

Executive Summary

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

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

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

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

INTEGRATED SAFETY MANAGEMENT SYSTEM, ISO 14001, AND OHSAS 18001

The Laboratory's Integrated Safety Management System (ISMS) incorporates management of environment (i.e., environmental protection and pollution prevention), safety, and health issues into all work planning. BNL's ISMS ensures that the Laboratory integrates DOE's five

Core Functions and seven Guiding Principles into all work processes. These safety processes contributed to BNL's achievement of registration under both the International Organization for Standardization (ISO) 14001 Standard (for the Laboratory's Environmental Management System) and the Occupational Safety and Health Assessment Series (OHSAS) 18001 Standard

(for the Laboratory's Safety and Health Program). Both standards require an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take correction actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness.

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

The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized ISO 14001 Environmental Management Standard. BNL was the first laboratory under the DOE Office of Science to become officially registered to this standard. BNL was also the first DOE 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 2009, an EMS and OHSAS surveillance audit determined that BNL remains in conformance with both standards. In their recommendation for continued certification, auditors from NSF-International Strategic Registrations, Ltd., highlighted more than 14 noteworthy practices, some of which include: a strong commitment to achievement of Laboratory-wide environmen-

tal, safety, and health (ES&H) objectives and targets; continued improvement in analysis of ES&H data to prevent issues from occurring; and strengths in environmental planning for the development of the Long Island solar farm. The auditors also identified one minor nonconformity: to improve the use of casual analysis for ES&H issues. Nine opportunities for improvement were also noted, such as continued reductions in paper use and cafeteria waste reduction. Corrective actions were prepared and tracked to closure.

Two DOE Orders, issued in 2008, incorporated the goals of the Presidential Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management. DOE Order 450.1A, Environmental Protection, established federal requirements for pollution prevention, reduction in toxic chemical use, purchase of environmentally preferred products, electronic stewardship, and the implementation of an EMS. DOE Order 430.2B, Departmental Energy, Utilities, and Transportation Management, established federal requirements for certain criteria, and requires an annual certification and submission of an Executable Plan. The Executable Plan provides a roadmap on how the Laboratory intends to meet these requirements. Executive Order 13514, signed in 2009, sets sustainability goals for federal agencies and focuses on making improvements in their environmental, energy, and economic performance. It also requires federal agencies to set a 2020 greenhouse gas emissions reduction target, increase energy efficiency, reduce fleet petroleum consumption, conserve water, reduce waste, support sustainable communities, and leverage federal purchasing power to promote environmentally responsible products and technologies. The Laboratory's EMS objectives and targets have been established to mirror these requirements, and most have already been incorporated within the program.

The Laboratory's strong Pollution Prevention (P2) Program is an essential element for the successful implementation of BNL's EMS. The P2 Program reflects the national and DOE pollution prevention goals and policies, and represents an ongoing effort to make pollution prevention

and waste minimization an integral part of the Laboratory's operating philosophy. Pollution prevention and waste reduction goals have been incorporated as performance measures into the DOE contract with BSA and into BNL's ESSH Policy. The overall goal of the P2 Program is to create a systems approach that integrates pollution prevention and waste minimization, resource conservation, recycling, and affirmative procurement into all planning and decision making. Five of 15 P2 proposals, submitted by employees to BNL's P2 Council, were funded in 2009, for a combined investment of approximately \$24,000. The anticipated annual savings from these projects is approximately \$33,650, for an average payback period of approximately 0.7 years. Initiatives to reduce, recycle, and reuse 9.7 million pounds of industrial, sanitary, hazardous, and radiological waste through the P2 program resulted in more than \$1.8 million in cost avoidance or savings in 2009.

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

BNL'S ENVIRONMENTAL MANAGEMENT PROGRAM

BNL's Environmental Management Program consists of several Laboratory-wide and facility-specific environmental monitoring and surveillance programs. These programs identify potential pathways of public and environmental exposure and evaluate the impacts BNL activities may have on the environment. An overview of the Laboratory's environmental programs and a summary of performance for 2009 follows:

Compliance Monitoring Program

BNL has an extensive program in place to ensure compliance with all applicable environmental regulatory and permit requirements. The Laboratory must comply with more than 100 sets of federal, state, and local environmental regulations, numerous site-specific permits, 17 equivalency permits for the operation of 14 groundwater remediation systems, and several other binding agreements. In 2009, the Laboratory complied with the majority of these requirements, and instances of noncompliance

were reported to regulatory agencies and corrected expeditiously. Routine inspections conducted during the year found no significant instances of noncompliance; however, the New York State Department of Environmental Conservation (NYSDEC) issued a warning notice in October for failure to report opacity violations within 2 days of the date of occurrence. Corrective actions have been implemented.

Nine external environmental audits were conducted in 2009 by federal, state, and local agencies that oversee BNL activities.

- NYSDEC conducted its formal inspection of the Laboratory's air compliance program; there were no violations noted.
- NYSDEC conducted its annual inspection of the Major Oil Storage Facility. Four conditions that required corrective action were identified: the need to properly prepare and paint some sections of Tank 611-06 and associated piping; provide confirmation that all "tell-tails" associated with tanks 611-09 and 611-10 are inspected and documented properly; registration and follow-up inspection of a new 1,000 gallon aboveground bio-diesel tank that was installed in the fuel off-loading facility; and evaluation of the cathodic protection system servicing tanks 3, 5, and 6, to ensure that it is adequately protecting the tanks. In addition, an inspection of the Laboratory's underground storage facilities and other smaller satellite fuel storage tanks identified one condition that required corrective action. This included the need to conduct and document testing of the automatic line-leak detectors for the tanks located at the on-site service station. Most conditions were corrected in accordance with NYSDEC directives prior to the end of calendar year 2009. With NYSDEC approval, the remaining conditions will be addressed in 2010.
- NYSDEC conducted an inspection of the Chemical Bulk Storage facilities. During this inspection, three issues were identified that required corrective action: the need to properly prepare and paint a small section on the west side of Tank 635-01; recalibration or replacement of remote level gauges

associated with Tanks 624-05 thru -08; and properly terminating the atmospheric vent associated with Tank 634-02 within the tank containment area. These issues were corrected in accordance with the NYSDEC request.

- The Suffolk County Department of Health Services (SCDHS) collected samples and conducted its annual inspection of the BNL potable water system; no issues were identified.
- SCDHS conducted quarterly inspections of the Laboratory's Sewage Treatment Plant (STP) to evaluate operations and sample the effluent; no performance or operational issues were identified. NYSDEC did not perform its annual surveillance inspection in 2009.
- SCDHS inspected several of the State Pollutant Discharge Elimination System (SPDES)-regulated outfalls and collected samples; no issues were identified.

Each year, several DOE assessments and inspections are performed at BNL. The DOE Brookhaven Site Office (BHSO) and the DOE Chicago Office evaluated the Laboratory's readiness to declare conformance to DOE Order 450.1A in December 2008. This order, along with its companion DOE Order 430.2B, established new requirements for DOE facilities in the areas of energy and water conservation, improved fleet management, and other sustainable practices. Order 450.1A requires DOE facilities to have an EMS that includes objectives and targets supporting the sustainability goals of the order, and the energy, water, fleet, and other goals of Order 430.2B. Overall, the assessment found that the EMS culture at BNL was strong due to the prior long-term establishment of an ISO 14001-registered EMS, and is clearly in conformance with DOE Order 450.1A. The Laboratory formally declared its conformance to these new requirements in April 2009. In addition, the DOE Chicago Office conducted an assessment of BNL's Environmentally Preferable Purchasing (EPP) program in June as part of the BHSO independent oversight program. The findings of this assessment were rolled up into one finding. The results indicated that, al-

though an improvement plan was prepared with actions to comply with the requirements related to the EPP requirements of DOE Order 450.1A, BNL was behind schedule on implementation of the actions. While the Laboratory committed to have all actions completed by early October 2009, one action remained open at the end of 2009. This action, to revise and issue the procurement subject area which includes requirements for EPP, will be completed in 2010.

Also in 2009, BNL conducted a programmatic self-assessment on several aspects of its environmental management program. Topics for this assessment were determined based on institutional risk, DOE and regulatory agency expectations, and the need to ensure that key environmental requirements are being implemented as designed. The self-assessment focused on requirements related to properly managing wastes generated at the Laboratory, including hazardous, industrial, mixed, radioactive, radioactive-regulated medical waste, and regulated medical waste. During the self-assessment, two Noteworthy practices, seven Nonconformances, and three Observations were noted. A causal analysis was performed and a corrective action plan was prepared for the identified nonconformances to address the issues. Progress on the actions will be tracked to closure in BNL's Institutional Assessment Tracking System.

BNL continues to be a certified Nevada Test Site (NTS) waste generator. As part of the NTS waste certification process, the NTS Maintenance and Operations Contractor conducts random unannounced inspections. NTS performed an unannounced inspection in May of 2009; there were no findings noted.

In 2009, emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility (CSF) were all within permit limits. There were 24 individual opacity excursions noted. These occurred in the first (3 instances), second (16 instances), and fourth (5 instances) quarters.

Approximately 1,232 pounds of ozone-depleting refrigerants were recovered from refrigeration equipment for reuse by other DOE facilities or federal agencies. These reductions included the disposition of eight cylinders of Halon 1301

from fixed fire suppression systems removed from operation and eight cylinders of Halon 1301 associated with portable fire extinguishing systems. These materials have been transferred to storage for shipment to the Department of Defense Ozone Depleting Substances Reserve.

Monitoring of BNL's potable water supply showed that all drinking water quality requirements were met in 2009. Most of the liquid effluents discharged to surface water and groundwater met applicable SPDES permit requirements; however, two minor excursions occurred during the year and were reported to NYSDEC and SCDHS. Groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

The Laboratory continues to reduce the number and severity of spills on site. In 2009, there were 11 reportable spills of petroleum products, antifreeze, or chemicals. While the total number of spills increased by two from 2008, the severity of releases was less. All releases were cleaned up to the satisfaction of NYSDEC.

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

Air Quality Program

BNL monitors radioactive emissions at three facilities on site to ensure compliance with the requirements of the Clean Air Act. During 2009, Laboratory facilities released a total of 1,833 curies of short-lived radioactive gases. EPA regulations require continuous monitoring of all sources that have the potential to deliver an annual radiation dose greater than 0.1 mrem to a member of the public; all other facilities capable of delivering any radiation dose require periodic confirmatory sampling. Although the dose to the public is less than 0.1 mrem and monitoring is not required by EPA, the Brookhaven Linear Isotope Producer (BLIP) is continuously monitored. Oxygen-15 (half-life: 122 seconds) and carbon-11 (half-life: 20.48 minutes) emitted from the BLIP constituted more than 97.9 percent of radiological air emissions on site in 2009. The combined emissions were approximately 31 percent lower than 2008 levels, primarily due to operation at lower energy levels.

Monitoring was also conducted at one other active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Releases from the TPL in 2009 continued to be very small (0.025 μ Ci). The rise in tritium releases from the HFBR in 2009 was due to decontamination and dismantlement (D&D) activities that included the removal of control rod blades; draining of tritiated heavy water from the reactor vessel, piping systems, and the fuel canal; and the opening of contaminated piping systems to allow for the removal of residual volumes of tritiated heavy water. From 2002 through 2008, emissions from the HFBR facility were monitored via air sampling at a frequency of one week per month. In 2009, the monitoring frequency was increased to bi-weekly to better account for changes in tritium emissions during planned D&D activities.

The Laboratory conducts ambient radiological air monitoring to verify local air quality and assess possible environmental and health impacts from BNL operations. Air monitoring stations around the perimeter of the site measure tritium and gross alpha and beta airborne activity. Results for 2009 continued to demonstrate that on-site radiological air quality was consistent with off-site measurements and with results from locations in New York State that are not located near radiological facilities.

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emissions monitoring to demonstrate compliance with emission limits. The CSF is the only BNL facility that requires monitoring. Two of the four boilers at the CSF, specifically 6 and 7, are equipped with continuous emission monitors to measure opacity and nitrogen oxide (NO_x) emissions. Opacity levels cannot exceed 20 percent, except for one 6-minute period per hour of not more than 27 percent opacity. In 2009, there were no exceedances of the NO_x emission standards for either boiler.

In 2009, opacity measurements in Boiler 6 were exceeded 16 periods during the second quarter and 5 periods during the fourth quarter. The first 12 second quarter excess opacity read-

ings occurred during the initial soot blowing cycle after the boiler was brought on line while combusting natural gas. Since opacity readings began to rise immediately after the boiler was fired with natural gas, it appears that the natural cleansing affect of natural gas caused these opacity excursions. The four other excess opacity readings recorded during the second quarter were the result of dust build-up on the optical head assembly. Subsequent cleaning of the assembly returned opacity levels back to normal. There was no apparent cause for the five excess opacity readings recorded during the fourth quarter. Two excess opacity readings for Boiler 7 recorded in February during a soot blowing cycle appear to have been an isolated incident. Changes in the sequence of the soot blowing cycle for Boiler 6 made in August 2005 have proven effective in eliminating most opacity exceedances due to soot blowing. Similar changes made to the soot blowing cycle on Boiler 7, after the installation of a new soot blowing controller in March 2006, have also been successful in eliminating most soot blowing opacity exceedances from this boiler.

Because natural gas prices were lower than residual fuel oil prices from May through December 2009, BNL used natural gas for most heating and cooling needs during these months. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably lower than in years when residual fuel oil was predominantly used.

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

Water Quality Surveillance Program

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

To assess the potential impact of discharges on the water quality of the Peconic River, surface water monitoring is conducted at several locations upstream and downstream of the STP discharge. The Carmans River, located to the west of BNL, is monitored as a geographical control location for comparative purposes, as it is not affected by Laboratory operations. In 2009, the average gross alpha and beta activity levels in the STP discharge were well below drinking water standards (DWS). Tritium detected at the STP originates from either HFBR sanitary system releases, or from small, infrequent batch releases that meet BNL discharge criteria from other facilities. Although the HFBR is no longer operating, tritium continues to be released from the facility at very low concentrations due to off-gassing. To minimize the quantity of tritium released to the STP, efforts have been made to capture most of the air compressor condensate collected in the equipment areas of the structure. In 2009, tritium was detected once in the STP effluent at a concentration above the minimum detectable activity (490 pCi/L), which is less than 3 percent of the drinking water standard. Although this was a low level of detection with high uncertainty, it may have been attributed to work to further ready the HFBR for decommissioning and decontamination. Tritium was also detected twice in the influent, but at levels just above the minimum detectable activity. In 2009, analysis of the STP effluent and the Peconic River continued to show no detection of cesium-137 (Cs-137), strontium-90 (Sr-90), or other gamma-emitting nuclides attributable to BNL operations.

The STP is also monitored for nonradiological contaminants. In 2009, nonradiological monitoring of the STP effluent showed that, except for isolated incidents of noncompliance, organic and inorganic parameters were within SPDES effluent limitations or other applicable standards. Two volatile organic compounds (VOCs), methyl chloride and acetone, were detected in the STP effluent, but at very low levels.

Discharges to recharge basins are sampled throughout the year for analyses of gross alpha and beta activity, gamma-emitting radionuclides, and tritium. Each recharge basin is a

permitted point-source discharge under the Laboratory's SPDES permit. In 2009, there were no reported gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins. Tritium was detected in a single sample collected at Basin HT-W at a very low level, and with high uncertainty. This basin receives discharges from the Collider-Accelerator complex.

Low concentrations of disinfection byproducts were periodically detected in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, lead to the formation of VOCs, including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Bromoform and acetone were detected above the minimum detection level for most recharge basins. In most instances, acetone was also found as a contaminant in the contract analytical laboratory, as evidenced by detections in blank samples.

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

Natural and Cultural Resource Management Program

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

wildlife populations, such as white-tailed deer and Canada geese.

BNL conducts routine monitoring of flora and fauna to assess the impact, if any, of past and present activities on the Laboratory's natural resources. Generally, deer sampled on site contain higher concentrations of Cs-137 than deer sampled from more than 1 mile off site. This is most likely because on-site deer consume small amounts of contaminated soil and graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. The maximum on-site concentration in 2009 was 1.8 times higher than the highest level reported in 2008, but continues to be much lower than the highest level ever reported (1996). The New York State Department of Health (NYSDOH) has formally reviewed the potential public health risk associated with elevated levels of Cs-137 in on-site deer and determined that neither hunting restrictions or formal health advisories are warranted. Testing of deer bones for Sr-90 indicated background levels. Sr-90 is present in the environment at background levels as a result of worldwide fallout from nuclear weapons testing. BNL continues to test for Sr-90 in bone to develop baseline information on this radionuclide and its presence in local white-tailed deer.

In an effort to restore fish populations, the Laboratory suspended most on-site fish sampling in 2001. By 2007, fish populations had recovered and annual on site sampling resumed. In 2009, Cs-137 was detected at low levels in all but two samples from the Peconic River system and appears to be declining compared with historic values. The cleanup of both on-and off-site portions of the Peconic River in 2004 and 2005 removed approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Natural decay and the removal of this contamination are expected to result in further decreases.

Nonradiological analysis of fish continued in 2009. All concentrations for metals are considered safe and do not pose any health risks to humans or other animals that may consume fish. Due to its known health risk, mercury is the metal of most concern. In general, a trend of decreasing mercury content downstream from BNL's STP is evident. Pesticide analysis in fish

was discontinued in 2008, since several years of sampling detected pesticides in only a few fish far off site. Polychlorinated biphenyl (PCB) analysis in fish was also discontinued off site, but continued to be performed for fish on site. Two fish samples tested positive for PCBs. Historically, PCBs have been found in both fish and sediment at BNL and periodically at other locations in the Peconic River. The cleanup of the Peconic River has removed most PCBs within the sediments on site.

Annual sampling of sediment, vegetation, and freshwater in the Peconic River and a control location on the Carmans River was conducted in 2009. On- and off-site aquatic vegetation and sediments contained low levels of Cs-137 and metals in amounts that were consistent with levels detected in previous years. Pesticides and PCB analyses of aquatic sampling were discontinued in 2008.

Under the Peconic River remediation project, sediment from the Peconic River was remediated to remove mercury and associated contaminants from the river. All sample results for 2009 met the mercury cleanup goal of 2.0 mg/kg. Five additional samples in a known area of higher mercury concentrations were also sampled; only one sample exceeded the cleanup goal. Supplemental sediment sampling was also conducted to evaluate elevated water column mercury concentrations at one station within the Peconic River, and identified a small on-site section of the river which will receive supplemental cleanup in the fall of 2010.

Water column sampling for mercury and methylmercury was performed at 20 Peconic River sampling locations, the STP, and one reference location on the Connetquot River in 2009. The general trend of total mercury in water samples decreased with increasing distance downstream from the STP. Methylmercury concentrations increased slightly from the STP to the BNL site border; then decreased gradually with increasing distance downstream of the BNL site border until reaching the historic range of concentrations for the Connetquot River reference station.

The five-year periodic confirmatory sampling of local farm vegetables was completed in 2009. Data shows that vegetables grown in the BNL

garden plot continue to support historic analyses that there are no Laboratory-generated radionuclides in on-site produce.

The Laboratory sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem and to foster interest in science. Wildlife programs are conducted at BNL in collaboration with DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning. In 2009, BNL's Environmental Protection Division hosted 19 interns and one faculty member who worked on a variety of projects, some of which include: invertebrate distribution surveys of the Carmans River, small mammal and flying squirrel surveys, the quantification of nitrogen in soils, bathymetry of a small lake, and surveying dragonflies and damselflies. Also in 2009, the Laboratory's GREEN institute and Open Space Stewardship Program (OSSP), established by BNL's Office of Education, continued to grow, and the Foundation for Ecological Research in the Northeast (FERN) continued work on video-based instruction for protocols used within OSSP.

The goal of BNL's Cultural Resource Management Program (CRMP) is to ensure the proper stewardship of BNL and DOE historic resources. Additional goals include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of resources to Laboratory personnel and the public for research and interpretation. Cultural resource management activities performed in 2009 included two field studies to evaluate the proposed Long Island solar farm project site; an archeological survey on 33 acres formally occupied by the World War I Camp Upon Remount Facility, in order to access the overall potential of the area for the presence of cultural resources; an architectural and archeological data recovery/assessment of a standing Civilian Conservation Corps era privy; identifying and relocating artifacts from BNL's Brookhaven Graphite Research Reactor

(BGRR) and HFBR; and outreach activities, including presentation on the Laboratory's cultural resources and tours of the on-site WWI trenches.

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

Groundwater Protection Management Program

BNL's extensive groundwater monitoring well network is used to evaluate progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater that enters and exits the site. The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. In 2009, the Laboratory collected groundwater samples from 806 on- and off-site monitoring wells during 1,800 individual sampling events.

Under the environmental surveillance program, ten active research and support facilities were monitored during 2009. Although no new impacts to groundwater quality have been discovered since 2001, groundwater quality continues to be impacted from past releases at two facilities: the former g-2 experiment within the Alternating Gradient Synchrotron (AGS) facility, and the Upton service station. Tritium continues to be detected at concentrations above the 20,000 pCi/L DWS in wells monitoring the g-2 source area. A short-term spike in tritium levels was observed in October 2009, and appears to be related to the flushing of residual tritium from the deep vadose zone following significant natural periodic fluctuations in the local water table. As a result of natural radioactive decay and dispersion in the aquifer, the g-2 tritium plume is breaking up into discrete segments. At the Upton service station, VOCs associated with historical petroleum and solvent spills continue to be detected in the groundwater at concentrations above the applicable DWS. The levels of VOCs are expected to decrease over time by means of natural attenuation.

The primary mission of the Laboratory's Comprehensive Environmental Response,

Compensation and Liability Act (CERCLA) groundwater program is to operate and maintain groundwater treatment systems and prevent additional groundwater contamination from migrating off site. During 2009, BNL continued to make significant progress in restoring groundwater quality with the removal of approximately 229 pounds of VOCs and approximately 1.9 mCi of Sr-90 with the treatment of more than 1.6 billion gallons of groundwater. To date, 6,363 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in the Operable Unit (OU) I South Boundary, OU III South Boundary, OU III Industrial Park, OU III Industrial Park East, OU III North Street, OU IV, Building 96, and Carbon Tetrachloride areas. Also to date, two of the treatment systems have removed approximately 21 mCi of Sr-90.

Chapter 7 of this report provides an overview of this program, and the SER Volume II, Groundwater Status Report, provides detailed descriptions, data, and maps relating to all groundwater monitoring performed in 2009.

Radiological Dose Assessment Program

BNL routinely assesses its operations to ensure that any potential radiological dose to members of the public, BNL workers, visitors, and the environment is "As Low As Reasonably Achievable" (ALARA). The potential radiological dose is calculated as the largest possible dose to a hypothetical Maximally Exposed Individual (MEI) at the BNL site boundary. For dose assessment purposes, the pathways include direct radiation exposure, inhalation, ingestion, immersion, and skin absorption. Radiological dose assessments at the Laboratory have consistently shown that the effective dose equivalent from operations is well below the EPA and DOE regulatory dose limits for the public and the environment. The dose impact from all BNL activities in 2009 was comparable to natural background radiation levels.

To measure direct radiation from Laboratory operations, 58 thermoluminescent dosimeters (TLDs) are placed on site and 14 TLDs are placed in surrounding communities. An additional 30 TLDs are placed in a lead-shielded

container for use as reference and control TLDs for comparison purposes. In 2009, the average dose from all TLDs showed there was no additional contribution to on- and off-site locations from BNL operations.

The annual on-site external dose from all potential sources, including cosmic and terrestrial radiation, was 71 ± 10 mrem (710 ± 100 μ Sv), and the annual off-site external dose was 67 ± 7 mrem (670 ± 70 μ Sv). The effective dose to the MEI from air emissions was $7.20E-2$ mrem (0.72 μ Sv). The ingestion pathway dose was estimated as 7.10 mrem (71 μ Sv) from consumption of deer meat and 0.17 mrem (1.7 μ Sv) from consumption of fish caught in the vicinity of the Laboratory. The total dose to the MEI from all pathways was estimated as 7.34 mrem (73 μ Sv). The dose from the air inhalation pathway attributable to BNL operations was less than 1 percent of EPA's annual regulatory dose limit of 10 mrem (100 μ Sv), and the total dose was less than 8 percent of DOE's annual dose limit of 100 mrem ($1,000$ μ Sv) from all pathways. Doses to aquatic and terrestrial biota were also evaluated and found to be well below the regulatory limits.

As a part of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) review process at BNL, any source that has the potential to emit radioactive materials is evaluated for regulatory compliance. In 2009, the following radiological sources were evaluated for potential contribution to the overall site dose:

A preliminary NESHAP evaluation was performed in 2008 for the removal of the graphite pile and bioshield at the BGRR. In 2009, based on the results of waste characterization studies, smear results, and radiological inventory of the graphite pile and biological shield, the effective dose equivalent to the MEI from this project was estimated to be $1.33E-02$ mrem/year. The facility will be continuously monitored for radionuclides during the removal of these materials, which is expected to be completed in 2011.

Underground waste lines, which were abandoned in 1961, were used to transfer radioactive liquid waste from the BNL Hot Laboratory in Building 801 to the Waste Concentration Facility. In 2009, remediation work began on the removal of the waste transfer lines, stream line,

soil below the pipes, a portion of the concrete culvert, and the non-acid off-gas pipe under the HFBR. The effective dose equivalent to the MEI from this project was estimated to be $1.38E-03$ mrem/year.

A NESHAPS compliance review for venting of the radioactive gases used in the gallium trichloride experiment in Building 555 was performed. A conservative estimate of effective dose equivalent to the MEI was estimated to be $2.37E-08$ mrem/year.

An investigation and characterization of the Brookhaven Avenue Cs-137 contamination at the Waste Loading Area within the former Hazardous Waste Management Facility was reviewed to determine the source term. The effective dose equivalent to the MEI was estimated to be $6.67E-05$ mrem/year.

A NESHAPS dose assessment was performed for the potential release of carbon-11 (half-life: 20 minutes) in an "Accident" scenario for inclusion in the Safety Analysis Report of BNL's cyclotron. A conservative estimate of effective dose equivalent to the MEI was estimated to be $2.64E-04$ mrem/year.

Stack modifications were made at the BLIP facility in order to comply with American National Standards Institute standards. The existing stack duct was removed and a new duct was installed. In addition, a new emission sampling system was also installed and will be tested during BLIP operations in 2010.

The HFBR reactor vessel, primary cooling water system, and fuel canal were drained in 2009. Control rod blades and beam plugs were also removed and shipped off site to a licensed disposal facility. Tritium levels in the reactor building were much higher than in previous years due to the remediation work being performed. The effective dose equivalent to the MEI was estimated to be $1.92E-4$ mrem/year.

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

Quality Assurance Program

The multilayered components of the BNL Quality Assurance (QA) Program ensure that all analytical data reported in this document

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

In 2009, the Laboratory used five off-site contract analytical laboratories to analyze en-

vironmental samples: General Engineering Lab (GEL), H2M Lab, Test American (TA), Chemtex Lab, and Brooks Rand. All analytical laboratories were certified by NYSDOH for the tests they performed for BNL, and were subject to oversight that included state and national performance evaluation (PE) testing, review of QA programs, and audits.

Based on the data reviews, data validations, and results of the independent PE assessments, the chemical and radiological results reported in this 2009 SER are of acceptable quality.

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