/L
Tetrachloroethylene	39	1	0.34	0.34	0.5	µg/L
Methylene chloride	39	14	0.2	2.31	0.5	µg/L
Chloroform	39	16	0.25	7.02	0.5	µg/L
Metals						
Barium	4	1	1.62	1.62	1	µg/L
Copper	4	1	0.536	0.536	3	µg/L
Sodium	4	1	554	554	100	µg/L
Zinc	4	1	5.17	5.17	3.3	µg/L
Arsenic	4	2	2.25	2.57	2	µg/L
General Chemistry Parameters						
Chloride	3	1	0.362	0.362	0.067	mg/L
Alkalinity (as CaCO3)	4	2	1.99	2.59	1.45	mg/L
Nitrogen	4	3	0.0388	0.336	0.033	mg/L
TDS	4	3	5.71	181	3.4	mg/L
Total Kjeldahl Nitrogen	4	3	0.0353	0.329	0.033	mg/L
Ammonia (as N)	4	4	0.0249	0.0491	0.017	mg/L

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

not performed according to a method required by the contract.

- *Poor recovery* – The compounds or radioisotopes added to the sample before laboratory processing were not recovered at the recovery ratio required by the contract.
- *Insufficient QA/QC data* – Supporting data received from the contract analytical laboratory were insufficient to allow validation of results.
- *Incorrect minimum detection limit (MDL)* – The contract analytical laboratory reported extremely low levels of analytes as "less than minimum detectable," but the contractually required limit is not used.
- *Invalid chain-of-custody* – There was a failure to maintain proper custody of samples,

as documented on COC forms.
- *Instrument failure* – The instrument did not perform correctly.
- *Preservation requirements not met* – The requirements identified by the specific analytical method were 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 was 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 2019 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 in Table 1. This issue 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 2019 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 2017b). During 2019, 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.

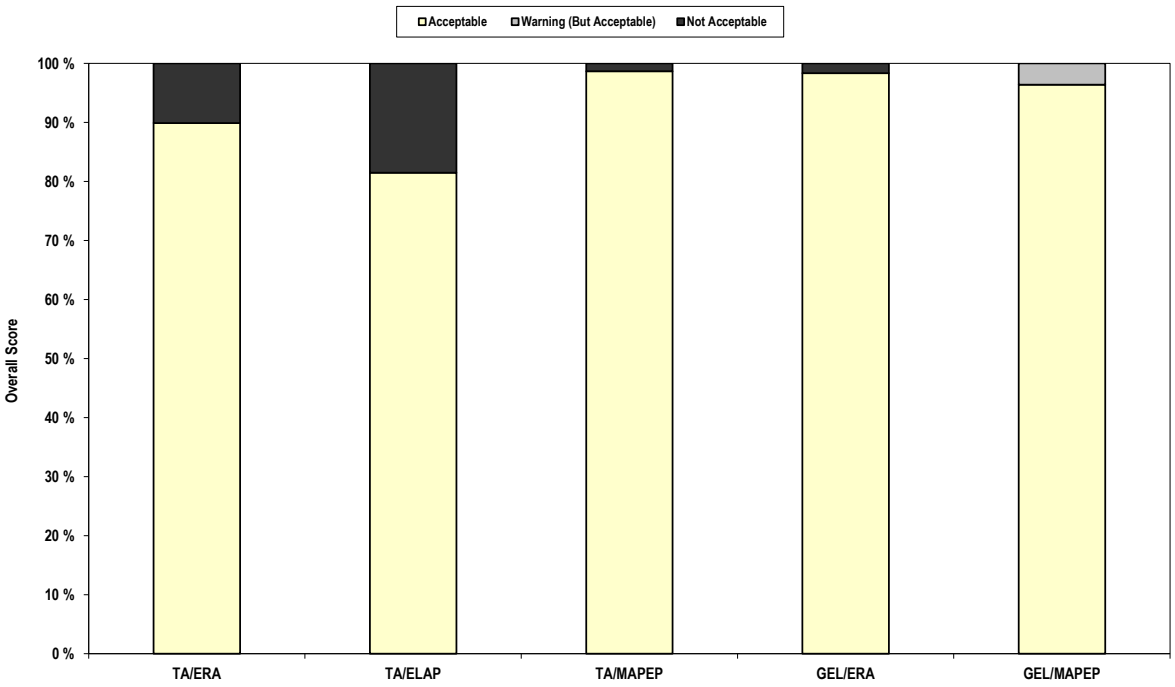
9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2019, 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.

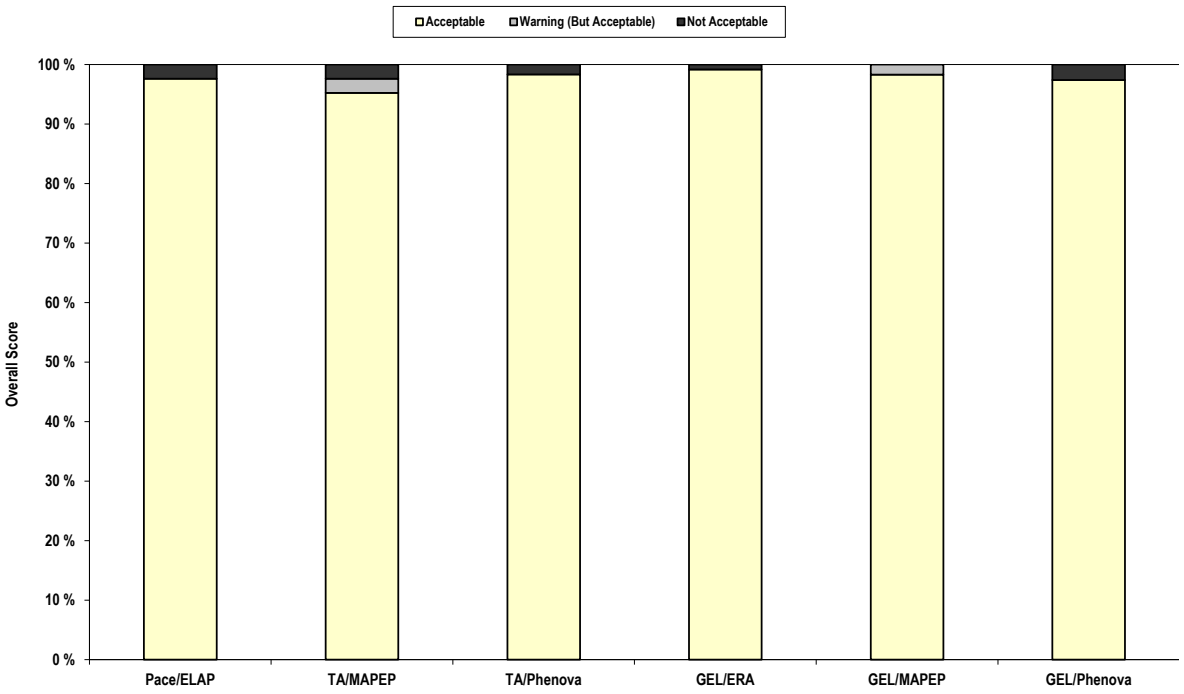
9.6 PERFORMANCE OR PROFICIENCY EVALUATIONS

Four of the contract analytical laboratories (ARS, GEL, PACE, and TA) participated in several national and state PE testing programs in 2019. Chemtex Lab did not participate in PE testing because there is no testing program for the specific analytes Chemtex analyzed for BNL (i.e., tolytriazole, polypropylene glycol monobutyl ether, and 1,1-hydroxyethylidene diphosphonic acid). Each of the participating laboratories took part in at least one testing program, and several laboratories participated in multiple programs. Results of the tests provide information on the quality of a laboratory's analytical capabilities. The testing was



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.

conducted by Environmental Resource Associates (ERA), the DOE required Mixed Analyte Performance Evaluation Program (MAPEP), Resource Technology Corporation, 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 value—a criterion set by the independent testing organizations.

Figure 9-2 summarizes radiological performance scores in the ERA, MAPEP, and ELAP programs. GEL had an average overall satisfactory score of 98 percent. TA had an overall satisfactory score of 93 percent. 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, MA- PEP, Phenova, and ELAP tests. For nonradiological tests, the laboratories received overall satisfactory result of 97 percent. Additional details on nonradio- logical 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, 90 percent were in the Acceptable range. TA participated in the ELAP evaluations; 81 percent of TA's ELAP tests on radiological samples were in the Acceptable range. The ELAP testing is based on a small sample group (20 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 2019, 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 99 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 95 percent of TA's and GEL's results, respectively, 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 97 percent of GEL's results were in the Acceptable range.

9.7 AUDITS

As part of DOE's Consolidated Audit Program (CAP) transitioning to a third-party accreditation program in 2018, TA was audited in 2019 (ANAB 2019a, b,c) by ANSI-ASQ National Accreditation Board (ANAB). During the audits, 36 nonconformities were cited. In all instances concerning parameters required by BNL, these findings did not affect BNL data.

ARS was assessed by ANAB and approval was given on October 12, 2018 (ANAB 2018b). GEL was assessed by A2LA and successfully completed the evaluation process on July 30, 2018 (A2LA 2018). Pace was assessed on December 29, 2016 (BNL 2016) by BNL and it was concluded that they remain an acceptable analytical laboratory. They are on a three-year cycle and thus the next scheduled assessment is in December 2019. There were no DOE CAP audits of the above-mentioned labs in 2019 as reflected on Table 2.

Based on the audit and assessments, the analytical laboratories met BNL criteria for Acceptable status.

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

Table 9-2. Summary Results of 2019 DOE CAP Audits*

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

* There were no DOE CAP audits on these laboratories during 2019.

to meet the DQO of each project. The results of the independent PE assessments and assessments of contractor laboratories summarized in this report are also used to assess the quality of the results. Therefore, the data used in this 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	Alternative 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 COC*	certificate to operate 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
D2O*	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
NO2	nitrogen dioxide
NOV	Notice of Violation
NOX*	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
NYSDOHNYS	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/gpicocuries 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	Relativistic 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
SO2	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 Sustainability 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
WTP	Water Treatment Plant
ZEV	zero emission vehicle

Technical Terms

These definitions reflect the typical manner in which the terms are used for this specific document and may not apply to all situations. Bold-face words in the descriptions are defined in separate entries.

A

AA (atomic absorption) – A spectroscopy method used to determine the elemental composition of a sample. In this method, the sample is vaporized and the amount of light it absorbs is measured.

accuracy – The degree of agreement of a measurement with an accepted reference or true value. It can be expressed as the difference between two values, as a percentage of the reference or true value, or as a ratio of the measured value and the reference or true value.

activation – The process of making a material radioactive by bombardment with neutrons, protons, or other high energy particles.

activation product – A material that has become radioactive by bombardment with neutrons, protons, or other high energy particles.

activity – Synonym for radioactivity.

Administrative Record – A collection of documents established in compliance with **CERCLA**. Consists of information the CERCLA lead agency uses in its decision on the selection of response actions. The Administrative Record file should be established at or near the facility and made available to the public. An Administrative Record can also be the record for any enforcement case.

aerobic – An aerobic organism is one that lives, acts, or occurs only in the presence of oxygen.

aerosol – A gaseous suspension of very small particles of liquid or solid.

ALARA (As Low As Reasonably Achievable) – A phrase that describes an approach to minimize exposures to individuals and minimize releases of radioactive or other harmful material to the **environment** to levels as low as social, technical, economic, practical, and public policy considerations will permit. ALARA is not a dose limit, but a process with a goal to keep dose levels as far below applicable limits as is practicable.

alpha radiation – The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of only an inch or so. Despite its low penetration ability, alpha radiation is densely ionizing and therefore very damaging when ingested or inhaled. Naturally occurring radioactive sources such as radon emit alpha radiation.

air stripping – A process for removing **VOCs** from contaminated water by forcing a stream of air through the water in a vessel. The contaminants evaporate into the air stream. The air may be further treated before it is released into the atmosphere.

ambient air – The surrounding atmosphere, usually the outside air, as it exists around people, animals, plants, and structures. It does not include the air immediately adjacent to emission sources.

analyte – A constituent that is being analyzed.

anneal – To heat a material and then cool it. In the case of thermoluminescent dosimeters (TLDs), this is done to reveal the amount of radiation the material had absorbed.

anion – A negatively charged ion, often written as a superscript negative sign after an element symbol, such as Cl^-.

anthropogenic – Resulting from human activity; anthropogenic radiation is human-made, not naturally occurring.

AOC (area of concern) – Under **CERCLA**, this term refers to an area where releases of hazardous substances may have occurred or a location where there has been a release or threat of a release of a hazardous substance, pollutant, or contaminant (including **radionuclide**s). AOCs may include, but need not be limited to, former spill areas, landfills, surface impoundments, waste piles, land treatment units, transfer stations, wastewater treatment units, incinerators, container storage areas, scrap yards, cesspools, tanks, and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

aquifer – A water-saturated layer of rock or soil below the ground surface that can supply usable quantities of **groundwater** to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

ARPA (Archaeological Resources Protection Act) – This law, passed in 1979, has been amended four times. It protects any material remains of past human life or activities that are of archaeological interest. Known *and potential* sites of interest are protected from uncontrolled excavations and pillage, and artifacts found on public and Indian lands are banned from commercial exchange.

AS/SVE (air sparging/soil vapor extraction) – A method of extracting **volatile organic compounds** from the **groundwater**, in place, using compressed air. (In contrast, air stripping occurs in a vessel.) The vapors are typically collected using a soil vapor extraction system.

B

background – A sample or location used as reference or control to compare BNL analytical results to those in areas that could not have been impacted by BNL operations.

background radiation – **Radiation** present in the environment as a result of naturally occurring radioactive materials in the Earth, cosmic radiation, or human-made radiation sources, including fallout.

beta radiation – Beta radiation is composed of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is more penetrating than alpha radiation, but it may be stopped by materials such as aluminum or Lucite™ panels. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

blank – A sample (usually reagent-grade water) used for quality control of field sampling methods, to demonstrate that cross contamination has not occurred.

blowdown – Water discharged from either a boiler or cooling tower in order to prevent the build-up of inorganic matter within the boiler or tower and to prevent scale formation (i.e., corrosion).

BOD (biochemical oxygen demand) – A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.

Bq (becquerel) – A quantitative measure of **radioactivity**. This alternate measure of activity is used internationally and with increasing frequency in the United States. One Bq of activity is equal to one nuclear decay per second.

bremsstrahlung – Translates as "fast braking" and refers to electromagnetic radiation produced by the sudden retardation of a charged particle in an intense electric field.

C

CAA (Clean Air Act), CAA Amendments (CAAA) – The original Clean Air Act was passed in 1963, but the U.S. air pollution control program is based on the 1970 version of the law. The 1990 Clean Air Act Amendments (CAAA) are the most far-reaching revisions of the 1970 law. In common usage, references to the CAA typically mean to the 1990 amendments. (*source*: EPA's "Plain English Guide to the Clean Air Act" glossary, accessed 3-7-05)

caisson – A watertight container used in construction work under water or as a foundation.

cap – A layer of natural or synthetic material, such as clay or gunite, used to prevent rainwater from penetrating and spreading contamination. The surface of the cap is generally mounded or sloped so water will drain off.

carbon adsorption/carbon treatment – A treatment system in which contaminants are removed from **groundwater**, surface water, and air by forcing water or air through tanks containing activated carbon (a specially treated material that attracts and holds or retains contaminants).

carbon tetrachloride – A poisonous, nonflammable, colorless liquid, CCl_4.

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) – Pronounced "sir-klah" and commonly known as Superfund, this law was enacted by Congress on December 11, 1980. It created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified

The law authorizes two kinds of response actions: short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response, and long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on **EPA**'s National Priorities List (NPL). CERCLA was amended by the Superfund Amendments and Reauthorization Act (**SARA**) on October 17, 1986, accessed 03-7-05)

CFR (Code of Federal Regulations) – A codification of all regulations developed and finalized by federal agencies in the Federal Register. The CFR is arranged by "title," with Title 10 covering energy- and radiation-related issues, and Title 40 covering protection of the environment. Subparts within the titles are included in citations, as in "40 CFR Subpart H."

characterization – Facility or site sampling, monitoring, and analysis activities to determine the extent and nature of contamination. Characterization provides the basis of necessary technical information to select an appropriate cleanup alternative.

Ci (curie) – A quantitative measure of radioactivity. One Ci of activity is equal to 3.7E+10 decays per second. One curie has the approximate activity of 1 gram of radium. It is named after Marie and Pierre Curie, who discovered radium in 1898.

Class GA groundwater – New York State Department of Environmental Conservation classification for high quality groundwater, where the best intended use is as a source of drinking water supply.

closure – Under **RCRA** regulations, this term refers to a hazardous or solid waste management unit that is no longer operating and where potential hazards that it posed have been addressed (through clean up, immobilization, capping, etc.) to the satisfaction of the regulatory agency.

CO_2 equivalent (CO_2e) – The universal unit of measurement to indicate the GWP of each of the six GHGs expressed in terms of the GWP of one unit of CO_2. It is used to evaluate the release (or the avoided release) of differ-

ent 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 management requirements for this waste in 6 **NYCRR** Part 360.

Q

QA (quality assurance) – In environmental monitoring, any action to ensure the reliability of monitoring and measurement data. Aspects of QA include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC (quality control) – In environmental monitoring, the routine application of procedures to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

qualifier – A letter or series of letter codes in a graph or chart indicating that the associated value did not meet analytical requirements or was estimated.

quenching – Anything that interferes with the conversion of decay energy to electronic signal in the photomultiplier tubes of detection equipment, usually resulting in a reduction in counting efficiency.

R

R (roentgen) – A unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. It is named after the German scientist Wilhelm Roentgen, who discovered x-rays.

RA (removal actions, "removals") – Interim actions that are undertaken to prevent, minimize, or mitigate damage to the public health or environment that may otherwise result from a release or threatened release of hazardous substances, pollutants, or contaminants pursuant to **CERCLA**, and that are not inconsistent with the final remedial action. Under CERCLA, **EPA** may respond to releases or threats of releases of hazardous substances by starting an RA to stabilize or clean up an incident or site that immediately threatens public health or welfare. Removal actions are less comprehensive than *remedial* actions. However, removal actions must contribute to the efficiency of future remedial actions.

radiation – Some atoms possess excess energy, causing them to be physically unstable. Such atoms become stable when the excess energy is released in the form of charged particles or electromagnetic waves, known as radiation.

radiation event – A single detection of a charged particle or electromagnetic wave.

radioactive series – A succession of **nuclide**s, each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member of the series is called the parent and the intermediate members are called daughters or progeny.

radioactivity – The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as "activity."

radionuclide – A radioactive element characterized by the number of protons and neutrons in the nucleus. There are several hundred known radionuclides, both artificially produced and naturally occurring.

RCRA (Resource Conservation and Recovery Act) Pronounced "rick-rah," this act of Congress gave **EPA** the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of nonhazardous wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (*see* CERCLA). In 1984, amendments to RCRA called the Hazardous and Solid Waste Amendments (HSWA, pronounced "hiss-wa") required phasing out the land disposal of hazardous waste. Some other mandates of this strict law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank (UST) program.

recharge – The process by which water is added to a zone of saturation (aquifer) from surface infiltration, typically when rainwater soaks through the earth to reach an aquifer.

recharge basin – A basin (natural or artificial) that collects water. The water will infiltrate to the aquifer.

release – Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment. The National Contingency Plan also defines the term to include a threat of release.

rem – Stands for "**roentgen** equivalent man," a unit by which human radiation dose is assessed (*see also* **Sv**). The rem is a risk-based value used to estimate the potential health effects to an exposed individual or population. 100 rem = 1 sievert.

remedial (or **remediation) alternatives** – Options considered under **CERCLA** for decontaminating a site such as an operable unit (**OU**) or area of concern (**AOC**). Remedial actions are long-term activities that prevent the possible release, or stop or substantially reduce the actual release, of substances that are hazardous but not immediately life-threatening. *See also* feasibility study (**FS**) and Record of Decision (**ROD**).

residual fuel – Crude oil, Nos. 1 and 2 fuel oil that have a nitrogen content greater than 0.05 weight percent, and all fuel oil Nos. 4, 5, and 6, as defined by the American Society of Testing and Materials in ASTM D396-78, *Standard Specifications for Fuel Oils,* (c. 2001).

riparian – An organism living on the bank of a river, lake, or tidewater.

ROD (Record of Decision) – A document that records a regulatory agency's decision for the selected remedial ac-

tion. 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 understanding of the radiation emitted as radioactive materials decay to a stable state. To better comprehend the radiological information in the Site Environmental Report (SER), it is important to remember that not all radiations are the same and that different kinds of radiation affect living beings differently.

This appendix includes discussions on the common sources of radioactivity in the environment, types of radiation, the analyses used to quantify radioactive material, and how radiation sources contribute to radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides that are of environmental interest at Brookhaven National Laboratory (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

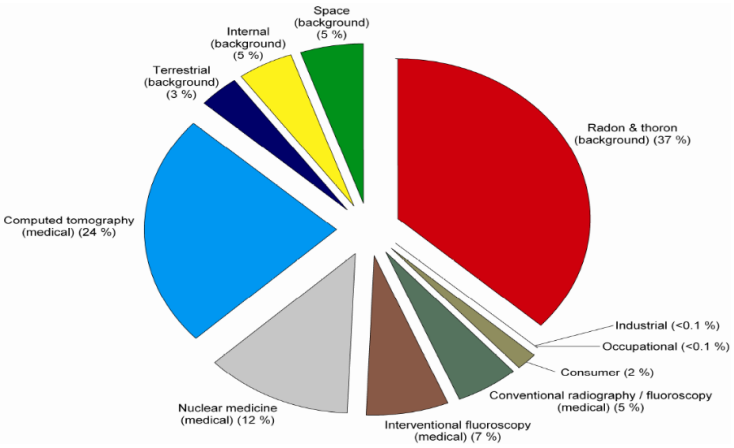

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). *Source: NCRP Report No. 160 (NCRP 2009)*

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 synthetic 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 (containing polonium-210), smoke detectors (containing americium-241), cardiac pacemakers (containing plutonium-238), fertilizers (containing isotopes from uranium and thorium decay series), and tobacco products (containing polonium-210 and lead-210). The average dose from consumer products to a person living in the United States is 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, (BLIP) 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

APPENDIX E: BNL SITE SUSTAINABILITY PLAN:
STATUS SUMMARY FOR FISCAL YEAR 2019

New SSP Category	FY19 Performance Status	FY20 Planned Actions & Contributions
Energy Management This category focuses on all energy-related topics such as energy intensity, metering and benchmarking, Energy Independence & Security Act (EISA) §432 audits, non-fleet fuel use, and greenhouse gas (GHG) emissions.	Energy Intensity BNL's energy intensity for FY 2019 was 236,426 British thermal units/gross square foot (Btu/gsf) and was 27.2 percent lower than the base year of 2003. This lower intensity level saved BNL nearly $2.5 million in FY 2019. FY19 was the fourth full year with the results of the Utility Energy Service Contract (UESC) Phase I project. The energy savings were verified to be within a few percent of the original estimates. The UESC has contributed to lowering BNL's overall energy intensity value. The Temperature Setback Policy is continually communicated to the Laboratory via several methods, including Earth Day events and presentations to facility managers and Laboratory management. Metering Three hundred advanced electric meters were installed and capture over 98 percent of consumed electricity. Of the 159 buildings greater than 4,000 square feet, 153 (96 percent) advanced meters were installed. EISA Section 432 Evaluations Energy audits of HVAC systems, lighting, and office equipment continue to be used to identify opportunities for energy conservation. The findings help to develop policies on operation and equipment needs. These audits are being performed in conjunction with ongoing Facility Condition Assessment (FCA) surveys in order to reduce additional costs and administrative oversight needs. All information has been placed in EPA's Portfolio Manager Program for benchmarking. Information from the energy and water audits was taken into consideration with the recently completed Investment Grade Audit (IGA) for another potential UESC effort.	Energy Intensity Further reductions in energy intensity continue to be the biggest energy-related challenge for BNL. Since the late 1970's, BNL has implemented numerous energy conservation projects, meeting two of the three previous energy intensity reduction goals of 30 percent (1985 vs. 1973), 30 percent (2003 vs. 1985), and 30 percent (2015 vs. 2003). BNL has begun a UESC Phase II effort. If cost-effective projects can be identified for Phase II, BNL will be able to reduce energy intensity. All energy-related projects will be analyzed using Life-Cycle Analyses. BNL will continue all the best practices currently in place, including HVAC setback, steam charge-back, and lighting upgrades. Metering Additional meters will be installed as opportunities become available. EISA Section 432 Evaluations BNL will continue with the cost-effective Energy Survey/ FCA approach in FY 2020 and beyond.
Water Management This category focuses on activities undertaken to reduce potable and non-potable water consumption, comply with stormwater management requirements, and improve water efficiency.	Potable-water usage fell from 931 million gallons/year in FY 1999 (average of 2.55 million gallons per day) to about 368 million gallons/year in FY 2019 (average of one million gallons per day), a reduction of 64.0 percent. BNL's annual water use intensity has decreased from 101 gallons per square foot to 76.5 gallons per square foot, a 24.4 percent water usage reduction since base-year 2007.	BNL will continue to implement BNL's Water Management Plan and reduce water usage by implementing best management practices. BNL will continue to utilize water-efficient processes and plumbing fixtures to conserve water in new construction buildings and renovations.

New SSP Category	FY19 Performance Status	FY20 Planned Actions & Contributions
Waste Management This category focuses on the site's approach/ vision for addressing waste management, pollution prevention (source reduction) and recycling measures, and construction and demolition (C&D) waste reduction.	During FY 2019, the recycling rate (annual diversion rate for non-hazardous solid waste) was approximately 68 percent. This number does not account for major one-time projects that generate large amounts of debris, such as building demolition or land clearing for construction. Taking the building demolition into account that occurred during FY 2019 (Building 134 and the 528 and 902 modulars), as well as the removal of trees associated with the construction of a traffic circle, the recycling rate jumped to 80 percent as much of the C&D debris was sent to a recycler and the trees were composted on site.	BNL's waste diversion program is expected to remain intact in the future years. BNL will re-evaluate landfilled wastes during 2020 to see if there is opportunity to divert this waste stream back to a waste-to-energy facility. Plans are in place to continue demolition of World War II structures. Apartment number 367 will be demolished during FY 2020. Resulting concrete from the demolition will be crushed on site to convert to Recycled Concrete Aggregate (RCA) for use as a road base on firebreak roads or as underlay in parking areas, saving dollars that would otherwise be used to purchase this type of material. Wood and metal debris will also be segregated and sent for recycling.
Fleet Management This category focuses on the site's approach and vision for addressing fleet optimization, and strategies used to reduce petroleum use and increase alternative fuel use.	Fiscal Year 2019 was the first full year that BNL utilized Telematics to track fleet operations. The fleet management software helps monitor fleet utilization and vehicle idling. In a broader sense, the Lab was able to see how the vehicles travelled in much more detail and obtained more information on the vehicles themselves. BNL replaced some of the older fleet vehicles with newer, more fuel-efficient and alternative fueled vehicles.	Fleet management will continue to work with the General Services Administration (GSA) to order and utilize alternative-fueled and newer, more fuel-efficient vehicles during every replacement cycle. BNL has funded a project in FY 2020 to install the infrastructure needed to support charging stations for three to four electric vehicles. This infrastructure will enable future rollouts of electric vehicles, planned to be ordered in the fall of 2020.
Renewable Energy This category focuses on site efforts towards utilizing renewable energy resources.	BNL purchased 20,000,000 kilowatt hours (kWh) of Renewable Energy Credits (RECs) for 2019 to meet the Renewable Energy requirement of 7.5 percent. BNL's RECs have been and will continue to be purchased through a competitive solicitation process. Each solicitation includes the latest DOE requirements, including the required in-service dates. In 2019, BNL's 816 kW Northeast Solar Energy Research Center (NSERC) facility produced 1,018,429 kWh that were consumed by BNL's facilities. The RECs were retained by BNL and were not sold.	BNL will continue to operate the NSERC facility and provide for further expansion when sufficient funds are identified. REC purchases will continue in order to meet applicable renewable energy and clean energy goals. Renewable energy systems, especially solar hot water, are considered in all new construction and major building renovations. To date, it has been difficult to find cost-effective projects. However, a new office building, the Science and User Support Center (SUSC), will be designed in 2020 and will potentially incorporate a number of concepts, including solar hot water heating and potentially a solar wall for pre-heating. BNL continues to pursue opportunities to implement a true microgrid on site. BNL is continuing discussions with energy storage providers and various governmental agencies to explore options such as hosting large utility-scale battery storage systems on site.

New SSP Category	FY19 Performance Status	FY20 Planned Actions & Contributions
Sustainable Buildings This category focuses on all aspects pertaining to sustainable building initiatives such as HPSB as well as building inventory changes.	**Sustainable Buildings** HPSB Guiding Principles Currently, 11 percent of non-excluded buildings have achieved 100 percent of the Guiding Principles and an additional nine percent are at 90 percent or higher. Of the excluded buildings, three percent are at 90 percent or higher. As BNL constructs new buildings and demolishes old non-compliant buildings, this percentage will increase. New Building Design All buildings designed from 2007 were designed to meet the New York State Energy Code. The new buildings designed during FY 2018 were Building 742 (HEX Beamline Satellite) and Building 748 (Laboratory for Bio-Molecular Science); construction is expected to be completed in FY 2020. To the extent that is practical and applicable, these new buildings will meet the Guiding Principles. While not a new building, Building 725 is undergoing a major renovation and those areas were designed to meet the Guiding Principles. Net Zero Buildings BNL has been discussing the option of applying the output of the NSERC to make one or more of the buildings net-zero. A final selection is anticipated in early FY 2020. Regional and Local Planning, Coordination, and Involvement Discussions continue with staff of the Long Island Railroad for a Discovery Park-proposed railroad station. A study has been completed and $20M approved in the HPSB Guiding Principles budget to construct this new station.	**Sustainable Buildings** Sustainable Buildings HPSB Guiding Principles/New Building Design Although overall site funding will drive the exact schedule, as new buildings are constructed to be fully compliant with the Guiding Principles and old non-compliant buildings are demolished, the percentage of buildings that are compliant with the Guiding Principles will further increase. New Building Design Currently, the only new building in design that will meet the Guiding Principles is the SUSC Building. Net Zero Buildings For designs starting in FY 2020, where economically feasible, BNL will ensure net-zero requirements are included in future designs. BNL is continuing to evaluate net-zero concepts in the preliminary design of the SUSC but discussions with staff in the Science Laboratories Infrastructure (SLI) program indicate the current funding constraints will make it difficult to justify additional costs associated with achieving net zero. Climate-Resilient Design and Management BNL will continue to incorporate the Climate Resiliency Design Guidelines to all new large construction projects which considers present and future climate conditions in assessing environmental impacts on the project. Strategies for Design (42 USC 6834) In lieu of the requirement gap between 42 USC 6834 and 10 CFR Part 433 Subpart B, new building construction and/or modernization will follow the Guiding Principles for Sustainable Federal Buildings to reduce energy consumption.

New SSP Category	FY19 Performance Status	FY20 Planned Actions & Contributions
Acquisitions and Procurement This category focuses on all relevant sustainable acquisition information efforts to improve supply chain GHG emissions.	BNL has incorporated contract clauses within its vendor contracts that designate environmentally preferred products (EPP), services, and equipment. BNL uses the Vinimaya system ("E-Buy") for most purchases of BioPreferred products. The tabular matrix of commonly purchased items (based on the manufacturer's part number) that are EPP compliant has been updated with additional products. Challenges remain as vendor information regarding recycled content for all categories is lacking, making conformance time-intensive and difficult for purchasers. In 2018, BNL established Environmental Management System (EMS) objectives to improve EPP purchasing performance for a wide range of products. The efforts focused on promoting the requirements with requisitioners. BNL received the Green Electronics Council's 2019 Electronic Product Environmental Assessment Tool (EPEAT) Purchaser Award at the Gold Level; two 2018 DOE Federal Green Challenge awards for waste diversion and electronics reuse and recycle; and the 2018 GreenBuy Prime award for winning GreenBuy Gold Awards three times.	During 2020, BNL will continue to develop the Commonly Ordered Items page, provide E-Buy training specific to EPP purchasing requirements, and provide support to requisitioners with questions. BNL will write new EMS objectives to promote that program and drive improvement. BNL will also audit its EPP program during FY 2020 to identify areas where further purchasing improvements can be made, as well as opportunities to improve data collection to better represent current conformance.
Measures, Funding, and Training This category focuses on efforts to implement identified Efficiency & Conservation Measures (ECM) through appropriations, performance contracts, or other funding mechanisms, and discuss sustainability-related training or education for employees. This section also highlights ECMs and additional funding needed beyond planned activities and typical operation costs for meeting the goal.	Internally funded energy conservation and sustainability related initiatives include a continuation of best practices, with continued emphasis on temperature setback during unoccupied periods. 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 has low energy rates to operate its research programs, which makes it difficult to find cost-effective projects. BNL completed its first UESC in 2015, which is performing well and meeting the original energy savings estimates. A second UESC project is being planned and will incorporate lessons learned. 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. Additionally, numerous employees attend training programs to maintain their professional certifications including PE, CEM, Green Professional, LEED, and many others.	BNL is in the process of developing a UESC Phase II project that will include energy conservation measures for lighting, HVAC, controls, and a water side economizer, as well as rebalancing Building 555 (Chemistry), BNL's most energy-intensive building. The recently completed IGA estimates the energy savings at 36,354 mmBtu/year for a reduction of 22 percent from the total affected building baseline. The economics of this potential second UESC II effort are less cost effective than the previous UESC. BNL management is currently evaluating the project and will make a decision regarding whether or not to move forward in early FY 2020.

New SSP Category	FY19 Performance Status	FY20 Planned Actions & Contributions
Travel and Commute This category focuses on all information pertaining to the site's business travel and commute data, including participation in regional and local planning.	Overall, Scope 3 emissions were up 19.2 percent from FY 2018 (16,106 metric tons carbon dioxide equivalent [MT CO2e]), and 4.7 percent lower than the FY 2008 baseline value. The increase from FY 2018 is largely due to a 3,975 MT CO2e jump in air travel GHG emissions and, to a lesser extent, a 380 MT CO2e rise in commuting GHGs. The increase in commuting GHG emissions from 2018 was due in part to a 4.5 percent increase in the average daily number of commuters, and adjustments to the relative percentages of employee passenger vehicles and light duty vehicles to match those in the Safeguards & Security Division's Vehicle Registration Database.	Combined electricity purchases of conventional power and hydropower are expected to rise 20.6 percent from the FY 2019 total to 338,800 megawatt hours (MWh) in FY 2025. Using eGrid 2016 transmission and distribution (T&D) loss factors, Northeast Power Coordinating Council, Inc. (NPCC) Long Island total output, and NPCC Upstate non-baseload output emission rates, estimated T&D GHG emission will increase to 6,936 MT CO2e in FY 2025.
Fugitives and Refrigerants This category focuses on all fugitive emissions or refrigerants used at the site and any efforts (current and/or planned) to reduce or minimize GHG emissions (along related challenges or opportunities).	The bulk of BNL's process and fugitive GHG emissions (besides those from insulating gas leaks of SF6 from the Tandem Van de Graaff accelerator vessels) were due to periodic purging of carrier gases used in STAR detector subsystems during the FY 2019 Relativistic Heavy Ion Collider experimental run. The recirculation system on the STAR multi-gap resistive plate time of flight (TOF) subsystem reduced purged gas releases of HFC-134a by 86.5 percent throughout the experimental run (208.14 MtCO2e). Environmental Protection Division worked with Facilities & Operations (F&O) Production Division staff to conduct a joint self-audit of their Refrigerant Management Program to identify actions that may be taken to improve the program, and to address any program gaps and deficiencies. Preventative maintenance inspections of four 2.4 kilovolt (kV) and 13 13.8-kV sulfur hexafluoride (SF6) gas-insulated switches, plus four 69 kV SF6 gas-insulated circuit breakers, were conducted in FY 2019 as part of BNL's proactive program to identify and mitigate leaks of the Laboratory's SF6 gas-insulated, high-energy equipment. Recorded equipment temperature readings and pressure gauge readings during the inspection provided no evidence of SF6 leaks.	Job plans for the next scheduled preventative maintenance inspections of SF6 gas-insulated switches and circuit breakers will be released on April 1, 2020. Annual preventative maintenance inspections will also be released on April 1, in concurrence with the job plans.

New SSP Category	FY19 Performance Status	FY20 Planned Actions & Contributions
Electronic Stewardship This category focuses on the acquisition, operations and management, and disposal techniques of all electronics reported, as well as data centers efficiency improvements.	**Acquisition/Operations** 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. During FY 2019, the Laboratory procured printer management software that will help remotely manage printers and will allow the Lab to enforce duplex printing as a default setting when the printer supports it. BNL evaluated the feasibility of extending the desktop computer power management policy to other operating systems. This activity will not be continued. **End of Life** Approximately 964 desktop computers, 244 laptops, 48 tablets, and 41 servers were reused internally by BNL personnel as well as numerous other small electronics in FY 2019. BNL held two employee household E-Waste collection days during the year. **Data Centers** BNL completed an evaluation of its existing data centers in response to the Data Center Optimization Initiative (DCOI) from the summer of 2016. The internal assessment identified eight data centers that meet the new DCOI criteria. Additional resources will be needed to meet the goal of power usage effectiveness (PUE) less than 1.5. Four of the eight data centers will require the installation of additional metering in order to determine the actual PUE. The data center associated with the Core Facility Revitalization (CFR) project is currently in the construction phase. Preliminary preparation began in June 2019. The completed CFR is targeting a PUE of less than 1.3 in accordance with the recent DCOI.	**Acquisition/Operations** The Laboratory will continue to require that all printers, laptops, and desktop computers ordered through the E-Pro system have an EPEAT "Gold" certification. Since procuring the printer management software, going forward in FY20, BNL will utilize this software to help remotely manage printers and enforce duplex printing as a default setting when the printer supports it. This new software will replace the old print servers. ITD is in the process of implementing the software and migrating printers. **End of Life** BNL will continue to dispose of electronic waste in an environmentally sound manner through a certified R2 recycler. However, electronics collected internally will be tracked separately from home collections in order to clarify internal generation rates and to help monitor the effectiveness of the home collection days. **Data Centers** Meeting the PUE of 1.5 for the existing data centers will require a significant investment. Further, four of the eight existing data centers will require the installation of new metering, which is partially in progress. BNL will work to identify the actions and resources needed to meet the PUE 1.5 requirement for the eight existing data centers and, if cost effective, begin the process of obtaining potential funding. The data center associated with the CFR project is in the design phase and is targeting a PUE of less than 1.3 in accordance with the recent DCOI. The CFR project received CD-2 approval and started construction in June of 2019, with a projected completion of 2023.

New SSP Category	FY19 Performance Status	FY20 Planned Actions & Contributions
Resilience This category focuses on resilience-related topics. Organizational resilience is the ability of an agency to adapt to changing conditions and withstand or recover from disruption. Resilience efforts help sites manage risks to DOE assets, infrastructure, and operations.	**Resilience Strategies** During FY 2019, BNL's Office of Emergency Management (OEM) conducted a Loss of Power exercise specific to F&O to identify gaps or concerns regarding electrical power issues. OEM also performed two accountability exercises for all employees. Accountability exercises are performed on a quarterly basis and are required by the Department of Energy on behalf of the Office of Human Capital. OEM streamlined the exercises and fine-tuned the methodology to account for BNL employees. OEM maintains the Continuity of Operations Plan (COOP) and meets with the Continuity of Emergency Response Group annually to discuss the specific mission-essential functions at BNL. OEM also maintains specific plans such as the Pandemic/Influenza, Power Outage, Severe Weather, Hurricane, and Emergency plans. The Essential Personnel webpage was updated to include a new interface that allows individual employees to view their current status.	**Resilience Strategies** The All Hazards Survey is scheduled for an update in FY 2020. Accountability exercises will continue to be performed on a quarterly basis, as required by the Department of Energy on behalf of the Office of Human Capital. OEM will continue to maintain the COOP as well as other specific emergency plans (i.e., Pandemic/Influenza Plan, Power Outage Plan, Severe Weather Plan, Hurricane Plan, Emergency Plan).

2019 Site Environmental Report

Reader Response Form

The 2019 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 _____

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Phone _____

Email _____

Comments, Suggestions, or Questions

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