BROOKHAVEN NATIONAL LABORATORY

2002 Site Environmental Report

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ABOUT THE COVER

The beautiful nature photos selected for the front and back covers of the Brookhaven National Laboratory 2002 Site Environmental Report depict some of the wildlife on site. The Laboratory is home to a wide variety of plants, birds, reptiles, amphibians, and mammals including some protected species. Chapter 6 discusses the Laboratory's Natural Resource Management Program.

Front cover, Brown Thrasher.

Back cover, right to left,

- a. green frog surrounded by pollen in the Peconic River;*
- b. Eastern Towhee sitting on a scrub pine;*
- c. white-tailed deer buck on a hill;*
- d. wild turkeys on a grassy field;*
- e. Canada goose with goslings near a stream on site.*

Cover Wildlife Photography by Roger Stoutenburgh

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BROOKHAVEN NATIONAL LABORATORY

2002 Site Environmental Report

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Brookhaven Science Associates, LLC
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EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

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**A MESSAGE FROM
THE LABORATORY DIRECTOR**

When I became Director of Brookhaven National Laboratory (BNL) in April 2003, I was already somewhat familiar with the site, having worked on collaborations here at several points during my 36-year career at IBM. As I remembered from those visits, the 5,300-acre BNL site is a special one, featuring forests of oak and pine, abundant wildlife, including deer, fox, and turkey, and some of the brightest minds in science conducting research at some truly extraordinary machines. I appreciate the importance of respecting our environment and minimizing our impact on it as much as possible. As Director, I expect nothing less than excellence from our employees and visitors, both in terms of the science carried out here and in our role as responsible stewards of the environment.

In 2002, the Laboratory continued to demonstrate environmental leadership across the Department of Energy (DOE) complex by having our environmental management system (EMS) recertified to the globally recognized ISO 14001 standard. In 2001, BNL became the first DOE Office of Science, and the first Long Island-based organization to achieve third-party registration to the ISO14001 standard. In 2002, the Laboratory also received recognition for its EMS from the staff of *Environmental Protection* magazine, naming BNL as one of five "Facilities of the Year."

We continued to make substantial progress in addressing historical issues in 2002, removing hundreds of tons of radioactive soils and waste from the site, completing construction of a new groundwater treatment system, and conducting an important pilot study that will help guide the cleanup of the Peconic River.

BNL was also successful in terms of our commitment to limiting current and future impacts to the environment. Pollution prevention projects in 2002 saved more than \$1.5 million and resulted in the reduction or reuse of more than 2 million pounds of industrial, sanitary, hazardous, and radioactive waste. We also saw a promising increase in the number of pollution prevention proposals submitted by scientific staff, and eight projects, funded at an initial cost of approximately \$120,000, are expected to save the Laboratory more than \$268,000 each year.

The annual publication of the Site Environmental Report is just one of many ways the Laboratory keeps our neighbors, regulators, employees, and other interested parties informed about environmental issues and progress at the site. Communication with these groups has become an integral part of our operations, and must remain so if we intend to be successful in our scientific endeavors. So, as we continue to set grand challenges for ourselves, both in terms of scientific advances and operational excellence, we keep in mind our motto, "Exploring Earth's Mysteries...Protecting Its Future."

A handwritten signature in black ink that reads "Praveen Chaudhari". The script is fluid and cursive, with the first name and last name clearly legible.

Praveen Chaudhari
Laboratory Director

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Executive Summary

The 2002 Site Environmental Report (SER) is prepared in accordance with DOE Order 231.1, “*Environment, Safety and Health Reporting*,” and summarizes the status of Brookhaven National Laboratory’s (BNL) environmental programs and performance and restoration efforts, as well as any impacts, both past and present, that Laboratory operations have had on the environment. The document is intended to be technical in nature. A summary of the report is also prepared as a separate document to provide a general overview and includes a CD version of the full report.

Operated by Brookhaven Science Associates (BSA) for the Department of Energy (DOE), BNL manages its world-class scientific research with particular sensitivity to environmental and community issues. BNL’s motto, “Exploring Life’s Mysteries...Protecting its Future,” reflects BNL’s management philosophy to fully integrate environmental stewardship into all facets of its missions, with a healthy balance between science and the environment.

ENVIRONMENTAL MANAGEMENT SYSTEM

BSA takes environmental stewardship very seriously. As part of their commitment to environmentally responsible operations, an Environmental Management System (EMS) was established at BNL that ensures environmental issues are systematically identified, controlled, and monitored. It also provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual environmental improvement.

The Laboratory’s EMS was designed to meet the rigorous requirements of the globally recognized International Organization for Standardization (ISO) 14001 Environmental Management Standard, with additional emphasis on

compliance, pollution prevention, and community involvement. BNL was the first U.S. DOE Office of Science Laboratory to become officially registered to the ISO 14001 standard, in July 2001. Annual audits conducted by NSF-International Strategic Registrations, LTD, an accredited ISO 14001 registrar, are required to maintain the registration. In 2002, an EMS Surveillance Audit determined that BNL remains in conformance with the ISO 14001 Standard. The audit identified one major non-conformance, one opportunity for improvement, and strong evidence of continual improvement, including 12 noteworthy practices.

ENVIRONMENTAL MANAGEMENT PROGRAMS

BNL’s Environmental Management Program consists of several Laboratory-wide and facility-specific environmental programs. The cornerstone of BNL’s programs for environmental management is its Environmental Stewardship Policy, which states the Laboratory’s intentions and principles regarding overall environmental management and provides a framework for planning and action. The stewardship policy is posted throughout the Laboratory and on the BNL website and is included in all training programs for new employees.

BNL has an extensive program in place to ensure full compliance with all applicable environmental regulatory requirements and permits. BNL must comply with more than 50 sets of federal, state, and local regulations, as well as numerous site-specific permits. The Laboratory is committed to achieving and maintaining full compliance with these environmental requirements and agreements. In 2002, the New York State Department of Environmental Conservation (NYSDEC) granted BNL’s request to modify its State Pollutant Discharge Elimination System (SPDES) permit, which reduced monitoring at

several outfalls. Also in 2002, BNL's request for a final Title V permit was issued from NYSDEC. This permit consolidated all applicable federal and state requirements for BNL's regulated emission sources into a single document.

The goal of BNL's Groundwater Protection Management Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a cost-effective manner that is consistent with federal, state, and local regulations. Since the beginning of active groundwater remediation in 1997, BNL has removed more than 3,000 pounds of volatile organic compounds by treating nearly 5.5 billion gallons of groundwater.

BNL's Pollution Prevention Program was established to seek ways to eliminate waste and toxic materials. Pollution prevention is integrated into all planning and decision making at the Laboratory. In 2002, pollution prevention projects saved more than \$1.5 million and resulted in the reduction or reuse of over 2 million pounds of waste. Also in 2002, BNL was selected as one of five winners of "Environmental Facility of the Year" by *Environmental Protection* magazine. The magazine noted that the winners "used innovative approaches to protect the environment while simultaneously boosting their companies' bottom lines."

Wastes generated at the Laboratory are managed at a state-of-the-art facility designed especially for the management of hazardous, industrial, radioactive, and mixed wastes. In 2002, there was a significant reduction in the quantity of wastes generated from routine operations. Nonroutine waste generation varies from year to year depending on restoration activities.

The goals of BNL's Water Conservation Program are to reduce the consumption of potable water and to reduce the impact of clean water discharges on Sewage Treatment Plant operations. In 2002, water consumption was down from 2001 levels, with an overall reduction of 52 percent. BNL's water supply met all primary potable water requirements.

BNL's Energy Management Group works to reduce BNL's energy use and costs by identifying cost-effective, energy-efficient products; monitoring energy use and utility bills; and assisting in

obtaining the least expensive energy sources possible. In 2002, due to fuel purchasing strategies, BNL saw an overall cost avoidance of \$15,000. BNL also received \$235,000 for new energy conservation projects.

The Facility Review Project of 1997 was a comprehensive examination of all site facilities, existing or demolished, to identify any past or current activities that could potentially degrade the environment. In 2000, the Facility Review Disposition Project Plan (BNL 2000a) was approved; this provided the mechanisms needed to rank risk, to schedule, and to resolve the issues identified during the Facility Review Project. In 2002, significant progress was made to disposition the remaining open operational and legacy issues that the Facility Review Project identified. Of the original 1,675 issues identified, only 36 legacy issues remain open. All other issues were either closed or their management was transferred to an existing program or project.

The Environmental Restoration Group oversees the Laboratory's Superfund activities. Restoration monitoring is used to determine the overall impacts of past operations, to delineate contamination, and to ensure that removal actions are effective and that remediation systems are performing as designed. As part of its goal to complete on-site and off-site cleanup of contamination from past disposal practices, BNL addressed some of its legacy issues in 2002 by completing remediation, restoration, and construction of several groundwater monitoring projects, and completing a Pilot Study of remediation technologies for the Peconic River, Operable Unit V.

The Natural and Cultural Resource Management Program is a result of a merger, in 2002, of the former Natural Resource Program and the newer Cultural Resource Program. The Natural Resource Program was designed to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource protection with BNL's mission. Goals include protecting and monitoring the ecosystem, conducting research, and communicating with Laboratory staff and the public.

The Upton Ecological and Research Reserve was established in November 2000, when DOE

dedicated 530 acres of BNL property as an ecological research reserve to be managed by the U.S. Fish & Wildlife Services. A technical advisory group (TAG) was then formed to assist with decisions on research objectives. In 2002, TAG awarded multiple research grants to investigate important local ecological issues.

A Cultural Resource Management Plan was undertaken because, under the National Historic Preservation Act and the Archeological Resource Protection Act, BNL is required to identify, evaluate, and consider the effects of federal actions on historical and archeological sites eligible for listing or inclusion on the National Register of Historic Places. In 2002, BNL continued to identify, assess, and document BNL's historic and cultural resources. Also in 2002, the New York Historic Preservation Officer concurred with BNL's determination that ten World War II era buildings were not eligible for listing on the National Register of Historic Places. Additional activities included completion of a draft Brookhaven Graphite Research Reactor (BGRR) video documenting the history of the BGRR, and cultural resource surveys of World War I training trenches and foundations on site.

In 2002, 114 proposed projects underwent environmental evaluations for compliance with the National Environmental Policy Act (NEPA). Of these projects, 101 were minor actions requiring no additional documentation and 13 projects were addressed through the submission of Environmental Evaluation Notification Forms. All of the projects received categorical exclusions.

ENVIRONMENTAL MONITORING

BNL has a comprehensive, sitewide Environmental Monitoring Program that identifies potential pathways for exposure to the public and the environment; evaluates what impact BNL activities may be having on the environment; and ensures compliance with environmental permit requirements. In 2002, there were a total of 5,381 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges. The three components to the environmental monitoring program include compliance, restoration, and surveillance monitoring.

Compliance monitoring is conducted to ensure that wastewater effluents, air emissions, and groundwater monitoring data comply with regulatory and permit limits. An overview of compliance in 2002 includes: emissions of nitrogen oxides and carbon monoxide were within permit limits; approximately 1,000 pounds of ozone-depleting refrigerants were recovered for recycling; monitoring of the BNL potable water system showed that the potable water supply met all primary drinking water requirements; groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality; and liquid effluents discharged to surface water and groundwater met all New York State Pollutant Discharge Elimination System permit requirements with the exception of two excursions at the Sewage Treatment Plant and three at other outfalls. The five permit excursions were reported to NYSDEC. There were 19 spills of petroleum products reportable to outside regulatory agencies; 17 were less than 10 gallons and all were cleaned up or addressed to the satisfaction of NYSDEC.

BNL underwent 12 environmental audits by external regulatory agencies in 2002. Of the more than 1,000 New York State hazardous waste compliance requirements, BNL met all but three, receiving a Preliminary Finding and Administrative Complaint. Immediate corrective action was taken to address one of the three issues. The two remaining issues are being reviewed by BNL management and counsel to determine their validity and applicability to BNL.

Restoration monitoring is performed to determine the overall impact of past operations, to delineate the real extent of contamination, and to ensure that removal actions are effective and that remedial systems are performing as designed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA). In 2002, progress in cleanup and prevention activities for groundwater remediation were tracked by sampling 745 monitoring wells during over 2,000 individual sampling events. Six on-site groundwater remediation systems removed 720 pounds of

VOCs and returned more than one billion gallons of clean water to the aquifer. Progress was shown by the reduced contaminant concentrations and the decreasing size of the groundwater contaminant plumes.

Surveillance monitoring is used to assess potential environmental impacts resulting from routine facility operations and includes the collection of ambient air, surface water, groundwater, flora, fauna, and precipitation samples which are analyzed for radiological, organic, and inorganic contaminants. Routine reviews of data collected by thermoluminescent dosimeters (devices to measure radiation exposure) are also performed under this program.

BNL operations discharge treated wastewater to surface waters via the Sewage Treatment Plant (STP) or to groundwater recharge basins. Analytical data for 2002 showed that the average gross alpha and beta activity levels in the STP were well below drinking water standards. Tritium releases to the Peconic River continue to decline and cesium-137 and strontium-90 were detected infrequently in the effluent at levels significantly less than the drinking water standard.

Environmental monitoring continues to determine whether current or historical activities are affecting BNL's natural resources. In 2002, deer and fish sampling results were consistent with previous years. Local farm-grown produce, and vegetables grown in the BNL garden plot, continue to support historical analyses that there are no Laboratory-generated radionuclides in the farm produce.

An evaluation of potential radiological dose above natural background levels to uninvolved workers, members of the public, and the environment determined that impact from BNL operations was minimal and well below regulatory limits. Radiological dose to aquatic and terrestrial biota was also assessed and was found to be insignificant and comparable to natural background radiation levels. Ten on-site remediation and waste management projects were evaluated for radiological emissions to the environment, and the dose impact from all the projects was determined to be below regulatory limits.

QUALITY ASSURANCE

BNL uses its on-site Analytical Services Laboratory and four off-site, contract laboratories to analyze its environmental samples. All of the off-site laboratories are certified by New York State and are subject to oversight that includes state and national performance evaluation testing, review of quality assurance programs, and audits.

BNL received a combined score of 96.2 percent "Overall Satisfactory" for the 573 radiological and nonradiological performance evaluation tests carried out in 2002. BNL's "Overall Satisfactory" score in radiological testing was 97 percent, an improvement over 2001. In nonradiological performance evaluation testing under the New York State Environmental Laboratory Approval Program for potable and nonpotable water, BNL received a "Satisfactory" rating of 96.8 percent.

The multilayered components of quality assurance monitored at BNL ensure that all analytical data reported in the SER are reliable and of high quality.

COMMUNICATION, OUTREACH, AND COMMUNITY INVOLVEMENT

BNL's solid knowledge regarding its potential environmental vulnerabilities and current operations come from programs such as the Facility Review Project, process evaluations, the work planning and control system, groundwater protection, environmental restoration, and information management systems that were designed to improve the Laboratory's environmental systems and performance. In 2002, the Laboratory continued to openly communicate with its employees, neighbors, regulators, and other interested stakeholders on environmental issues and plans, and progress involving Laboratory operations and environmental restoration activities.

In 2002, BNL hosted more than 29,000 visitors, including students and community members. Events such as the Environmental Services Division "Summer Sunday" provided visitors with an opportunity to learn about BNL's environmental research. BNL's participation in the Heckscher Spring Festival provided a unique opportunity to promote environmental responsibility and appre-

ciation to the public, along with other local organizations. BNL's annual celebration of Earth Day featured an on-site 4K race with proceeds forwarded to charity. The Environmental Stewardship Award Ceremony recognized employees who have demonstrated outstanding efforts in environmental stewardship. The annual "Your Environment" art contest provided students from local schools with an opportunity to create a poster

depicting the importance of environmental stewardship with regard to Long Island's environment. The three winning posters were selected for inclusion in the 2002 SER Summary.

Part of BNL's EMS includes a commitment to continual improvement in communication. The Laboratory continues to pursue mechanisms to communicate data in a more user friendly, visual, and timely manner.

2002 Site Environmental Report Team

The SER Production Team realizes that many other employees contributed to this report and thanks all contributors for their efforts.

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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. Also, Appendix A opens with a list of acronyms and their meanings.

Contents

A Message From the Laboratory Director	iii
Executive Summary	v
Acknowledgements	xi
List of Figures	xix
List of Tables	xxi
 CHAPTER 1: INTRODUCTION	 1-1
1.1 Site Environmental Report Purpose	1-1
1.2 Mission	1-1
1.3 Operations	1-2
1.4 History	1-3
1.5 Location and Local Population	1-4
1.6 Facilities and Operations	1-4
1.7 Geology and Hydrology	1-8
1.8 Climate	1-9
1.9 Ecological Resources	1-11
References and Bibliography	1-14
 CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM	 2-1
2.1 Stewardship under Brookhaven Science Associates	2-2
2.2 Environmental Stewardship Policy	2-2
2.3 Planning	2-4
2.3.1 Environmental Aspects	2-4
2.3.2 Legal and Other Requirements	2-5
2.3.3 Objective and Targets	2-5
2.3.4 Environmental Management Programs	2-5
2.3.4.1 Compliance	2-5
2.3.4.2 Groundwater Protection	2-6
2.3.4.3 Waste Management	2-6
2.3.4.4 Prevention and Minimization	2-6
2.3.4.5 Water Conservation	2-9
2.3.4.6 Energy Management and Conservation	2-14
2.3.4.7 Natural and Cultural Resource Management	2-16
2.3.4.8 Environmental Restoration	2-16
2.3.4.9 The Facility Review Project	2-18
2.4 Implementing the Environmental Management System	2-18
2.4.1 Structure and Responsibility	2-18
2.4.2 Communication and Community Involvement	2-19
2.4.3 Monitoring and Measurement	2-20
2.4.3.1 Compliance Monitoring	2-20
2.4.3.2 Restoration Monitoring	2-21
2.4.3.3 Surveillance Monitoring	2-21
2.4.4 EMS Assessments	2-22
2.5 Environmental Stewardship at BNL Today	2-23
References and Bibliography	2-24

CHAPTER 3: COMPLIANCE STATUS	3-1
3.1 Compliance with Environmental Requirements	3-2
3.2 Environmental Permits	3-2
3.2.1 Existing Permits	3-2
3.2.2 New or Modified Permits and Requests	3-2
3.2.2.1 State Pollutant Discharge Permits	3-2
3.2.2.2 Air Emissions Permits	3-2
3.2.2.3 Underground Injection Control Permit	3-6
3.3 National Environmental Policy Act	3-6
3.4 Historic Preservation and Archaeology	3-6
3.5 Clean Air Act	3-7
3.5.1 Conventional Air Pollutants	3-7
3.5.1.1 Boiler Emissions	3-7
3.5.1.2 Ozone-Depleting Substances	3-7
3.5.2 Hazardous Air Pollutants	3-8
3.5.2.1 Maximum Available Control Technology	3-8
3.5.2.2 Asbestos	3-8
3.5.2.3 Radioactive Airborne Emissions	3-8
3.6 Clean Water Act	3-8
3.6.1 Sewage Treatment Plant	3-9
3.6.1.1 Total Suspended Solids Removal	3-9
3.6.1.2 Fecal Coliform	3-9
3.6.1.3 Chronic Toxicity Testing	3-12
3.6.2 Recharge Basins and Stormwater	3-13
3.7 Safe Drinking Water Act	3-14
3.7.1 Potable Water	3-16
3.7.2 Cross-Connection Control	3-16
3.7.3 Underground Injection Control	3-16
3.8 Spill Prevention, Emergency Planning, and Reporting	3-20
3.8.1 Preventing Oil Pollution and Spills	3-20
3.8.2 Local and State Reporting Requirements	3-21
3.8.3 Spills and Releases	3-21
3.8.4 Major Petroleum Facility License	3-24
3.8.5 Chemical Bulk Storage	3-24
3.8.6 County Storage Requirements	3-26
3.9 Resource Conservation and Recovery Act	3-26
3.10 Polychlorinated Biphenyls	3-27
3.11 Pesticides	3-27
3.12 Wetlands and River Permits	3-27
3.13 Endangered Species Act	3-28
3.14 External Audits and Oversight	3-29
3.14.1 Inspections by Regulatory Agencies	3-29
3.14.2 Inspections by DOE	3-30
3.14.2.1 Air Emissions Programmatic Self-Assessment	3-30
3.14.2.2 Polychlorinated Biphenyls Programmatic Self-Assessment	3-30
3.14.2.2 Radioactive Waste Management BAO Assessment	3-30
3.14.3 Enforcement Actions and Memos	3-30
References and Bibliography	3-31

CHAPTER 4: AIR QUALITY	4-1
4.1 Radiological Emissions	4-1
4.1.1 Brookhaven Medical Research Reactor	4-1
4.1.2 High Flux Beam Reactor	4-2
4.1.3 Brookhaven Linac Isotope Producer	4-4
4.1.4 Evaporator Facility	4-4
4.1.5 Target Processing Laboratory	4-4
4.1.6 Additional Minor Sources	4-4
4.1.7 Uncharacterized Radiological Emission Sources Evaluated in 2002	4-5
4.2 Facility Monitoring.....	4-5
4.3 Ambient Air Monitoring	4-6
4.3.1 Gross Alpha and Beta Activity	4-7
4.3.2 Airborne Tritium	4-8
4.4 NonRadiological Airborne Emissions	4-9
References and Bibliography	4-10
CHAPTER 5: WATER QUALITY	5-1
5.1 Surface Water Monitoring Program	5-1
5.2 Sanitary System Effluents	5-2
5.2.1 Sanitary System Effluent – Radiological Analyses	5-3
5.2.2 Sanitary System Effluent – Nonradiological Analyses	5-7
5.3 Process-Specific Wastewater	5-8
5.4 Recharge Basins	5-10
5.4.1 Recharge Basins - Radiological Analyses.....	5-11
5.4.2 Recharge Basins - Nonradiological Analyses	5-12
5.4.3 Stormwater Assessment	5-13
5.5 Peconic River Surveillance	5-15
5.5.1 Peconic River - Radiological Analyses	5-16
5.5.2 Peconic River - Nonradiological Analyses	5-16
References and Bibliography	5-22
CHAPTER 6: NATURAL AND CULTURAL RESOURCES	6-1
6.1 Natural Resource Management Program	6-1
6.1.1 Identification and Mapping	6-1
6.1.2 Habitat Protection and Enhancement	6-2
6.1.2.1 Tiger Salamander Efforts	6-3
6.1.2.2 Other Species	6-3
6.1.3 Population Management	6-4
6.1.3.1 Wild Turkeys.....	6-4
6.1.3.2 White-Tailed Deer	6-5
6.1.4 Compliance Assurance and Potential Impact Assessment	6-5
6.2 Upton Ecological and Research Reserve	6-6
6.3 Monitoring Flora and Fauna	6-7
6.3.1 Deer Sampling	6-8
6.3.1.1 Cesium-137 in Deer.....	6-8
6.3.1.2 Unusual Cesium-137 Results in Deer Meat	6-10
6.3.1.3 Strontium-90 in Deer Bone	6-16
6.3.2 Small Mammal Sampling	6-16

6.3.3	Other Animals Sampled	6-17
6.3.4	Fish Sampling	6-17
6.3.4.1	Radiological Analysis of Fish	6-18
6.3.4.2	Fish Population Assessment	6-18
6.3.4.3	Nonradiological Analysis of Fish and Shellfish	6-19
6.3.5	Aquatic Sampling	6-21
6.3.5.1	Radiological Analysis	6-21
6.3.5.2	Metals in Aquatic Samples	6-22
6.3.5.3	Pesticides in Aquatic Samples	6-24
6.3.6	Vegetation Sampling	6-24
6.3.6.1	Farm and Garden Plants	6-24
6.3.6.2	Grassy Plants	6-25
6.3.6.3	Special Plant Sampling	6-26
6.4	Soil Sampling	6-27
6.5	Basin Sediments	6-29
6.5.1	Chemical Analysis	6-29
6.5.2	PCBs and Pesticides	6-30
6.5.3	Metals	6-30
6.5.4	Radiological Analysis	6-30
6.6	Toxicity Tests, Sewage Treatment Plant	6-30
6.7	Precipitation Monitoring	6-30
6.8	Wildlife Programs	6-33
6.9	Cultural Resource Activities	6-39

CHAPTER 7: GROUNDWATER PROTECTION		7-1
7.1	The BNL Groundwater Protection Management Program	7-1
7.1.1	Prevention	7-1
7.1.2	Monitoring	7-2
7.1.3	Restoration	7-2
7.1.4	Communication	7-2
7.2	Groundwater Protection Performance	7-2
7.3	Groundwater Monitoring	7-3
7.4	Supplemental Monitoring of Potable and Process Supply Wells	7-4
7.4.1	Radiological Results	7-4
7.4.2	Nonradiological Results	7-9
7.5	Environmental Surveillance Program	7-10
7.5.1	Research Facilities	7-10
7.5.1.1	Alternating Gradient Synchrotron Complex	7-10
7.5.1.2	Brookhaven Linac Isotope Producer	7-13
7.5.1.3	Relativistic Heavy Ion Collider	7-14
7.5.1.4	Brookhaven Medical Research Reactor	7-14
7.5.1.5	Building 801	7-15
7.5.2	Surveillance Monitoring of Support Facilities	7-16
7.5.2.1	Sewage Treatment Plant Area	7-16
7.5.2.2	Motor Pool Facility	7-16
7.5.2.3	Upton Service Station	7-17

7.5.2.4	Major Petroleum Facility	7-18
7.5.2.5	Waste Management Facility	7-18
7.5.2.6	Biology Department Greenhouse Area	7-19
7.5.2.7	Shotgun Range	7-19
7.5.2.8	Live Fire Range	7-19
7.6	Environmental Restoration Groundwater Monitoring Program	7-19
7.6.1	Background Monitoring	7-20
7.6.2	Operable Unit I	7-20
7.6.2.1	Former Landfill, Animal/Chemical Pits, and Glass Holes	7-20
7.6.2.2	Current Landfill	7-22
7.6.2.3	Current Landfill and FWMF Plumes	7-24
7.6.3	Operable Unit III	7-25
7.6.3.1	OU III Volatile Organic Compound Plumes	7-27
7.6.3.2	OU III Radionuclide Plumes	7-32
7.6.4	Operable Unit IV	7-35
7.6.4.1	1977 Oil/Solvent Spill Site	7-35
7.6.4.2	Building 650 and 650 Sump Outfall Areas (AOC 6)	7-35
7.6.5	Operable Unit V	7-36
7.6.6	Operable Unit VI, Biology Fields	7-36
7.7	Groundwater Treatment Systems	7-41
	References	7-42
CHAPTER 8: RADIOLOGICAL DOSE ASSESMENT		8-1
8.1	Direct Radiation Monitoring	8-1
8.1.1	Ambient Monitoring	8-2
8.1.2	Facility Area Monitoring	8-5
8.1.3	Building 650 Sump Outfall Monitoring	8-6
8.2	Air Emissions	8-6
8.2.1	Dose Modeling Program	8-7
8.2.2	Maximally Exposed Individual	8-7
8.2.3	Dose from Diffuse (Nonpoint) and Other Sources	8-7
8.2.3.1	Building 490	8-7
8.2.3.2	Soil Activation Studies	8-8
8.2.3.3	Building 901	8-8
8.2.3.4	Waste Management – BLIP Transfers	8-8
8.2.3.5	Waste Management – Respirator Cleaning	8-9
8.2.3.6	Waste Management – Compacting	8-10
8.2.3.7	Waste Management – Hot Cell	8-10
8.2.3.8	Sewage Treatment Plant	8-10
8.2.3.9	Mercury-Tritium Diffusion Pump	8-10
8.2.3.10	BGRR BGD Filter Removal	8-11
8.2.4	Dose from Point Sources	8-11
8.3	Ingestion Pathway	8-11
8.4	Cumulative dose	8-12
8.5	Dose to Aquatic and Terrestrial Biota	8-12
	References and Bibliography	8-13

CHAPTER 9: QUALITY ASSURANCE	9-1
9.1 Quality Program Elements	9-1
9.2 Sample Collection and Handling	9-2
9.2.1 Field Sample Handling	9-3
9.2.1.1 Custody and Documentation	9-4
9.2.1.2 Preservation and Shipment	9-4
9.2.2 Field Quality Control Samples	9-4
9.2.3 Tracking and Data Management	9-5
9.2.3.1 Sample Tracking	9-5
9.2.3.2 Data Management	9-5
9.2.3.3 Distribution of Analytical Data	9-5
9.3 Sample Analysis	9-5
9.3.1 ASL Qualifications	9-6
9.3.2 Contractor Lab Qualifications	9-6
9.4 Verification and Validation of Analytical Results	9-6
9.4.1 Verifying and Validating ASL Results	9-7
9.4.2 Verifying and Validating Off-Site Results	9-7
9.5 Analytical Laboratory QA/QC	9-7
9.6 ASL Internal Quality Assurance Program	9-7
9.6.1 Radiological Instrument Calibrations	9-8
9.6.2 Upgrades	9-8
9.6.3 Accuracy and Precision	9-8
9.6.3.1 Gross Alpha/Beta	9-8
9.6.3.2 Tritium	9-8
9.6.3.3 Strontium-90	9-9
9.6.3.4 Nonradiological Organic and Inorganic Analyses	9-9
9.7 Proficiency Evaluation Testing	9-9
9.7.1 Summary of Test Results	9-9
9.7.2 Radiological Assessments	9-11
9.7.2.1 EML Radiological Results	9-11
9.7.2.2 ELAP Radiological Results	9-11
9.7.2.3 ERA Radiological Results	9-11
9.7.3 Nonradiological Assessments	9-11
9.7.3.1 ELAP Nonpotable Water Results	9-11
9.7.3.2 ELAP Solid and Hazardous Waste Chemistry	9-11
9.7.3.3 ELAP Potable Water Results	9-11
9.7.3.4 Voluntary PE Studies	9-12
9.8 Audits	9-12
9.9 BNL Deer Investigation	9-12
9.10 Conclusions	9-13
References and Bibliography	9-13
Appendix A: Glossary	A-1
Acronyms and Abbreviations	A-1
Technical Terms	A-3
Appendix B: Concepts of Radioactivity	B-1
Appendix C: Radiological Data Methodologies	C-1
Appendix D: Instrumentation and Analytical Methods	D-1
Back Cover: Helpful Information on Units of Measure and Conversions	

List of Figures

Figure 1-1.	Upton Ecological and Research Reserve.	1-5
Figure 1-2.	Major Scientific Facilities at Brookhaven National Laboratory.	1-7
Figure 1-3.	Major Laboratory Support and Service Facilities.	1-8
Figure 1-4.	Groundwater Flow Map.	1-10
Figure 1-5.	Annual Wind Rose (2002).	1-11
Figure 1-6.	2002 Monthly Precipitation Versus 54-Year Monthly Average.	1-12
Figure 1-7.	Annual Precipitation Trend (54 Years).	1-12
Figure 1-8.	2002 Monthly Mean Temperature Versus 54-Year Monthly Average.	1-13
Figure 1-9.	Annual Mean Temperature Trend (54 Years).	1-13
Figure 2-1a.	Hazardous Waste Generation from Routine Operations, 1993–2002.	2-7
Figure 2-1b.	Mixed Waste Generation from Routine Operations, 1993–2002.	2-7
Figure 2-1c.	Radioactive Waste Generation from Routine Operations, 1993–2002.	2-7
Figure 2-1d.	Hazardous Waste Generation from ER and Nonroutine Operations, 1997–2002.	2-8
Figure 2-1e.	Mixed Waste Generation from ER and Nonroutine Operations, 1997–2002.	2-8
Figure 2-1f.	Radioactive Waste Generation from ER and Nonroutine Operations, 1997–2002.	2-8
Figure 2-2.	Water Consumption Trend.	2-15
Figure 2-3.	Building Energy Performance Since 1985.	2-16
Figure 3-1.	Maximum Concentration of Copper Discharged from the BNL Sewage Treatment Plant, 1998–2002.	3-11
Figure 3-2.	Maximum Concentration of Iron Discharged from the BNL Sewage Treatment Plant, 1998–2002.	3-11
Figure 3-3.	Maximum Concentration of Lead Discharged from the BNL Sewage Treatment Plant, 1998–2002.	3-11
Figure 3-4.	Maximum Concentration of Silver Discharged from the BNL Sewage Treatment Plant, 1998–2002.	3-12
Figure 3-5.	Maximum Concentration of Nickel Discharged from the BNL Sewage Treatment Plant, 1998–2002.	3-12
Figure 3-6.	Maximum Concentration of Zinc Discharged from the BNL Sewage Treatment Plant, 1998–2002.	3-13
Figure 3-7.	Maximum Concentration of Mercury Discharged from the BNL Sewage Treatment Plant, 1998–2002.	3-13
Figure 4-1.	Air Emission Release Points Subject to Continuous Monitoring.	4-2
Figure 4-2.	High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1993–2002).	4-3
Figure 4-3.	On-Site Ambient Air Monitoring Stations.	4-6
Figure 4-4.	Airborne Gross Beta Concentration Trend Recorded at Station P7.	4-7
Figure 5-1.	Schematic of BNL's Sewage Treatment Plant (STP).	5-2
Figure 5-2.	Tritium Concentration in Effluent from the Sewage Treatment Plant.	5-5
Figure 5-3.	Sewage Treatment Plant/Peconic River Annual Tritium Concentrations (1988 – 2002).	5-5
Figure 5-4.	Tritium Released to the Peconic River, 15-Year Trend (1988 – 2002).	5-6
Figure 5-5.	Cesium-137 in the Sewage Treatment Plant Influent and Effluent (1990 – 2002).	5-8
Figure 5-6.	BNL Outfall Locations.	5-10
Figure 5-7.	Schematic of Waste Use and Flow at BNL.	5-11
Figure 5-8.	Sampling Stations for Surface Water, Fish, and Shellfish.	5-17
Figure 6-1.	Vegetation Map of BNL.	6-2
Figure 6-2.	BNL Site Map Indicating the Boundary of the Upton Ecological and Research Reserve.	6-6
Figure 6-3.	Distribution of Deer Samples 1992–2002.	6-9
Figure 6-4.	Comparison of Cs-137 Average Concentrations in Deer, 2002.	6-15
Figure 6-5.	Five-Year Cs-137 Concentration Trends in Deer Meat at BNL and within 1 Mile.	6-15
Figure 6-6.	Farm and Gardening Sampling Locations.	6-25

Figure 6-7.	Typical World War I Trench Configurations.	6-40
Figure 6-8.	WWI Training Trench at Camp Upton, Circa 1918.	6-41
Figure 6-9.	WWI Training Trench As It Appears on the BNL Site Today.	6-41
Figure 7-1.	Groundwater Protection Performance 1998 through 2002.	7-3
Figure 7-2.	Locations of BNL Groundwater Monitoring Wells.	7-5
Figure 7-3.	Groundwater Flow and Water Table Elevation (June 2002) with Supply Wells Shown.	7-6
Figure 7-4.	Extent of VOC Plumes.	7-7
Figure 7-5.	Extent of Radionuclide Plumes.	7-8
Figure 7-6.	Extent of AGS g-2 Tritium Plume.	7-12
Figure 7-7.	Operable Unit I TVOC Plume Comparisons 1997 and 2002.	7-21
Figure 7-8.	Former Landfill, Animal/Chemical Pits, and Glass Holes Sr-90 Plumes.	7-23
Figure 7-9.	Former Waste Management Facility Sr-90 Plume.	7-26
Figure 7-10.	Operable Unit III TVOC Plume Comparisons 1997 and 2002.	7-28
Figure 7-11.	HFBR Tritium Plume Comparisons 1997 and 2002.	7-33
Figure 7-12.	BGRR and WCF Sr-90 Plumes.	7-34
Figure 7-13.	Operable Unit IV, AOC 6 Sr-90 Plume.	7-37
Figure 7-14.	Operable Unit V TVOC Plume Comparisons 1997 and 2002.	7-38
Figure 7-15.	Operable Unit VI EDB Plume Comparisons 1997 and 2002.	7-39
Figure 7-16.	Locations of BNL Groundwater Remediation Systems.	7-40
Figure 8-1.	On-Site TLD Locations.	8-2
Figure 8-2.	Off-Site TLD Locations.	8-3
Figure 9-1.	Flow of Environmental Monitoring QA/QC Program Elements.	9-3
Figure 9-2.	Radiological Proficiency Evaluation Scores in U.S. DOE and ERA Programs.	9-10
Figure 9-3.	Nonradiological Proficiency Evaluation Scores in ELAP, ERA, and Independent Programs.	9-10
Figure B-1.	Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem).	B-2

List of Tables

Table 2-1.	Elements of the Environmental Management System: Implementation of ISO 14001 at BNL.	2-3
Table 2-2.	Waste Reduction and Recycling Projects.	2-10
Table 2-3.	Recycling Program Summary.	2-15
Table 2-4.	Summary of 2002 Environmental Restoration Activities.	2-17
Table 2-5.	Issues Identified in the Facility Review Project, as of December 31, 2002.	2-18
Table 2-6.	Summary of BNL 2002 Sampling Program Sorted by Media.	2-22
Table 3-1.	Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL.	3-3
Table 3-2.	BNL Environmental Permits.	3-5
Table 3-3.	Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001.	3-10
Table 3-4.	Analytical Results for Wastewater Discharges to Outfalls 002–008 and 010.	3-14
Table 3-5.	Potable Water Wells and Potable Distribution System: Bacteriological, Inorganic Chemical, and Radiological Analytical Results (Maximum Concentration, Minimum pH Value).	3-17
Table 3-6.	Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, and Micro-Extractables.	3-18
Table 3-7.	Summary of Chemical and Oil Spill Reports.	3-22
Table 3-8.	Summary of Other BNL Environmental Occurrence Reports.	3-25
Table 3-9.	Existing Enforcement Actions and Agreements Issued to BNL, with Status.	3-31
Table 4-1.	Airborne Radionuclide Releases from Monitored Facilities.	4-3
Table 4-2.	Gross Activity in Facility Air Particulate Filters.	4-6
Table 4-3.	Gross Activity Detected in Air Particulate Filters.	4-7
Table 4-4.	Ambient Airborne Tritium Measurements in 2002.	4-8
Table 4-5.	Central Steam Facility Fuel Use and Emissions (1996 – 2002).	4-10
Table 5-1.	Tritium and Gross Activity in Water at the Sewage Treatment Plant.	5-4
Table 5-2.	Gamma-Emitting Radionuclides and Strontium-90 in Water at the Sewage Treatment Plant.	5-7
Table 5-3.	Sewage Treatment Plant (STP) Average Water Quality and Metals Analytical Results.	5-9
Table 5-4.	Radiological Analysis of Samples from On-Site Recharge Basins.	5-12
Table 5-5.	Water Quality Data for On-site Recharge Basin Samples.	5-13
Table 5-6.	Metals Analytical Results for On-Site Recharge Basin Samples.	5-14
Table 5-7.	Radiological Results for Surface Water Samples Collected along the Peconic and Carmans Rivers.	5-18
Table 5-8.	Water Quality Data for Surface Water Samples Collected along the Peconic and Carmans Rivers.	5-19
Table 5-9.	Analysis of Metals in Surface Water Samples Collected along the Peconic and Carmans Rivers.	5-20
Table 6-1.	New York State Threatened, Endangered, and Species of Special Concern.	6-3
Table 6-2.	Radiological Analysis of Deer Tissue.	6-11
Table 6-3.	Radiological Analysis of Small Mammals (Squirrels).	6-17
Table 6-4.	Radiological Analysis (Whole Body) of Fish from the Peconic River System and Control Locations.	6-19
Table 6-5.	2001 and 2002 Fish Population Survey Results in the Peconic River (STP to HM-N).	6-19
Table 6-6.	Metals Analysis of Fish and Shellfish from the Peconic River System and Control Locations.	6-20
Table 6-7.	Pesticide Analysis of Fish and Shellfish from the Peconic River System and Control Locations.	6-21
Table 6-8.	Radiological Analysis of Shellfish, Aquatic Vegetation, Water, and Sediment.	6-22
Table 6-9.	Metals Analysis of Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.	6-23
Table 6-10.	Pesticide and PCB Analysis of Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.	6-24
Table 6-11.	Radiological Analysis of Farm and Garden Produce.	6-26

Table 6-12.	Radiological Analysis of Grass and Other Vegetation.	6-26
Table 6-13.	Radiological Analysis of Special Vegetation Sampling at the Former Waste Management Facility (FWMF).	6-27
Table 6-14.	Radiological Analysis of Soil Samples.	6-28
Table 6-15.	Semivolatile Organic Compound Analysis of Basin Sediments.	6-31
Table 6-16.	PCB Analysis of Basin Sediments.	6-33
Table 6-17.	Pesticide Analysis of Basin Sediments.	6-34
Table 6-18.	Metals Analysis of Basin Sediments.	6-36
Table 6-19.	Radiological Analysis of Basin Sediments.	6-38
Table 7-1.	Potable Well Radiological Analytical Results.	7-9
Table 7-2.	Potable Water Supply Wells Water Quality Data.	7-10
Table 7-3.	Total Metals Concentration Data for Potable Water Supply Well Samples.	7-11
Table 7-4.	BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2002.	7-41
Table 8-1.	On-Site Direct Radiation Measurements.	8-4
Table 8-2.	Off-Site Direct Radiation Measurements.	8-5
Table 8-3.	Facility Area Monitoring.	8-5
Table 8-4.	Effective Dose Equivalent from Facilities	8-9
Table 8-5.	BNL Site Dose Summary.	8-13
Table C-1.	Typical Minimum Detection Limits for Gross Activity and Tritium Concentrations in Water.	C-2
Table C-2.	Typical Minimum Detection Limits for Gamma Spectroscopy Analysis.	C-2
Table C-3.	Typical Minimum Detection Limits for Chemical Analyses by BNL Analytical Services Lab and Off-Site Analytical Laboratories.	C-2
Table D-1.	ASL Certified Organic Analytes.	D-3
Table D-2.	ASL Certified Metals and Anions.	D-3

Introduction

Each year, Brookhaven National Laboratory, a U.S. Department of Energy national laboratory, prepares an annual Site Environmental Report summarizing the status of its environmental programs and performance, as well as any impacts, both past and present, that Laboratory operations have had on the environment. Located in the center of the unique Pine Barrens ecosystem of Long Island, New York, Brookhaven National Laboratory is committed to conducting its mission of research and education in a safe and environmentally responsible manner. Chapter 1 describes the site's facilities, ecological resources, demographics, and history. It also discusses local characteristics in terms of geology, hydrology, and climate, providing background material for the technical information in the chapters that follow.

1.1 SITE ENVIRONMENTAL REPORT PURPOSE

Brookhaven National Laboratory (BNL) prepares an annual Site Environmental Report (SER) in accordance with the U.S. Department of Energy's (DOE) Order 231.1, "Environment, Safety and Health Reporting." The SER summarizes BNL's on-site environmental data; environmental management performance; compliance with applicable Environmental Protection Agency (EPA), DOE, state, and local regulations; and environmental, restoration, and surveillance monitoring programs. The report is written to meet DOE requirements and guidelines and to inform BNL employees, outside regulators, and the general public of BNL's environmental performance during the year in review.

BNL has been preparing annual SERs since 1971. In June 2001, BNL published *Radiological Emissions and Environmental Monitoring for Brookhaven National Laboratory, 1947–1961* (Meinhold and Meinhold 2001). That report, combined with *Radiological Environmental Monitoring Report for Brookhaven National Laboratory, 1967–1970* (Meinhold and Hull 1998), as well as other individual reports written from 1962 through 1966, has enabled BNL to compile and record nearly all of its environmental history since the Laboratory's inception in 1947.

The 2002 SER describes the status and results of BNL's environmental protection programs for the calendar year and is intended to be a technical document. It is available in hard copy and as a downloadable file on the BNL web page at <http://www.bnl.gov/esd/ser.htm>. A summary of the SER is also prepared as a separate document to provide a general overview and includes a CD version of the SER (see inside front cover for ordering information). The SER Summary provides environmental information to BNL's employees, stakeholders, visitors, students, and members of the public, in support of BNL's educational and community outreach program.

1.2 MISSION

BNL's broad mission is to produce excellent science in a safe, environmentally responsible manner with the cooperation, support, and appropriate involvement of the scientific and local communities. The Laboratory plays a lead role in the DOE Science and Technology mission and contributes to the DOE missions in Energy Resources, Environmental Quality, and National Security. The fundamental elements of BNL's role in support of these key DOE missions are:

- 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 to transfer them to other organizations and to the commercial sector.
- To disseminate technical knowledge, to educate new generations of scientists and engineers, to maintain technical capabilities in the nation's workforce, and to encourage scientific awareness in the general public.

It is BNL's policy to integrate environmental stewardship into all facets of its missions and operations. BNL's Environmental Stewardship Policy, which is posted throughout the site, represents the highest level of commitment to conducting research and operational activities in a manner that protects the ecosystem and the health of employees on site and of the general public.

1.3 OPERATIONS

Established in 1947, BNL is a multi-program national laboratory operated for DOE by Brookhaven Science Associates (BSA), a not-for-profit partnership between Battelle Memorial Institute and the Research Foundation of the State University of New York on behalf of the State University of New York at Stony Brook. BSA began operating the Laboratory on March 1, 1998 under DOE Contract No. DE-AC02-98CH10886. From 1947 to 1998, BNL was operated by Associated Universities Incorporated. Prior to 1947, the site was operated as Camp Upton, a U.S. Army training camp, which was active from 1917 to 1920 during World War I and from 1940 to 1946 during World War II. Many of the cultural resources from this era are preserved in the Camp Upton Museum (see Chapter 6 for details).

BNL conducts research in physics and in chemical, biological, biomedical, and environmental sciences, as well as energy technologies. BNL also builds and operates major world-class research facilities available to university, indus-

trial, and government scientists. Approximately 3,000 scientists, engineers, technicians, and support staff work at BNL, and more than 4,000 guest researchers from all over the world visit the site each year to participate in scientific collaborations. Some important scientific discoveries and research at BNL include major discoveries in particle physics; the use of L-dopa to treat Parkinson's disease; work on magnetically levitated (Maglev) trains; the radionuclide thallium-201, used in millions of heart stress tests each year; pollution-eating bacteria; structural studies of the Lyme disease protein for new vaccines; asbestos-digesting foam; quiet jackhammers; promising cocaine addiction treatments; and cleaner, more efficient oil burners. In 2001, BNL was ranked by *Environmental Protection* magazine as one of the top five major institutions worldwide for its impact in environmental research and received three Energy 100 Awards from DOE for scientific and technological achievements. The recognized research included studies of drug addiction and drug action using the Positron Emission Tomography (PET) imaging technique; invention of the Flame Quality Indicator, a device that measures flame brightness in oil burners; and development of techniques for preventing and diagnosing Lyme disease. In 2002, BNL chemist Raymond Davis, Jr. and two colleagues won the 2002 Nobel Prize in Physics for detecting solar neutrinos, which are ghostlike particles produced in the nuclear reactions that power the sun. Also in 2002, a BNL atmospheric chemist was one of four recipients of Southampton College's first annual environmental leadership awards for research on strategies to control the nation's air quality problems.

BNL is the largest employer on eastern Long Island, with an annual budget of over \$450 million. Most of this budget directly supports the local economy through wages and purchases of materials and services. In fiscal year 2002, BNL purchased more than \$31 million worth of supplies and services from Long Island businesses. Construction of new buildings, repair of the Laboratory's aging infrastructure, and environmental cleanup accounted for a large part of the local expenditures. Employee salaries, wages, and fringe benefits accounted for 58

percent, or almost \$269 million, of BNL's total budget of \$463 million in 2002. Additionally, most of the Laboratory's employees live and shop locally in Suffolk County and throughout Long Island. An independent Suffolk County Planning Commission report concluded that BNL's spending for operations, procurement, payroll, construction, medical benefits, and technology transfer spreads throughout Long Island's economy, making BNL vital to Long Island's economic health (Kamer 1995).

1.4 HISTORY

BNL was founded in 1947 by the Atomic Energy Commission. The objective was to build a regional laboratory that could provide researchers with powerful tools too costly for their home institutions to build and maintain. Although BNL no longer operates any research reactors, the Laboratory's first major scientific facility was the Brookhaven Graphite Research Reactor (BGRR), which operated from 1950 to 1969 and is now being decommissioned. The BGRR was used for peaceful scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. The BGRR's capacity was replaced and surpassed in 1965 by the High Flux Beam Reactor (HFBR), which provided neutrons to researchers in diverse subjects ranging from solid state physics to art history. During a scheduled maintenance shutdown in 1997, workers discovered a leak in the HFBR's spent fuel storage pool; in November 1999, the Secretary of Energy decided that the HFBR would be permanently closed. All spent fuel has been transported to DOE's Savannah River Site.

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, the Brookhaven Medical Research Reactor (BMRR) in 1959, and the Brookhaven Linac Isotope Producer (BLIP) in 1973. Chemists and physicians could view the inner workings of the brain in 1977 with the advent of PET cameras. Two more imaging techniques were added to the PET research efforts to form the Center for Imaging and Neuroscience in 1996. Except for the BMRR, all of these medical facilities are cur-

rently operating. Due to a reduction of research funding, the BMRR shut down on December 20, 2000. All spent fuel has been transported to DOE's Savannah River Site.

High-energy particle physics research at BNL began in 1952 with the Cosmotron, the first particle accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Noble Prize-winning discovery in 1957. In 1960, the Alternating Gradient Synchrotron (AGS), a much larger accelerator that surpassed the Cosmotron's capabilities, became operational. The AGS, still in operation, has yielded many discoveries of new particles and phenomena, for which BNL researchers were awarded three Nobel Prizes in Physics in 1976, 1980, and 1988. The Tandem Van de Graaff accelerator, also still in use, began operating in 1970 and is the starting point of the chain of accelerators that provide gold and other heavy ions for experiments at the Relativistic Heavy Ion Collider (RHIC), discussed below. In 1982, researchers began using the National Synchrotron Light Source (NSLS), which guides charged particles in orbit inside a donut-shaped electron storage ring for use in a wide range of physical and biological experiments.

The RHIC, the Laboratory's new two-ringed particle accelerator, began operation in 2002. The four RHIC detectors record full-energy collisions that recreate (on a microscopic scale) the hot, dense conditions that are thought to have existed when the universe first formed. This enables scientists to study the basic components of matter as they existed in their earliest forms. In August 1999, the RHIC became the first facility at BNL and also on Long Island to receive International Organization for Standardization (ISO) 14001 Environmental Management System certification (see Chapter 2 for details). The RHIC is an example of BNL's commitment to fully integrate today's world-class science with world-class protection of the environment.

Historical operations and past waste management practices at the Laboratory permitted the release of chemicals and radioactive materials that resulted in soil and groundwater contamination. In 1989, BNL was added to the federal Comprehensive Environmental Response,

Compensation and Liability Act (CERCLA) National Priorities List of environmentally contaminated sites identified for priority cleanup. Since then, BNL has made significant progress toward improving environmental operations and remediating past contamination. In 2002, BNL received an “Outstanding” performance rating from DOE for its environment, safety, and health performance. BNL also received an “Outstanding” performance rating in pollution prevention measures, which are a key component of the Laboratory’s Environmental Management System.

1.5 LOCATION AND LOCAL POPULATION

BNL is located in Suffolk County on Long Island, New York, about 60 miles east of New York City. The Laboratory’s 5,265-acre site is near Long Island’s geographic center and is part of the Town of Brookhaven, the largest township (both in area and population) in Suffolk County. More than 75 percent of the Laboratory’s approximately 3,000 employees live within a 15-mile radius of BNL. Approximately 150 people reside long-term in apartments and cottages on site, and many of the approximately 4,000 scientists and students who visit each year stay in the Laboratory’s short-term housing. In addition to the resident staff and visiting scientists, more than 29,000 visitors participated in educational outreach activities conducted on site in 2002.

1.6 FACILITIES AND OPERATIONS

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

- 500 acres originally developed by the Army (as part of Camp Upton) and still used for offices and other operational buildings
- 200 acres occupied by large, specialized research facilities
- 550 acres occupied by outlying facilities, such as the Sewage Treatment Plant, research agricultural fields, housing facilities, and fire breaks
- 400 acres of roads, parking lots, and connecting areas.

The balance of the site, approximately 3,600 acres, is mostly wooded and represents the native Pine Barrens ecosystem. In November 2000,

DOE set aside 530 acres of undeveloped land at BNL as the Upton Ecological and Research Reserve (Figure 1-1). Further details regarding the reserve and BNL’s natural resources can be found in Section 1-9 of this chapter and in Chapter 6.

The major scientific facilities at BNL are pictured and briefly described in Figure 1-2. As described in Section 1.4, there are three nonoperational research reactors (the BGRR, the HFBR, and the BMRR). In addition to the scientific facilities, numerous other facilities (described below) support BNL’s science and technology mission by providing basic utility and environmental services (Figure 1-3):

- *Water Treatment Plant.* The potable water treatment facility has a capacity of 5 million gallons per day. Potable water is obtained from six on-site wells. Three wells located along the western boundary of the site are treated with a lime softening process to remove naturally occurring iron. The plant is also equipped with dual air-stripping towers to ensure that volatile organic compounds (VOCs) are at or below New York State drinking water standards. Three wells located along the eastern section of the developed site are treated with carbon to ensure that VOC levels meet the standards.
- *Central Chilled Water Plant.* This facility provides chilled water sitewide for air conditioning and process refrigeration via underground piping. The plant has a large refrigeration capacity with once-through cooling, and reduces the need for local refrigeration plants.
- *Central Steam Facility (CSF).* This dual-fuel-fired plant provides high-pressure steam for facility and process heating sitewide. Both natural gas and 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.
- *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 the CSF boilers to burn natural gas as well as oil has significantly reduced

Figure 1-1. Upton Ecological and Research Reserve.

- BNL's reliance on oil as a fuel source.
- *Sewage Treatment Plant.* This facility treats sanitary and certain process wastewater from BNL facilities prior to discharge into the Peconic River, similar to the operations of a municipal sewage treatment plant. The plant has a design capacity of 3 million gallons per day. Effluent is monitored and controlled under a permit issued by the New York State Department of Environmental Conservation (NYSDEC).
- *Waste Management Facility.* This facility is a state-of-the-art complex for managing the wastes generated from BNL's research and operations activities. The facility began operation in December 1997 and was built with advanced environmental protection systems and features. It houses two areas that have permits from NYSDEC for storing hazardous wastes prior to shipment for treatment and disposal at other permitted facilities.
- *Fire Station.* The BNL Fire Department provides on-site fire suppression, emergency medical services, hazardous material response, salvage, and damage control. The Fire Station houses six response vehicles. The fire rescue group responds within five minutes to any emergency in the core area of the Laboratory and within eight minutes to emergencies in the outer areas (RHIC and eastern portions of the site).

1. RELATIVISTIC HEAVY ION COLLIDER (RHIC)

RHIC is one of the world's largest and most powerful accelerators. RHIC's main physics mission is to study particles smaller than atoms.

2. ALTERNATING GRADIENT SYNCHROTRON (AGS)

The AGS is used for high-energy physics research and accelerates protons to energies up to 30 GeV, and heavy-ion beams to 15 GeV. A 200 MeV Linear Accelerator, described below, serves as a proton injector for the AGS booster and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven Linac Isotope Producer (BLIP) facility.

3. AGS BOOSTER

The AGS Booster is a circular accelerator, 200 meters in circumference, that receives either a proton beam from the Linac, or heavy ions from the Tandem Van de Graaff. The AGS Booster accelerates proton particles and heavy ions before injecting them into the AGS ring. This facility became operational in 1992.

4. LINEAR ACCELERATOR (LINAC) AND BROOKHAVEN LINAC ISOTOPE PRODUCER (BLIP)

The Linac provides beams of polarized protons for the AGS and for the Relativistic Heavy Ion Collider. BLIP utilizes the excess beam capacity of the Linac to produce radioisotopes used in research and medical imaging. It is one of the key production facilities in the nation for radioisotopes which are crucial to clinical nuclear medicine. It also supports research on new diagnostic and therapeutic radiopharmaceuticals.

5. HEAVY ION TRANSFER LINE (HITL)

The HITL connects the Tandem Van de Graaff and the AGS Booster. This interconnection permits ions of intermediate mass to be injected into the AGS where they can be accelerated to an energy of 15 GeV. These ions then are extracted and sent to the AGS experimental area for physics research.

6. RADIATION THERAPY FACILITY (RTF)

Part of the Medical Research Center, the RTF is a high-energy dual x-ray mode linear accelerator for radiation therapy of cancer patients. This accelerator delivers therapeutically useful beams of x-rays and electrons for conventional and advanced medical radiotherapy techniques.

7. BROOKHAVEN MEDICAL RESEARCH REACTOR (BMRR)

The BMRR was the world's first nuclear reactor built exclusively for medical research applications and therapy. It produced neutrons in an optimal energy range for experimental treatment of a type of brain cancer known as glioblastoma multiforme. This reactor stopped operating in December 2000.

8. SCANNING TRANSMISSION ELECTRON MICROSCOPE (STEM)

This facility includes two microscopes, STEM 1 and STEM 3, used for biological research. Both devices allow scientists to see the intricate details of living things, from bacteria to human tissue.

9. NATIONAL SYNCHROTRON LIGHT SOURCE (NSLS)

The NSLS utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings which operate at energies of 750 MeV vacuum ultraviolet (VUV) and 2.5 GeV (x-ray). The synchrotron radiation produced by the stored electrons is used for VUV spectroscopy and x-ray diffraction studies.

10. HIGH FLUX BEAM REACTOR (HFBR)

The HFBR was one of the premier neutron physics research facilities in the world. Neutron beams produced at the HFBR were used to investigate the molecular structure of materials, which aided in pharmaceutical design and materials development as well as expanded the knowledge base of physics, chemistry, and biology. A leak in the fuel storage pool was discovered in 1997. Since that time, the HFBR has not been in operation and was permanently shut down in November 1999.

11. TANDEM VAN DE GRAAFF AND CYCLOTRON

These two facilities are used in medium-energy physics investigations and for producing special nuclides. The heavy ions from the Tandem Van de Graaff also can be injected into the AGS Booster for physics experiments.

12. BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)

No longer in operation, the BGRR was used for scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering.

Figure 1-2. Major Scientific Facilities at Brookhaven National Laboratory.

Figure 1-3. Major Laboratory Support and Service Facilities.

1.7 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 sole source aquifer system beneath Long Island. In times of sustained drought, the river water typically recharges to the groundwater; with normal to above-normal precipitation, the river receives water from the aquifer. In 2002, there was no flow of the Peconic River off site due to drought conditions

(see Chapter 5 for details on Peconic River sampling).

In general, the terrain of the BNL site is gently rolling, with elevations varying between 44 and 120 feet above mean sea level. Depth to groundwater from the surface of the land ranges from 5 feet near the Peconic River to about 80 feet in the higher elevations of the central and western portions of the site. The hydrology of the local area is well defined. Studies of Long Island hydrology and geology in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits, composed of highly permeable glacial sands and gravel, are between 120 and 250 feet thick (Warren et al. 1968, Scorca et al.

1999). Water penetrates these deposits readily and there is little direct runoff into surface streams unless precipitation is intense. These sandy deposits store large quantities of water called the Upper Glacial aquifer. On average, about half of the annual precipitation is lost to the atmosphere through evapotranspiration and the other half percolates through the soil to recharge the groundwater (Koppelman 1978). The area has a high average recharge rate (22 inches per year) that varies seasonally.

The Long Island Regional Planning Board and Suffolk County have identified the BNL site as overlying a deep-flow recharge zone for Long Island groundwater (Koppelman 1978, Suffolk County Department of Health Services 1987). Precipitation and surface water that recharge within this zone have the potential to replenish the deep Magothy and Lloyd aquifer systems lying below the Upper Glacial aquifer. Experts estimate that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. The extent to which groundwater at the BNL site contributes to deep flow recharge has been confirmed through the use of an extensive network of shallow and deep wells installed at BNL and surrounding areas (Geraghty and Miller 1996). This groundwater system is the primary source of drinking water for both on- and off-site private and public supply wells and, as such, has been designated a sole source aquifer system by EPA. BNL uses approximately 1.8 million gallons of groundwater per day to meet potable water needs and heating and cooling requirements. Approximately 60 percent of the water pumped from BNL supply wells is returned to the aquifer through on-site recharge basins. About 22 percent is discharged into the Peconic River. Human consumption, evaporation (cooling tower and wind losses), and sewer line losses account for the remaining 18 percent. An additional 3.6 million gallons of groundwater are pumped each day from remediation wells for treatment and then returned to the aquifer by way of recharge basins.

Groundwater flow direction across the BNL site is influenced by natural drainage systems moving eastward along the Peconic River, southeast toward the Forge River, and south toward the Carmans River (Figure 1-4). 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 BNL (Figure 1-4). Groundwater north of the divide flows northward and ultimately discharges to the Long Island Sound. Groundwater south of the divide flows southward and discharges to south shore streams, the Peconic River, Great South Bay, Peconic Bay, and the Atlantic Ocean. The regional groundwater flow system is discussed in greater detail in *Stratigraphy and Hydrologic Conditions* (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 and Miller 1996). In general, this means that groundwater travels for approximately 20 to 22 years as it moves from the central, developed area of the site to the BNL southern boundary.

1.8 CLIMATE

The Meteorological Group at BNL has been collecting meteorological data on site since 1949. The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall (Nagle 1975, 1978). Figure 1-5 shows the 2002 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 (90 meters).

The average annual snowfall for BNL is 29.6 inches. The winter of 2002 was particularly mild, with a total of 5.5 inches of snowfall, the second lowest seasonal snowfall recorded on site. The average annual precipitation for BNL is 48.36 inches. Although the summer of 2002 was mostly dry, the total precipitation of 52.07 inches was above average. This was due to more rainfall than usual from September through December. Figures 1-6 and 1-7 show the 2002 monthly and the 54-year annual precipitation data.

The average yearly temperature on site is 50.0°F. In general, 2002 was a warm year, with

Explanation: The arrows formed by the wedges indicate wind direction. Each concentric circle represents a 5% frequency, that is, how often the wind came from that direction. The wind direction was measured at heights of 10 and 90 meters. This diagram indicates that the predominant wind direction was from the south-southwest, at both levels.

Figure 1-5. Annual Wind Rose (2002).

an average temperature of 52.7°F, almost three degrees above average. One record-low daily temperature and fifteen record-high daily temperatures were recorded. On May 19, the temperature dipped to the freezing point. The most dramatic high temperature occurred on

January 29, when the temperature reached 69.5°F, which is 11.5°F higher than the previous record, set in 1974. On April 16, the temperature reached 89.5°F, also 11.5°F higher than the record, set in 1976. In general, using a linear average, temperatures at BNL have increased 2.05°F over the past 54 years, compared to a worldwide average surface temperature increase of 0.5°F over approximately the same time period (Jones et al. 1999). Figures 1-8 and 1-9 show the 2002 temperatures and the historical annual mean temperatures.

1.9 ECOLOGICAL RESOURCES

The BNL property is located in the oak/chestnut forest region of the Coastal Plain and constitutes about 5 percent of the 100,000-acre New York State-designated region known as the Central Pine Barrens. Part of the Peconic River, which runs through BNL, is designated “scenic” by the New York State Wild, Scenic, and Recreational River System Act (New York State 1972). As noted before, due to the general topography and porous soil, the land is very well drained and generally there is little surface runoff or open standing water. However, depressions form small, pocket wetlands with standing water on a seasonal basis (vernal pools), and there are six significant, regulated wetlands on site. Thus, a mosaic of wet and dry areas on the site 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. Portions were then cleared again in 1940 when Camp Upton was reactivated. Other past disturbances include fire, local flooding, and draining. Current operations minimize disturbances to the more natural areas of the site. More than 230 plant species have been identified on site, including the stiff goldenrod plant, a New York State threatened species.

The 15 mammal species identified at BNL include species common to mixed hardwood forests and open grassland habitats, and some New York State threatened, endangered, and species of special

Figure 1-6. 2002 Monthly Precipitation Versus 54-Year Monthly Average.

Figure 1-7. Annual Precipitation Trend (54 Years).

concern (see Chapter 6 for details). To eliminate or minimize any negative effects that Laboratory operations might cause, precautions are in place to protect the on-site habitat and natural resources. The white-tailed deer population changes from year to year, due to varying winter conditions and food supply. Estimates of the deer population began in

1966 and have fluctuated from a low of 85 deer per square mile in 1992 to a high of 236 per square mile in the winter of 2000–2001. In the winter of 2001–2002, the deer population was estimated at 135 per square mile. Other wildlife species of interest that inhabit the site include wild turkey, red fox, eastern box turtle, and red-tailed hawk. A

Figure 1-8. 2002 Monthly Mean Temperature Versus 54-Year Monthly Average.

Figure 1-9. Annual Mean Temperature Trend (54 Years).

discussion of the Laboratory's natural resource program can be found in Chapter 6.

At least 85 species of birds are known to nest at BNL, and more than 130 species have been documented as visiting the site. These numbers can be attributed to BNL's location in the Atlantic Flyway and to the scrub/shrub

habitats that offer food and rest to migratory songbirds. Open fields bordered by hardwood forests on site offer excellent hunting areas for birds such as hawks.

Permanently flooded retention basins and other watercourses support amphibians and aquatic reptiles. Nine amphibian and ten reptile

species have been identified on site, as well as nine species of fish. Ecological studies at BNL have confirmed 15 breeding sites for the New York State endangered eastern tiger salamander (*Ambystoma t. tigrinum*) in vernal pools and some recharge basins. In 1999, the New York State Department of Environmental Conservation listed the banded sunfish (*Etheostoma t. obesus*) as a threatened species. This species lives solely within the Peconic River system, including backwater areas of the river on site (Scheibel 1990). In 2000, the New York State threatened swamp darter fish (*Etheostoma fusiforme*) was positively identified on site in one of the larger ponds associated with the Peconic River.

A state threatened insect, the frosted elfin butterfly (*Callophrys irus*), was added to BNL's list of protected species in 2001 due to the presence of appropriate on-site habitat and reports of previous sightings. This small butterfly lays its eggs on lupine, where the caterpillars feed. In 2002, ecologists tried to confirm this butterfly's presence during its breeding season, but the attempt was unsuccessful.

In November 2000, DOE established the Upton Ecological and Research Reserve (Upton Reserve) at BNL (see Figure 1-1). DOE then entered into an Inter-Agency Agreement with the U.S. Fish and Wildlife Services (FWS) to manage the Upton Reserve. A technical advisory group (TAG) made up of local land management agencies was then formed to assist BNL and FWS with technical expertise and to provide input into decision making. The 530-acre reserve makes up 10 percent of the Laboratory's property and is located on the eastern portion of the site, within the Core Preservation Area of the Pine Barrens. This land creates a unique ecosystem of forests and wetlands that provide a habitat for more than 220 species of plants and 162 species of mammals, birds, reptiles, and amphibians, some of which are endangered, threatened, or of special concern. As part of its commitment to protecting the environmental assets of its sites, DOE is providing FWS with \$200,000 a year over a five-year period to conduct research and resource management programs for the conser-

vation, enhancement, and restoration of wildlife and habitat in the reserve. In 2002, this funding helped support activities in outreach, conservation, and habitat protection. Four grants, selected by the TAG, were also awarded to support Pine Barrens-related research. Details regarding these activities and the research grants can be found at <http://www.bnl.gov/esd/reserve/default.htm>. DOE, BNL, and FWS continue to work with neighbors of the reserve, environmental organizations, regulatory agencies, and other stakeholders to develop a comprehensive, ecosystem-based Natural Resource Management Plan for BNL and the reserve (see Chapter 6 for details).

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Environmental Management System

2

One of Brookhaven National Laboratory's highest priorities is ensuring that the Laboratory's environmental performance measures up to its world-class status in science. Brookhaven Science Associates, the contractor operating the Laboratory on behalf of the U.S. Department of Energy, takes environmental stewardship very seriously. As part of their commitment to environmentally responsible operations, they have established an Environmental Management System (EMS).

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

BNL's EMS became officially registered to the ISO 14001 standard in July 2001. Annual audits are required to maintain the registration. The audits are conducted by NSF-International Strategic Registrations, LTD, an accredited ISO 14001 registrar. The purpose of the audits is to validate that the EMS is being maintained and to identify evidence of continual improvement (a requirement of the ISO 140001 standard). In 2002, an EMS Surveillance audit determined that BNL remains in conformance with the ISO 14001 Standard. The audit identified one minor non-conformance, one opportunity for improvement, and strong evidence of continual improvement, including 12 noteworthy practices.

In 2002, BNL continued its strong support of the Pollution Prevention Program. This program seeks ways to eliminate waste and toxic materials and is the preferred approach to resolving environmental issues at BNL. Work planning processes incorporate the prevention approach, and benefits continue to accumulate. Pollution prevention projects saved more than \$1.5 million and resulted in the reduction or reuse of approximately 2.07 million pounds of waste during 2002. The ISO 14001-registered EMS and the nationally recognized Pollution Prevention Program both contributed to BNL being selected as one of five winners of the "Environmental Facility of the Year" award by Environmental Protection magazine. In selecting BNL, the magazine noted that the winners "used innovative approaches to protect the environment while simultaneously boosting their companies' bottom lines."

BNL continues to address legacy issues under the Environmental Restoration Program. The Laboratory is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and cleanup progress.

2.1 STEWARDSHIP UNDER BROOKHAVEN SCIENCE ASSOCIATES

The International Organization for Standardization's ISO 14001 is a globally recognized standard that defines the structure of an organization's environmental management system (EMS) for purposes of improving the organization's environmental performance. The process-based structure of ISO 14001 is based on the "Plan-Do-Check-Act" improvement cycle. The standard requires an organization to develop an environmental policy, create plans to implement the policy, implement the plans, check progress and take corrective actions, and review the system annually to ensure its continuing suitability, adequacy, and effectiveness. To gain registration to the standard, an organization must comply with the set of 17 ISO 14001 requirements that are listed and described in Table 2-1.

Brookhaven National Laboratory's EMS is officially registered to the ISO 14001 standard. The Laboratory's EMS was originally registered in July 2001, becoming the first Department of Energy Office of Science laboratory to obtain third-party registration to this globally recognized environmental standard. In order to achieve registration, the Laboratory underwent an independent audit of its environmental management system to verify that the system conformed to all ISO requirements and that it was effectively implemented. The certification also requires BNL to undergo annual audits by an accredited auditing firm to assure that the system is maintained.

In 2002, an EMS Surveillance audit determined that BNL remains in conformance with the ISO 14001 Standard. The audit identified one minor nonconformance, one opportunity for improvement, and strong evidence of continual improvement, including 12 noteworthy practices. In its recommendation for continued certification, NSF International Strategic Registrations, Ltd., an independent third-party environmental review firm from Ann Arbor, Michigan, singled out 14 aspects of BNL's program as being particularly noteworthy. These included BNL's comprehensive use of computer technology to help provide environmental guidance, the thoroughness of the Laboratory's experimental project reviews, and its systems for identifying environmental protec-

tion priorities and tracking issues. NSF reviewers also noted that BNL's environmental management system was the most thoroughly and systematically implemented program they had encountered to date. BNL's environmental management system received a DOE Pollution Prevention Award for "Excellence in Management," the first organization ever to receive this award.

2.2 ENVIRONMENTAL STEWARDSHIP POLICY

The cornerstone of an EMS is a commitment to environmental protection at the highest levels of the organization. The Environmental Stewardship Policy, issued and signed by the Laboratory Director, is a statement of BNL's intentions and principles regarding overall environmental performance. It provides a framework for planning and action and is included in training programs. The Environmental Stewardship Policy is posted throughout the Laboratory and on the BNL website: www.bnl.gov.

The Environmental Stewardship Policy contains the following goals and commitments, focusing on compliance, pollution prevention, cleanup, community outreach, and continual improvement:

- Achieve and maintain compliance with applicable environmental requirements. These requirements include more than 50 sets of local, state, and federal laws and regulations; 13 DOE Directives; eight Executive Orders; and numerous operating permits.
- Integrate pollution prevention/waste minimization, resource conservation, and compliance into BNL activities during planning and decision making. Adopt cost-effective practices that eliminate, minimize, or mitigate environmental impacts. This includes conserving natural resources and ensuring that environmental emissions, effluents, and waste generation are as low as reasonably achievable (ALARA).
- Define, prioritize, and aggressively correct and clean up existing environmental problems. This commitment encompasses removal or treatment of contamination caused by historical practices. It also includes strengthening the environmental monitoring program to ensure that controls designed to protect the environment are working, and to

Table 2-1. Elements of the Environmental Management System: Implementation of ISO 14001 at BNL.

Environmental Policy	The Environmental Stewardship Policy is a statement of BNL's intentions and principles regarding overall environmental performance. It provides a framework for planning and action. In the policy, BNL has reaffirmed its commitment to compliance, pollution prevention, cleanup, community outreach, and continual improvement.
Environmental Aspects and Impacts	<p>When operations have an environmental aspect, BNL implements the EMS to minimize or eliminate any potential impact. As required by the ISO 14001 Standard, BNL evaluates its operations, identifies the aspects of operations that can impact the environment, and determines which of those impacts are significant. BNL has determined that the following aspects of its operations have the potential to affect the environment:</p> <ul style="list-style-type: none"> ▪ Waste generation ▪ Atmospheric emissions ▪ Liquid effluents ▪ Storage or use of chemicals and radioactive materials ▪ Natural resource usage – power and water consumption ▪ Historical/cultural resources ▪ Environmental noise ▪ Disturbances to endangered species/protected habitats ▪ Soil activation ▪ Historical contamination ▪ Other facility-specific compliance aspects.
Legal and Other Requirements	BNL has implemented and continues to improve the Standards Based Management System (SBMS), a web-based system designed to deliver Laboratory-level requirements and guidance to all staff. New or revised requirements (e.g., new regulations) are analyzed to determine their applicability to the Laboratory, and to identify whether actions are required to achieve compliance. This may involve developing or revising Laboratory documents or operating procedures, implementing administrative controls, providing training, installing engineered controls, or increasing monitoring.
Objectives and Targets	<p>The Performance Based Management System is designed to develop, align, balance, and implement the Laboratory's strategic objectives, including environmental objectives. Objectives and targets are developed by Fiscal Year (FY). In FY 2002, they included:</p> <ul style="list-style-type: none"> ▪ Maintain and improve the Environmental Management System ▪ Achieve full compliance with applicable environmental requirements ▪ Invest in Pollution Prevention initiatives ▪ Improve communications, trust, and relationship with stakeholders on environmental programs ▪ Fully implement the groundwater protection program ▪ Ensure responsible stewardship of natural and historical resources on site.
Environmental Management Program	Organizations within BNL develop action plans detailing how they will achieve their objectives and targets, and commit the necessary resources to successfully implement both Labwide programs and facility-specific programs. BNL has a Pollution Prevention Program to conserve resources and minimize waste generation. BNL also has a budgeting system designed to ensure that priorities are balanced and that resources essential to the implementation and control of the EMS are provided.
Structure and Responsibility	All employees at BNL have specific roles and responsibilities in key areas including environmental protection. Environmental and waste management technical support personnel assist the line organizations with their environmental responsibilities. Every BNL employee is required to develop a Roles, Responsibilities, Accountabilities, and Authorities document signed by the employee, their supervisor, and the supervisor's manager. Specifics on environment, safety, and health performance expectations are included in these documents.
Training, Awareness and Competence	Extensive training on EMS requirements has been provided to staff whose responsibilities include environmental protection. The training program includes general environmental awareness for all employees, regulatory compliance training for select staff, and specific courses for managers, internal assessors, EMS implementation teams, and operations personnel whose work can impact the environment.
Communication and Community Involvement	BNL continues to improve processes for internal and external communications on environmental issues. The Laboratory solicits input from interested parties such as community members, activists, civic organizations, elected officials, and regulators. Communication is accomplished primarily through the Citizens Advisory Committee and/or the Brookhaven Executive Roundtable. At the core of the communication and community involvement programs are the Environmental Stewardship Policy and the Community Involvement Policy and Plan.

(continued on next page)

Table 2-1. Elements of the Environmental Management System: Implementation of ISO 14001 at BNL *(concluded)*.

EMS Documentation	BNL has comprehensive, up-to-date Laboratory-wide environmental documents describing the EMS. A web-based system called the Standards Based Management System (SBMS) provides access to Laboratory-wide procedures and manuals that tell staff how to control processes and perform work at BNL in a way that protects the environment. SBMS has improved the quality, usability, and communication of Laboratory-level requirements.
Document Control	SBMS contains a comprehensive document control system to ensure the effective management of procedural documents. When facilities require additional procedures to control their work, document control protocols are implemented to ensure that workers have access to the current versions of procedures.
Operational Control	Operations at the Laboratory are evaluated for the adequacy of current controls to prevent impacts to the environment. As needed, additional administrative or engineered controls are identified and plans for upgrades and improvements are developed and implemented.
Emergency Preparedness and Response	BNL has an emergency preparedness and response program and specialized staff to provide timely response to hazardous materials or other environmental emergencies. This program includes procedures for preventing, as well as responding to, emergencies.
Monitoring and Measurement	Effluent and emission monitoring helps ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL has a comprehensive, sitewide Environmental Monitoring Program. Results are reported to regulatory agencies and summarized annually in this Site Environmental Report. In addition, BNL tracks and trends its progress and performance in achieving environmental objectives and performance measures.
Nonconformance and Corrective and Preventive Actions	BNL continues to improve processes that identify and correct problems. This includes implementation of a Lessons Learned Program to prevent recurrences, a robust Self-Assessment Program, and an electronic, web-based assessment and action tracking system.
Records	EMS-related records, including audit and training records, are maintained to ensure integrity, facilitate retrieval, and protect them from loss.
EMS Audit	To periodically verify that the EMS is operating as intended, audits are conducted. These audits, conducted as part of the sitewide self-assessment program, are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. An independent accredited registrar also conducts ISO 14001 registration audits. In addition, compliance with regulatory requirements is verified through routine inspections, operational evaluations, and periodic audits.
Management Review	In addition to audits, a management review process has been established to involve top management in the overall assessment of environmental performance, the EMS, and progress toward achieving environmental goals. This review also identifies, as necessary, the need for changes to and continual improvement of the EMS.

provide early detection of a potential threat to the environment (see Section 2.4.3).

- Maintain a positive, proactive, and constructive relationship with neighbors in the community, regulators, DOE, and other stakeholders. Openly communicate with stakeholders about program planning, progress, and performance (see Section 2.4.2).
- Continually improve the environmental management system and performance. Establish appropriate environmental objectives and performance indicators to guide these efforts and measure our progress. To maintain certification, BNL will employ proactive measures to prevent problems. When problems do occur,

the approach is to investigate the root cause and take corrective actions as appropriate.

2.3 PLANNING

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

2.3.1 Environmental Aspects

An environmental aspect is any element of an organization's activities, products, or services than can interact with the environment. As re-

quired by the ISO 14001 Standard, BNL evaluates its operations, identifies the aspects of operations that can impact the environment, and determines which of those impacts are significant. BNL's criteria for significance are based on both actual and perceived impacts of its operations and on regulatory requirements. BNL utilizes several processes to identify and review environmental aspects. Key among these processes is the Work Planning and Control process, which was revised in 2002. Environmental professionals worked closely with the revision team to ensure that environmental requirements were integrated into the process. Aspects and impacts are evaluated annually to ensure that the significant aspects and potential impacts continue to reflect the concerns of stakeholders and changes in regulatory requirements. BNL's list of aspects and significance criteria remained unchanged in 2002.

2.3.2 Legal and Other Requirements

To implement the compliance commitments of the Environmental Stewardship Policy and to meet its legal requirements, BNL has systems in place to review changes in federal, state, or local environmental regulations and communicate those changes to affected staff. A published procedure, the *Requirements Management* subject area, is used to document these reviews and record the actions required to ensure compliance. (Requirements are delivered to all staff through the web-based Standards Based Management System in the form of Laboratory-wide procedures, called "subject areas.")

2.3.3 Objective and Targets

The establishment of environmental objectives and targets is accomplished through the 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 critical outcomes. BNL works with DOE to clearly define expectations and performance measures. Factors for selecting environmental priorities include:

- Significant environmental aspects

- Risk and vulnerability (primarily, threat to the environment)
- Legal requirements (laws, regulations, permits, enforcement actions)
- Commitments (in the Environmental Stewardship Policy, to regulatory agencies, to the public)
- Importance to DOE, the public, and other stakeholders.

Laboratory-level objectives and targets are developed on a Fiscal Year (FY) schedule. In FY 2002 (October 1, 2001 through September 30, 2002), these objectives included:

- Maintain and improve the Environmental Management System
- Achieve full compliance with applicable environmental requirements
- Invest in pollution prevention initiatives
- Improve communications, trust, and relationships with stakeholders on environmental programs
- Fully implement the groundwater protection program
- Ensure responsible stewardship of natural and historical resources on site.

2.3.4 Environmental Management Programs

Organizations within BNL develop action plans detailing how they will achieve their objectives and targets and commit the necessary resources to successfully implement both Laboratory-wide and facility-specific programs. BNL has a budgeting system designed to ensure that priorities are balanced, and that resources essential to the implementation and control of the EMS are provided.

BNL has several important environmental programs developed and funded to further integrate environmental stewardship into all facets of BNL's missions. The key programs are described below.

2.3.4.1 Compliance

BNL has an extensive program to ensure full compliance with all applicable environmental regulatory requirements and permits. Some programs are routine, such as the National Emission Standards for Hazardous Air Pollutants, National Pollutant Discharge Elimination System, and Re-

source Conservation and Recovery Act (RCRA) compliance programs. Other programs are special projects or initiatives, such as upgrading petroleum and chemical storage tank facilities, upgrading the sanitary sewer system, closing underground injection control devices, retrofitting or replacing air conditioning equipment refrigerants, and managing legacy waste. See Chapter 3 for a thorough discussion of these programs and their status.

2.3.4.2 Groundwater Protection

BNL's Groundwater Protection Management Program is designed to prevent impacts to groundwater and to restore groundwater quality by integrating pollution prevention efforts, monitoring groundwater restoration projects, and communicating on performance. BNL has also developed a Groundwater Protection Contingency Plan that defines an orderly process for taking corrective actions quickly in response to unexpected monitoring results. Key elements of the groundwater program are the full and timely disclosure of any off-normal circumstances and regular communication on the performance of the program. Chapter 7 provides additional details about the Groundwater Protection Management Program and monitoring results for 2002.

2.3.4.3 Waste Management

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

The Waste Management Division is responsible for the collection, transportation, storage, and off-site disposal of site-generated wastes. Wastes are managed at a state-of-the-art facility designed especially for managing hazardous, industrial, radioactive, and mixed wastes.

The Waste Management Facility complex is comprised of three-staging areas: a facility for hazardous wastes, regulated by RCRA; a mixed-

waste building for wastes that are both hazardous and radioactive; and a reclamation building for radioactive waste. The RCRA and mixed-waste buildings are managed under a permit issued by the New York State Department of Environmental Conservation (NYSDEC). These buildings are utilized for short-term storage of wastes before they are packaged or consolidated for off-site shipment to permitted treatment and disposal facilities. In 2002, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 6.9 tons
- Mixed waste: 141 cubic feet
- Radioactive waste: 6,613 cubic feet.

These quantities represent significant reductions from previous years, as shown in Figures 2-1a through c. Routine operations are defined as ongoing industrial and experimental operations. The picture is not complete however, without consideration of wastes generated from "nonroutine" or one-time events and waste generated from environmental restoration activities. BNL is currently cleaning up facilities and areas containing radioactive and chemical contamination resulting from historical operations. Waste recovered through restoration and decommissioning activities is managed by the Environmental Restoration (ER) group with oversight by BNL's Waste Management Division. Nonroutine waste includes construction and demolition wastes, environmental restoration wastes, legacy waste, lead-painted debris, lead shielding, and PCB waste. Figures 2-1d through 2-1f show wastes generated under the Environmental Restoration Program and nonroutine operations. Waste generation from these activities varies significantly from year to year. This is to be expected as environmental restoration activities move from remedial investigations and feasibility studies to remedial actions, which change annually based on the progress of the cleanup schedule.

2.3.4.4 Prevention and Minimization

Brookhaven National Laboratory's broad mission is to produce excellent science in a safe, environmentally responsible manner with the co-operation, support, and appropriate involvement

Figure 2-1a.
Hazardous Waste Generation from
Routine Operations, 1993–2002.

Figure 2-1b.
Mixed Waste Generation from Routine
Operations, 1993–2002.

Figure 2-1c.
Radioactive Waste Generation from
Routine Operations, 1993–2002.

Figure 2-1d.
Hazardous Waste Generation
from ER and Nonroutine
Operations, 1997–2002.

Figure 2-1e.
Mixed Waste Generation
from ER and Nonroutine
Operations, 1997–2002.

Figure 2-1f.
Radioactive Waste Generation
from ER and Nonroutine
Operations, 1997–2002.

of the scientific and local communities. A strong Pollution Prevention (P2) Program is an essential element of successful accomplishment of this mission. The BNL P2 Program reflects the national and Department of Energy pollution prevention goals and policies and represents an ongoing effort to make pollution prevention and waste minimization an integral part of the BNL operating philosophy.

DOE has incorporated pollution prevention and waste reduction goals into Brookhaven Science Associates (BSA's) contract. BSA, in recognition of its environmental stewardship responsibilities, potential for cost savings, and stakeholder concerns, has incorporated pollution prevention elements into the BNL Environmental Stewardship Policy and the Critical Outcomes. Key elements of the P2 Program include the following:

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

Proposals for funding pollution prevention opportunities are submitted to the BNL P2 Council. In January 2002, the P2 Council announced the winners of the "Return on Investment" funding competition. In FY02, the P2 Council funded eight proposals, investing a total of approximately \$120,000. The savings generated by the projects

is estimated at \$268,000, for an average payback period of only five months.

The sustained efforts of the BNL Pollution Prevention and recycling programs have achieved significant reductions in waste generated by routine operations, as shown in Figures 2-1a through 2-1c. This continues a positive trend started in FY01, and is further evidence that pollution prevention planning is well integrated into the work planning process. These positive trends are also driven by the ISO 14001 EMS's emphasis on preventing pollution and establishing objectives and targets to reduce environmental impact.

Implementation of pollution prevention opportunities, recycling programs, and conservation initiatives has significantly reduced both waste volumes and management costs. In 2002 alone, these efforts resulted in more than \$1.5 million in cost avoidance or savings and approximately 2.074 million pounds of materials being reduced, recycled, or reused. Table 2-2 describes the projects that were implemented in 2002 and includes the number of pounds of materials reduced, reused, or recycled and the estimated cost benefit of each project.

BNL also has an active and successful solid waste recycling program. The on-site recycling program involves all employees. In 2002, BNL collected more than 209 tons of paper for recycling. In addition to paper, the recycling program collects many other kinds of materials, including cardboard, bottles and cans, construction debris, motor oil, scrap metals, lead, automotive batteries, printer and toner cartridges, fluorescent light bulbs, machine coolant, and antifreeze. Table 2-3 shows the total number of tons (or units) of these materials recycled in 2002.

2.3.4.5 Water Conservation

BNL has a strong water conservation program and has achieved dramatic reductions in water use since the mid 1990s. The Laboratory continuously 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 systems, and reuse of once-through cooling water for

Table 2-2. Waste Reduction and Recycling Projects.

Waste Description	Project Type	Pounds Reduced, Reused, Recycled, or Conserved in 2002	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details*
Electrophoretic mini-gels	Microscale Chemical Use	2,200	Hazardous Waste - Lab Pack	\$10,400	\$1,670	\$8,730	Minimizing silver waste from silver-staining electrophoretic mini-gels will avoid waste disposal costs and result in lower material costs (\$6,000).
Hydraulic oil	Product Substitution	1,000	Industrial	\$17,000	\$7,500	\$9,500	The retrofit of garbage truck hydraulics with steel-braided hydraulic lines and a vegetable-based hydraulic oil will reduce the number of reportable spills, as well as associated cleanup costs (\$15,000).
Hydraulic oil	Product Substitution	3,000	Industrial	\$26,000	\$8,000	\$18,000	The retrofit of hydraulic lift bays in the Motor Pool Shop to vegetable-based oil minimized the potential for petroleum-based hydraulic oil leaks or spills and subsequent cleanup costs (\$20,000).
Sewage sludge	Volume Reduction	234,000	Radioactive	\$910,000	\$193,400	\$716,600	Disposing of 60,000 gallons of radioactive STP liquid waste through a contractor would have cost \$910,000. Instead, the waste was dried using rollofs, absorbent, and lime and was sent away on rail cars for proper disposal. Also, a second drying bed was built to dry sludge (96% volume reduction) from the anaerobic sludge digester.
CO ₂ snow cleaning	Source Reduction	0	Hazardous/Industrial	\$5,000	\$5,000	\$0	Equipment was purchased to evaluate CO ₂ snow cleaning for NSLS instrumentation and CAD applications. This project is expected to reduce solvent usage (hazardous waste) and aqueous cleaning wastes (industrial waste). Due to a late purchase date, the equipment was not evaluated during this calendar year.
Film and other radioisotopic imaging	Substitution	300	Hazardous/Industrial	\$22,000	\$25,000	-\$3,000	Replacing the film-based autoradiography and other radioisotopic imaging with a Phosphor Imager reduced the generation of hazardous waste by 200 lb and industrial waste by 100 lb. Additional projected annual savings are \$3,000 for supply costs and \$15,000 for labor reduction.
Digital imaging system	Substitution	282	Hazardous/Radioactive/Industrial	\$25,000	\$25,000	\$0	Using a digital imaging system rather than traditional technology reduced hazardous waste (134 lb), radioactive waste (80 lb), and industrial waste (68 lb). Additional projected savings are annual supply costs of \$3,000 and reduced annual labor costs of \$20,000.
Fluorescence-based assay	Substitution	200	Mixed	\$30,550	\$22,000	\$8,550	Development of a fluorescence-based assay for the DNA-dependent protein kinase (DNA-PKcs) to replace current ³² P assay.

Table 2-2. Waste Reduction and Recycling Projects (continued).

Waste Description	Project Type	Pounds Reduced, Reused, Recycled, or Conserved in 2002	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details*
Photographic waste	Segregation	2,320	Hazardous	\$4,640	\$0	\$4,640	In 2001, the Photography and Graphic Arts Division implemented a pollution prevention project to segregate hazardous fixer from nonhazardous developer. This reduced the hazardous waste stream by approximately 2,320 lb per year.
Photographic waste from X-ray film processor	Source Reduction	765	Hazardous	\$3,115	\$0	\$3,115	In 2001, the X-ray film processor at the clinic was replaced with a more efficient processor, reducing hazardous waste generation by 90 gal/year. This avoids the cost of disposal (765 lb) and saves \$1,585 in reduced labor costs.
Photobresist waste	Source Reduction	500	Hazardous	\$1,000	\$0	\$1,000	In 2001, a fully aqueous developer solution was installed in the printed circuit laboratory for processing dry film photoresist. The system replaced a solvent-based process that formerly generated approximately 500 lb of hazardous waste annually.
Heavy metal solutions from	Source Reduction	10,200	Hazardous	\$26,400	\$0	\$26,400	With funding from the Pollution Prevention Council, in 2001 a xenon pressure cell was installed to allow preparation of samples for protein crystallography without the use of toxic heavy metal solutions. The project is estimated to eliminate 1,200 gallons of heavy metal hazardous waste (10,200 lb). Additionally, approximately \$6,000 savings is expected from reduced labor and handling.
Lead acid batteries	Recycled	12,600	Hazardous	\$25,200	\$0	\$25,200	Estimate 40 lb per battery and avoided disposal costs as hazardous waste.
Ion exchange wastewater	Source Reduction	1,250	Hazardous and Sanitary Wastewater	\$2,500	\$100	\$2,400	Prefilters were added to the deionization system to polish make-up water entering the ion exchange system. This extended the useful life of the ion exchange resins, requiring less frequent regeneration. The regeneration process generates hazardous and sanitary wastewaters.
Smoke Detectors	Source Reduction	120	Mixed	\$1,050	\$400	\$650	Forty americium and/or radium smoke detectors were removed from service and returned to the manufacturer. They were replaced with energy-efficient nonrad photoelectric units. This project avoided disposal as mixed waste (5 ft ³).

Table 2-2. Waste Reduction and Recycling Projects (continued).

Waste Description	Project Type	Pounds Reduced, Reused, Recycled, or Conserved in 2002	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details*
Tritium Exit signs	Source Reduction	112	Mixed	\$14,700	\$6,000	\$8,700	Twenty-eight tritium Exit signs were removed from service and returned to the manufacturer. They were replaced with energy-efficient light emitting diode (LED) signs. This project reduced the risk of tritium gas release and avoided disposal of discarded signs as mixed waste (70 ft ³).
Cooling water	Reuse	153,000	Radioactive	\$153,000	\$0	\$153,000	Approximately 18,000 gal (153,000 lb) of cooling water were reused in the main magnet cooling water system, avoiding disposal as radioactive waste water.
Short half-life waste	Decay in Storage	3,950	Radioactive	\$1,575	\$0	\$1,575	Short half-life isotopes, particularly phosphorus-32 and phosphorus-33, are frequently used in life sciences experiments. Wastes generated from these operations (63 ft ³) were managed in accordance with BNL decay-in-storage requirements, rendering the wastes eligible for volumetric release.
Filters	Decay in Storage	1,920	Radioactive	\$6,250	\$0	\$2,410	Filters from the air handlers in the Linear Accelerator facility become contaminated with beryllium-7, a short-lived isotope eligible for decay. The filters were managed in accordance with the decay-in-storage requirements, surveyed, and declared releasable as industrial waste.
Oily waste water	Source Reduction	6,240	Industrial	\$20,280	\$0	\$20,280	In 2001, the Pollution Prevention Council funded the installation of automatic oil-water separators on compressor blowdown stations to capture the oily discharge and save disposal and labor costs. Labor savings are estimated at \$7,800/yr.
Lubricating oil	Energy Recovery	38,400	Industrial	\$76,800	\$500	\$78,700	Approximately 4,800 gallons of lubricating oils were collected, tested for suitable use as waste oil fuel, and used for energy production at the Central Steam Facility, eliminating waste disposal costs. The cost of analysis is estimated at \$500. Procurement savings are \$.50/gallon.
Cooling tower chemicals	Source Reduction	6,375	Industrial	\$15,000	\$0	\$15,000	Ozone water treatment units were installed on cooling towers at two RHIC experiments to provide biological control of cooling water. These systems eliminate the need for water treatment chemicals (typically toxic biocides), save labor, and reduce analytical costs for monitoring cooling tower blowdown. Savings are estimated at \$15,000/year.

Table 2-2. Waste Reduction and Recycling Projects (continued).

Waste Description	Project Type	Pounds Reduced, Reused, Recycled, or Conserved in 2002	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details*
Hydraulic oil	Source Reduction	6,000	Industrial	\$33,000	\$0	\$33,000	In past years, hydraulic line breaks have caused a significant number of reportable spills and costly response and cleanup. This project, funded in 2001 by the Pollution Prevention Council, replaced hydraulic lines on heavy equipment with steel-braided lines, and replaced the petroleum-based hydraulic oil with vegetable oil, which biodegrades and is subject to fewer reporting requirements if it does spill. This project reduced the frequency of spills and resulting response and cleanup costs. Avoided disposal costs are based on 6,000 lb of industrial waste. Estimated savings from reduced response and cleanup costs are \$33,000.
Emergency generator	Reuse	0	Recycle/Reuse	\$0	\$2,686	\$24,000	A generator was obtained from DOE Fluor-Fenol through the DOE Materials Exchange Service. The cost shown was the fee to transport the generator from Ohio.
Brokk model 250	Reuse	0	Recycle/Reuse	\$0	\$1,000	\$80,000	A remotely operated hydraulic excavator from DOE Princeton Plasma Laboratory was obtained through the DOE Materials Exchange Service. The \$1,000 was the transportation cost from New Jersey.
Blasocut coolant machining	Recycled/Reused	65,440	Industrial	\$130,880	\$0	\$143,180	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it labwide. Recycling involves aeration, centrifuge, and filtration. The cost of this recycling program is offset by savings in procurement and labor (dilution for use). In 2002, BNL recycled 8,180 gal (65,440 lb) of Blasocut lubricant. This avoided the cost of disposal as industrial waste and the cost for six drums of concentrate (\$4,800) and 150 empty drums for waste (\$7,500).
Used motor oil	Energy Recovery	37,240	Industrial	\$79,230	\$0	\$79,230	Used motor oil from the motor pool and the on-site gas station is picked up by Strebel's Laundry Service and used to fire their waste oil dryers. During calendar year 2002, 4,655 gallons of oil were picked up, avoiding the cost of disposal and 95 drums for shipping (\$50/drum).
Office paper	Recycled	418,200	Sanitary	\$16,728	\$0	\$16,728	Estimate \$80/ton for disposal as trash.
Cardboard	Recycled	314,480	Sanitary	\$12,579	\$0	\$12,579	Estimate \$80/ton for disposal as trash.

Table 2-2. Waste Reduction and Recycling Projects (continued).

Waste Description	Project Type	Pounds Reduced, Reused, Recycled, or Conserved in 2002	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details*
Scrap metal	Recycled	88,000	Sanitary	\$3,520	\$0	\$3,520	Estimate \$80/ton for disposal as trash.
Bottles/cans	Recycled	58,600	Sanitary	\$2,344	\$0	\$2,344	Estimate \$80/ton for disposal as trash.
Construction debris	Recycled	607,160	Sanitary	\$7,590	\$0	\$7,590	Estimate \$25/ton for disposal as trash.
TOTALS		2,073,854		\$1,683,331	\$298,256	\$1,503,621	

* Cost savings of projects funded by the BNL Pollution Prevention Council will be carried on the tracking system for three years.

other systems such as cooling towers. The goal is to reduce the consumption of potable water and reduce the possible impacts of clean water discharges on Sewage Treatment Plant operations. Figure 2-2 shows the eight-year trend of water consumption. The total annual reduction in 2002 compared with 1995 is approximately 700 million gallons.

2.3.4.6 Energy Management and Conservation

BNL's Energy Management Group has been in place since 1979. This group works to reduce BNL's energy use and costs by identifying cost-effective, energy efficient projects, by monitoring energy use and utility bills, and by assisting in obtaining the least expensive energy sources possible. The group is responsible for developing, implementing, and coordinating BNL's Energy Management Plan.

BNL has more than 4 million square feet of building space. Many BNL scientific experiments use particle beams generated and accelerated by electricity, with the particles controlled and aligned by large electromagnets. In 2002, BNL used approximately 278 million kWh of electricity, 2.7 million gallons of fuel oil and propane, and 273 thousand cubic feet of natural gas. (Fuel oil and natural gas produce steam at the Central Steam Facility.)

Natural gas use started in 1997 and is reducing the need for fuel oil. Using natural gas reduced emissions, saved energy, and lowered costs (see additional information on fuel use in Chapter 4). BNL is a participant in the Long Island Power Authority's (LIPA) Peak Load Reduction Curtailment Program. The Laboratory has agreed to reduce electrical demand during critical days throughout the summer when LIPA expects customer demand to meet or exceed the company's available supply. In return, BNL receives a rebate for each megawatt reduced for each critical day. The Laboratory's participation is significant to LIPA. BNL's portion represents more than 12 percent of the 95-megawatt load-curtailement program total, making the Laboratory the single largest program contributor.

In 2002, several energy-related projects and initiatives were completed. These included a project to eliminate once-through cooling water use in Building 902 that saves substantial potable water, fuel purchasing strategies that saved nearly \$6 million, and the connection of Building 911A to the central chilled water system, eliminating the need for two large, outdated chlorofluorocarbon (CFC) chillers. During 2002, work began on a project that will provide a solar heating system for BNL's swimming pool and the installation of a cover to reduce heat loss. BNL also received \$235,000 for new energy conservation projects and studies, including a new compressed air drying system at the Central Chilled Water Facility that will save nearly 30 percent of the energy currently used to produce compressed air.

Table 2-3. Recycling Program Summary.

Recycled Material	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Mixed paper	155	136	197	220	106	196	204	370	336	246	209
Cardboard	21	81	164	85	101	103	97	124	132	127	157
Bottles/Cans	12	12	18	11	15	21	22	21	20	29	19
Tires	9	21	7	11	17	18.6	11.5	15.2	0	0	3.5
Construction debris	809	495	495	627	837	799	527	352	243	289	304
Used motor oil (gallons)	—	—	4,000	3,350	4,275	4,600	3,810	3,570	3,295	3,335	1,920
Metals	201	210	33	153	158	266	64	47	534	38	48
Lead	—	—	—	—	—	4.4	3.7	0.7	2.5	0	0
Automotive batteries	—	5	0.81	0.72	6.8	4.3	2.1	1.1	2.2	4.8	6.3
Printer/Toner cartridges (units)	—	—	—	—	—	—	1,480/175	1,575/510	n/a	363	449
Fluorescent bulbs (units)	—	—	—	—	13,664	12,846	867	25,291	5,874	17,112	25,067
Blasocut coolant (gallons)	—	—	—	—	—	—	—	3,575	7,500	10,660	8,180
Antifreeze (gallons)	—	—	—	—	55	276	448	145	110	200	0
Tritium Exit signs (each)	—	—	—	—	—	—	—	—	185	190	28
Smoke detectors	—	—	—	—	—	—	—	—	—	171	40

Notes:

All units are tons unless otherwise noted.

— Denotes either not recycled in that year or data not available.

The National Energy Conservation Policy Act, as amended by the Federal Energy Management Improvement Act of 1988 and the Energy Policy Act of 1992, requires federal agencies to apply energy conservation measures and improve federal building design to reduce energy consumption per square foot. Current goals are to reduce energy consumption per square foot, relative to 1985, by 20 percent in 2000, 30 percent

by 2005, and 35 percent by 2010. BNL energy use per square foot in 2002 is 28 percent less than in 1985 (see Figure 2-3).

BNL's Energy Management Group continued their assistance with a demonstration and test of microturbines at the Laboratory in 2002. In cooperation with Keyspan Energy and the Energy Sciences and Technology Department and with financial assistance from the Federal Energy

Figure 2-2. Water Consumption Trend.

Figure 2-3. Building Energy Performance Since 1985.

Management Program, two microturbines were installed at the Laboratory as part of DOE's strategic effort to develop alternatives to large-scale power plants. BNL continues to maintain a contract with New York Power Authority, resulting in an overall cost avoidance of \$15 million. BNL will continue to seek out alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs.

2.3.4.7 Natural and Cultural Resource Management

The Laboratory continues to develop, enhance, and implement its Natural Resource Program, building on a foundation established by the Wildlife Management Plan. BNL has begun to develop a Cultural Resource Management Program to identify and manage properties that are determined to be eligible or potentially eligible for inclusion on the National Register of Historic Places. For more information about these programs, see Chapter 6.

2.3.4.8 Environmental Restoration

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress on December 11, 1980. As part of CERCLA, EPA established the

National Priorities List (NPL), which is a list of sites nationwide where cleanup of past contamination is required. BNL is listed on the NPL with 32 other Long Island sites (16 in Suffolk County—see <http://www.epa.gov/superfund/sites/npl/ny.htm>).

Each step of the Superfund cleanup process is reviewed and approved by DOE, the U.S. Environmental Protection Agency (EPA) and NYSDEC, under a contract called the "Inter-agency Agreement." This agreement was formalized in 1992. Most of the contamination at BNL 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 list and evaluate remedial action alternatives and present the proposed alternative.
- Issue a Record of Decision (the remedy/corrective action agreed to by DOE, EPA, and NYSDEC).
- Perform the Remedial Design/Remedial Action, which includes final design, construc-

Table 2-4. Summary of 2002 Environmental Restoration Activities.

Cleanup Project	Operable Unit/ Description	Environmental Restoration Program Actions
Soil Projects	OU I OU II OUVII	<ul style="list-style-type: none"> Boneyard project disposed of 1.3 million pounds of waste at Envirocare of Utah, an off-site LLW facility. Completed remediation and restoration of the Building 650 Sump and Sump Outfall soils (AOC 6). Sorted 6,800 cubic yards of soil and disposed of 700 cubic yards of soil from the Chemical Holes project at Envirocare of Utah. Remedial Action Work Plans for the Ash Pit and Meadow Marsh were submitted to regulators. <i>Phase 2 Landfill 5-Year Review Report</i> and <i>Annual Landfill Report</i> were submitted to regulators.
Groundwater Projects	OU III	<ul style="list-style-type: none"> Completed construction and began routine operations of on-site groundwater treatment system at the Western South Boundary for volatile organic compounds (VOCs). Began construction of an on-site groundwater treatment system Pilot Study for Sr-90 at the Chemical Holes. Continued installation of temporary and permanent monitoring wells for the HFBR tritium plume. Continued characterization and monitoring of tritium in the groundwater from the g-2 activated soil. Further preparation and review of the Engineering Evaluation and Cost Analysis was postponed pending collection of additional data. (This is not included under any specific OU at this time but it is an AOC.) During 2002, 1.3 million gallons of groundwater were treated and 720 pounds of volatile organics were removed. Since the first groundwater treatment system started operating in December 1996, approximately 3,662 pounds of volatile organic compounds have been removed from more than 5.5 billion gallons of groundwater. Completed pre-design characterization and designed five groundwater treatment systems to be installed south of BNL in East Yaphank and Manorville. Significant effort was focused on trying to obtain access to several properties south of BNL for the installation and operation of the planned groundwater treatment systems. Completed characterization of the Magothy Aquifer and submitted a draft Summary Report to the regulators for review.
	OU IV	<ul style="list-style-type: none"> A petition for system closure was submitted to the regulators for review of the OU IV air sparge and soil vapor extraction soil and groundwater treatment system. The system remains on stand-by. A draft <i>Five-Year Review Report for OU IV</i> was submitted to the regulators for review. Continued groundwater monitoring.
	OU VI	<ul style="list-style-type: none"> Continued monitoring of the EDB plume. Completed pre-design characterization and designed the groundwater treatment system to be installed south of BNL in Manorville.
	Groundwater Monitoring	<ul style="list-style-type: none"> Completed the <i>BNL 2001 Groundwater Status Report</i>. Collected and analyzed 2,065 groundwater samples from 615 monitoring wells. Issued the <i>Environmental Monitoring Plan, 2002 Update</i> that reflects implementation of the data quality objectives.
Peconic River	OU V	<ul style="list-style-type: none"> Initiated remedial action for the removal of contaminated soil from the Sewage Treatment Plant sand filter beds, berms, and sludge drying beds. Approximately 450 cubic yards of soil were shipped to Envirocare. Constructed a sediment trap near the BNL southeast boundary to minimize off-site flow of suspended material into the Peconic River. Conducted two pilot studies for evaluation of contaminated sediment removal and wetland restoration techniques along the Peconic River. Conducted baseline human health risk assessment for Peconic River. Prepared a revised Feasibility Study for the Peconic River.
Reactors	BGRR	<ul style="list-style-type: none"> The Below Ground Duct Cooler was removed. The cooler waste was sent Envirocare of Utah. The Above Ground Duct was removed. Sections of concrete duct were size-reduced to meet transportation and disposal site criteria. All duct sections were shipped and buried at Envirocare of Utah in 2002. The Below Ground Duct and associated soils were characterized in accordance with an approved Sampling and Analysis Plan. The characterization data were analyzed as part of the overall BGRR risk assessment and end state determination.
	HFBR	<ul style="list-style-type: none"> Completed the removal of all nine beam plugs from the Biological Shield. Completed the Preliminary Assessment/Site Investigation Sampling Plan. Successfully transferred experimental equipment for re-use to other sites. Equipment included: 60,000 lb Hot Cell to MIT, two 6,000-gallon LN2 tanks to CAD, and other shipments to the NIST reactor and other universities. Shipped 24 shield blocks to Hanford for disposal. Developed scope, cost, and schedules for five HFBR end-state alternatives ranging from No Action to Greenfields.

- tion specifications, and carrying out the remedy selected.
- The BNL site was initially divided into seven Operable Units (OUs), two of which were later combined to form OU II/VII. Significant progress was made in environmental restoration in 2002. Table 2-4 provides a description of each OU and a summary of environmental restoration actions taken during 2002. The goal of BNL's Environmental Restoration Program is to complete cleanup activities and install all groundwater treatment systems by 2006.

2.3.4.9 The Facility Review Project

The Facility Review Project was a comprehensive examination of all site facilities, existing or demolished, to identify any past or current activities with the potential to degrade the environment. During this project, BNL reviewed the entire operating history of the site and more than 900 systems, facilities, and operations including tanks, pipes, sumps, cesspools, storage areas, historical discharges, and current and past operating practices. Twenty-eight individuals from 15 other DOE facilities provided high-level technical and management support during the review. A final report was issued on October 7, 1998 (BNL 1998b).

The report identified 75 issues as having the highest priority due to the potential to contaminate groundwater above drinking water standards. Additionally, more than 1,675 issues that had the potential to impact the environment were identified as needing further evaluation. These were further subdivided into operational and

legacy issues. In March 2000, the Facility Review Disposition Project Plan (BNL 2000a) was approved. This three-year project provides the mechanisms needed to rank risk, to schedule, and to resolve the issues identified during the Facility Review Project.

In 2002, significant progress was made to disposition the remaining open operational and legacy issues. Of the original 1,675 issues identified as having the potential to impact the environment, only 36 legacy issues remain open. All other issues were either closed (1,639 issues) because they require no further action, or their management was transferred (332 issues) to an existing program or project. See Table 2-5 for a breakdown of the number of issues and their status.

A Final Report for the Facility Review Disposition Project (FRDP) will be prepared in 2003 and will describe the methods and processes used to disposition all issues identified during the FRDP. In addition, a FRDP Follow-up Project Plan will be developed which will address the disposition of the final 36 legacy issues, as well as tracking the ultimate disposition of all transferred issues.

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. Every BNL employee is required to develop a Roles, Responsibilities, Accountabilities, and Authorities document signed by the employee, their supervisor, and the

Table 2-5. Issues Identified in the Facility Review Project, as of December 31, 2002.

Category	Rank/Type of Issue	Number	Dispositioned	% Dispositioned
Operational Issues (Responsible organization exists); 1,175 issues needed further evaluation	Rank 1–3: Potential to impact groundwater, but not above drinking water standards	176	176	100%
	Rank 4–6: Lower priority, requiring engineering controls or documentation	999	999	100%
Legacy Issues (Responsible organization defunct); 500 issues needed further evaluation	Rank 1–3: Potential to impact groundwater, but not above drinking water standards	212	202	95%
	Rank 4–6: Lower priority, requiring engineering controls or documentation	288	263	91%
Total		1,675	1,639	98%

supervisor's manager. Specifics on environment, safety, and health performance expectations are included in this document.

BSA has clearly defined expectations for staff and management. Under the BSA performance based management model, senior management has communicated their expectation that all line managers and staff take full responsibility and be held accountable for environmental, safety, and health performance. Environmental and waste management technical support personnel assist the line organizations with their environmental responsibilities. The Environmental Compliance Representative program, initiated in 1998, continues to be well received and is an effective means of integrating environmental planning and pollution prevention into the work planning processes of the line organizations. A comprehensive training program for staff, visiting scientists, and contractor personnel is in place, thus ensuring that all personnel are aware of their environmental responsibilities.

2.4.2 Communication and Community Involvement

When BSA was awarded the contract to manage BNL in 1998, they made a commitment to establish an effective partnership between DOE, the Laboratory, and a full range of community members to address issues that affect quality of life in the community. At the core of the communication and community involvement programs are the Environmental Stewardship Policy and the Community Involvement Policy and Plan (available at <http://www.bnl.gov/community/>).

The Environmental Stewardship Policy contains a commitment to maintain a positive, proactive, and constructive relationship with the community and regulators, and to promote open communication on environmental performance. The Community Involvement Policy and Plan was written with input from both internal and external stakeholders; it documents BSA's efforts to ensure that the public will be kept informed of issues; that the Laboratory will actively seek and consider input from regulators, stakeholders, and the general public; and that opportunities will continue to be provided for an open, two-way exchange of information, knowledge, and perspectives.

The Laboratory continues efforts to improve working relationships with regulatory agencies by sharing information and working to resolve issues on plans, priorities, and corrective actions that are important to the regulators. BNL meets regularly with regulators from NYSDEC, EPA Region II, and the Suffolk County Department of Health Services. Suffolk County inspectors have a permanent office on site.

Another forum for communication is the Brookhaven Executive Roundtable, which was established by DOE in August 1997. The Roundtable includes staff from the offices of local, state and federal elected officials, regulatory agencies, and representatives from DOE and the Laboratory.

In addition, the Community Advisory Council (CAC) was established in September 1998. The Council, which serves in an advisory capacity to the Laboratory Director, consists of representatives from 27 varied stakeholder groups, including civic, business, union, health, education, employee, and environmental organizations. At monthly meetings, both the Roundtable and the CAC are given frequent updates on Laboratory activities, environmental issues, and progress. Feedback and recommendations from the CAC are considered in the Laboratory's decision-making processes.

The CAC closely follows and gives feedback to the Laboratory on remediation activities. These activities include groundwater issues, the final disposition of the Brookhaven Graphite Research Reactor (BGRR), and plans for cleaning up portions of the Peconic River. In 2001, the CAC recommended conducting pilot programs to attempt to minimize impacts to the Peconic River wetlands. In 2002, the CAC tracked the results of the pilot programs including wetland revegetation, electrochemical technology, vacuum guzzling, and phytoremediation, as well as the Peconic River Risk Assessment project. The Laboratory's Pollution Prevention Program generated a great deal of interest within the CAC and plans were undertaken to host a Pollution Prevention Workshop in 2003. Additionally, BNL scientists presented on research on ecosystems and climate, mercury impacts on human health and environment, and processes to encapsulate mercury.

Stakeholders were provided with many other opportunities to learn about and provide input on issues of importance to them. These included working groups, roundtables, and one-on-one interactions with managers and subject matter experts. Input is actively sought to help the Laboratory make better decisions that take the community's values and perspectives into account. Public outreach activities include briefings to local civic and community groups; meetings and presentations to local, state, and federal regulators and elected officials; and regular interactions with the business and educational communities. The Laboratory uses a Correspondence and Commitment Tracking System to track and ensure response to communications from interested external parties. Laboratory Envoys, who are well educated about BNL and its issues, regularly interact with individuals and groups in the community, gathering feedback and responding to concerns.

During 2002, BNL hosted more than 29,000 visitors, including students and community members who participated in "Summer Sunday" open houses, science museum visits, high school, college and community tours, and special outreach programs. One Summer Sunday was devoted to increasing the community's appreciation for the environment through activities, demonstrations, literature, and displays. During this event, visitors learned about the Laboratory's initiatives in energy conservation ranging from research involving fuel cells and oil burners to the use of alternate fuel vehicles.

The Laboratory also maintains an informative website, <http://www.bnl.gov>; issues press releases; and publishes the *Brookhaven Bulletin* (a weekly employee newsletter), *cleanupdate* (a periodic newsletter on environmental cleanup), *Laboratory Link* (a monthly brief on research activities), and e-mail updates to keep the public and employees informed about the Laboratory's science and a wide variety of Laboratory activities and issues, including environmental issues. Chapter 6 discusses additional outreach activities associated with the Natural and Cultural Resources Program.

In 2002, BNL celebrated the thirty-third anniversary of Earth Day with a variety of activities involving BNL staff and the commu-

nity, including environmental awards, an art contest, a four-mile race, and an on-site Office Swap (for reuse of office products). The Laboratory also participated in an off-site Earth Day celebration. BSA contributed corporate funds in support of these events as part of their commitment to environmental stewardship.

2.4.3 Monitoring and Measurement

Effluent and emissions monitoring helps ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL has a comprehensive, sitewide Environmental Monitoring Program. This program identifies potential pathways for exposure of the public and the environment, as well as evaluating what impact BNL activities may be having on the environment. It also ensures compliance with environmental permit requirements.

The monitoring program is reviewed and revised, as necessary, on an annual basis to reflect changes in permit requirements, changes in facility-specific monitoring activities, or the need to increase or decrease monitoring based on the review of previous analytical results. As required under DOE Order 5400.1 (1988), BNL's Environmental Monitoring Plan, Triennial Update (BNL 2002c) outlines annual sampling goals by media and frequency. The 2002 plan also specifies the data quality objectives associated with the monitoring program.

There were a total of 5,381 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges in 2002 under the Environmental Monitoring Program, as shown in Table 2-6. This does not include samples taken to characterize wastes for disposal purposes or nonroutine samples collected in support of restoration characterization activities. Specific sampling programs for the various media are described further in Chapters 3 through 7.

There are three components to the Environmental Monitoring Program: compliance, restoration, and surveillance monitoring.

2.4.3.1 Compliance Monitoring

Compliance monitoring is conducted to ensure that wastewater effluents, air emissions,

and groundwater monitoring data comply with regulatory and permit limits issued under the federal Clean Air Act, Clean Water Act, Oil Pollution Act, Safe Drinking Water Act, and the New York State equivalents. Included in compliance monitoring are the following:

- *Air emissions monitoring* is conducted at reactors, accelerators, and other radiological emission sources, as well as the Central Steam Facility. Real-time, continuous emission monitoring equipment is installed and maintained at some of these facilities or samples are collected and analyzed periodically to ensure compliance with regulatory requirements. Analytical data are routinely reported to the permitting authority (see Section 3.5 of Chapter 3 for details).
- *Wastewater discharge monitoring* is performed at the point of discharge to ensure that the effluent complies with release limits in BNL's State Pollutant Discharge Elimination System (SPDES) permits. Fifteen point-source discharges are monitored under the BNL program: five under the Environmental Restoration Program and 10 under the SPDES permit. As required by permit conditions, samples are collected daily, weekly, monthly, or quarterly and monitored for organics, inorganics, or radiological parameters. Monthly reports that provide analytical results and an assessment of compliance for that reporting period are filed with the permitting agency. See Section 3.6 of Chapter 3 for details.
- *Groundwater monitoring* is also performed in accordance with permit requirements. Specifically, monitoring of groundwater is required under the Major Petroleum Facility License for the Central Steam Facility, and the RCRA permit for the Waste Management Facility. Extensive groundwater monitoring is also conducted under the ER program as required under the Records of Decision for many of the Operable Units or Areas of Concern (see Chapter 7 for details). Additionally, to ensure that the Laboratory maintains a viable potable water supply, groundwater is monitored as required by the New York State Department of Health. See

Chapter 3 for details on potable water supply monitoring programs and results.

2.4.3.2 Restoration Monitoring

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

This program typically involves collecting soil and groundwater samples to determine the lateral and vertical extent of the contaminated area. Samples are analyzed for organics, inorganics, and radiological contaminants, and the analytical results are compared with guidance, standards, cleanup goals, or background concentrations. Areas where impacts have been confirmed are fully characterized and, if necessary, remediated to mitigate continual impacts. Followup monitoring of groundwater is conducted in accordance with a Record of Decision.

2.4.3.3 Surveillance Monitoring

Pursuant to DOE Order 5400.1, surveillance monitoring is performed in addition to compliance monitoring, to assess potential environmental impacts that could result from routine facility operations. The Surveillance Monitoring Program involves collecting samples of ambient air, surface water, groundwater, flora, fauna, and precipitation. Samples are analyzed for radiological, organic, and inorganic contaminants. Additionally, data collected by thermoluminescent dosimeters (devices to measure radiation exposure) on and off site are routinely reviewed under this program.

Control samples (also called background or reference samples) also are collected on and off the site to compare BNL results to areas that could not have been impacted 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-spe-

Table 2-6. Summary of BNL 2002 Sampling Program Sorted by Media.

Environmental Media	No. of Sampling Events*	Purpose
Groundwater	2,345	To evaluate impacts of past and present operations on groundwater quality, under the Environmental Restoration, Environmental Surveillance, and Compliance programs.
On-site recharge basins	126	Recharge basins used for wastewater and stormwater disposal were monitored in accordance with discharge permit requirements and for environmental surveillance purposes.
Potable water	148	Potable water wells and the BNL distribution system were monitored routinely for chemical and radiological parameters to ensure compliance with Safe Drinking Water Act requirements and for environmental surveillance purposes.
Sewage Treatment Plant and Peconic River	364	The STP influent and effluent and several downstream Peconic River stations were monitored routinely for organic, inorganic, and radiological parameters to assess BNL impacts on the river. The number of samples taken depends on flow—e.g., samples are scheduled for collection at Station HQ one time per month, but if there is no flow, no sample can be collected. See discussion in Chapters 3 and 5.
Precipitation	8	Precipitation samples were collected from two locations to determine if radioactive emissions have impacted rainfall, and to monitor worldwide fallout from nuclear testing. The data were also used, along with wind speed and direction, temperature, and atmospheric stability, to help model atmospheric transport and diffusion of radionuclides.
Air — Tritium	340	Silica gel cartridges were used to collect atmospheric moisture for subsequent tritium analysis. These data were used to assess tritium levels downwind of the reactors. Due to several years of nondetectable measurements, and the shutdown of the HFBR, monitoring was reduced from weekly to once per month in several areas of the site in 2000. See discussion in Chapters 4 and 8.
Air — Particulate	468	Gross alpha/beta and gamma analysis was performed on samples of particulate matter collected from air samples. The purpose is to look for any impact from BNL operations.
Air — Charcoal	104	Charcoal samples were used to assess for radioiodines, which could be released in emissions.
Fauna	120	Fish, deer, and small mammals were monitored to assess impacts on wildlife associated with past (or current) BNL operations.
Flora	79	Since the primary pathway from soils to fauna is via ingestion, vegetation was sampled to assess uptake of contaminants by plants and hence to fauna. This number includes 33 samples taken of farm produce.
Soils	843	Soil samples were collected from adjacent farms and other local areas to confirm that Laboratory emissions have no impact on surrounding areas. Soil samples were also collected in Environmental Restoration investigative work.
Miscellaneous	290	Samples were collected periodically from manholes and other locations to assess compliance with regulatory requirements. This number includes samples taken by the ESD field sampling team for Plant Engineering (e.g., collected during sewer line cleanouts).
Total number of sampling events	5,381	This number includes all the samples identified in the EMP (BNL 2002), plus samples collected by the ESD field sampling team as special requests. The number does not include samples collected to monitor Environmental Restoration air and water treatment system processes, or samples taken by the Waste Management Division, waste generators, or Environmental Compliance Representatives for waste characterization purposes.

*In one sampling event, multiple samples may be collected from a single location. For example, during one sampling event, separate samples for tritium, gross alpha and beta, and VOCs may be collected from a groundwater monitoring well.

cific 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 EMS is operating as intended, audits are conducted. These

audits are part of the sitewide self-assessment program and are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. An independent, accredited registrar also conducts annual ISO 14001 registration audits. In addition, compliance with regulatory requirements is verified through routine inspections, operational evaluations, and focused compliance audits. BNL's Assessment Program consists of several processes.

- *Self-assessment* is the systematic evaluation of internal processes and performance. The approach for the environmental self-assessment program includes evaluating programs and processes within organizations that have environmental aspects. Conformance to ISO 14001 EMS requirements is verified, progress toward achieving environmental objectives is monitored, operations are inspected to verify compliance with regulatory requirements, and the overall effectiveness of the EMS is evaluated. Environmental experts routinely participate in these assessments. Management also conducts assessments to evaluate Laboratory environmental performance from a programmatic perspective, to determine if there are Laboratory-wide issues that require attention, and to facilitate the identification and communication of best management practices used in one part of the Laboratory that could improve performance in other parts. Laboratory management also routinely evaluates progress on key environmental improvement projects. BNL periodically teams with the local DOE office to perform assessments to facilitate the efficiency of assessment activities and ensure that the approach to performing the assessments meets DOE expectations.
- *Independent assessments* are performed by staff who do not have line responsibility for the work processes. These assessments verify the effectiveness and adequacy of management processes (including self-assessment programs) at the division, department, directorate, and Laboratory levels. Special investigations are also conducted to identify the root causes of problems, corrective actions, and lessons learned.

The Laboratory's Assessment Program is augmented by programmatic, external audits conducted by DOE. Staff from the offices of Battelle Memorial Institute and BSA subcontractors also perform periodic independent reviews. An independent third party conducts ISO 14001 registration audits of the environmental management system.

From June 4 through June 7, 2002, an ISO 14001 EMS Surveillance Audit was conducted by NSF-ISR, Ltd, an independent and accredited ISO 14001 registrar. The independent registrar determined that BNL's EMS remains in conformance with the ISO 14001 standard. The auditors identified one minor nonconformance, one opportunity for improvement, strong evidence of continuous improvement, and 12 noteworthy practices. A corrective action report that BNL prepared for the minor nonconformance was accepted by the auditor and will be tracked to closure.

BNL is also subject to extensive oversight by external regulatory agencies (see Chapter 3). Results of all assessment activities related to environmental performance are included, as appropriate, throughout this report.

2.5 ENVIRONMENTAL STEWARDSHIP AT BNL TODAY

BNL now has unprecedented knowledge of its potential environmental vulnerabilities and current operations due to programs such as the Facility Review Project, process evaluations, the work planning and control system, and the management systems for groundwater protection, environmental restoration, and information management. Compliance assurance programs are improving BNL's compliance status. Pollution prevention projects have reduced costs, minimized waste generation, and reused and recycled significant quantities of materials.

The Laboratory is openly communicating with neighbors, regulators, employees, and other interested parties on issues and progress. To regain and maintain stakeholder trust, BNL must continue to deliver on commitments and demonstrate real improvements in environmental performance. This annual Site Environmental Report is an important communication mechanism,

as it summarizes BNL's environmental programs and performance for the 2002 calendar year. Additional information about BNL's environmental programs is available on BNL's website at <http://www.bnl.gov>. Environmental project plans, status reports, procedures, and other environmental information are accessible to the general public at <http://www.bnl.gov/esd/>. The Laboratory continues to pursue other mechanisms to communicate data in a more user friendly, visual, and timely manner.

The existing BNL Environmental Management System is viewed as exemplary within DOE. BNL is the first DOE Office of Science national laboratory to obtain third-party registration to ISO 14001. Due to external recognition of BNL's knowledge and unique experience implementing the ISO 14001 EMS program, several DOE facilities and private universities have invited BNL to extend its outreach activities and share its experiences, lessons learned, and successes. As noted above, BNL's environmental programs and projects have been recognized with regional and national awards.

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

- The EMS has been strengthened, integrated with other BNL management systems, and formalized.
- Line ownership for environmental stewardship has been established, key roles and responsibilities have been identified and clarified, and expectations have been made explicit.
- A comprehensive environmental training program has been implemented.
- From the process evaluations, BNL has an improved understanding of environmental aspects, waste streams, and applicable requirements.
- There is much greater formality with regard to control of EMS documents, manuals, and procedures. Procedures and requirements have been updated, and environmental management programs have been improved.
- BNL has been very successful in achieving

environmental goals and Critical Outcomes. There have been successes in ISO 14001 registration and recertification, compliance improvements (e.g., facility modifications, implementation of SBMS, enhanced operational controls), and increased environmental knowledge and awareness on the part of management, employees, and visiting scientists.

- Communication on environmental issues has improved, occurs at the highest levels of management, and reporting is more formal. Managers are better informed about environmental aspects, issues, and performance.
- Core EMS teams representing many organizations have been formed. A consensus process is used to develop the system, improving acceptance and support.
- There has been strong penetration of the EMS throughout organizations, and cultural change has been sweeping.
- For more than 50 years, the unique, leading-edge research facilities at BNL have made many innovative scientific contributions possible. Today, BNL continues its research mission while paying much closer attention to cleaning up and protecting the environment. The Laboratory's environmental motto, which was generated in an employee suggestion contest, is "Exploring Earth's Mysteries ... Protecting Its Future." This reflects BNL's desire to balance world-class research with environmentally responsible operations.

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CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

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Compliance Status

Brookhaven National Laboratory is subject to more than 50 sets of federal, state, and local environmental regulations; numerous site-specific permits; equivalency permits for operation of seven groundwater remediation systems; and several other binding agreements. In 2002, BNL operated in compliance with the majority of these requirements, and programs are in place to address areas for continued improvement.

Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide were all within permit limits. Approximately 1,000 pounds of ozone-depleting refrigerants were recovered for recycling. Monitoring of the BNL potable water system showed that the potable water supply met all primary drinking water requirements. Groundwater monitoring at the Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality. During 2002, liquid effluents discharged to surface water and groundwater met all applicable New York State Pollutant Discharge Elimination System permit requirements with the exception of two excursions at the Sewage Treatment Plant and three at other outfalls. The five permit excursions were reported to the New York State Department of Environmental Conservation (NYSDEC).

Nineteen reportable spills of petroleum products occurred on site in 2002. Seventeen were less than 10 gallons, and all were cleaned up or addressed to the satisfaction of NYSDEC. The largest releases were associated with tank removal projects. BNL underwent 12 environmental audits by external regulatory agencies in 2002. These audits included inspections of petroleum storage, hazardous waste operations, air emissions from the Central Steam Facility, Sewage Treatment Plant operations, other regulated outfalls and recharge basins, and the potable water system. Of more than 1,000 New York State hazardous waste compliance requirements, BNL met all but three, receiving a Preliminary Finding and Administrative Complaint for three administrative deficiencies. Immediate corrective actions were taken to address one of the three and the two remaining issues are being reviewed for relevance to BNL operations. The Major Petroleum Facility was found to be in substantial compliance with the license, although several minor issues were identified. Corrective actions were implemented to address these issues. BNL continues to work with NYSDEC to resolve open items associated with past inspections of the Chemical Bulk Storage program.

3.1 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

Brookhaven National Laboratory (BNL) is subject to more than 50 sets of federal, state, and local environmental regulations; several site-specific permits; 10 equivalency permits for operation of groundwater remediation systems; and several other binding agreements. The federal, state, and local environmental statutes and regulations that BNL operates under are summarized in Table 3-1, along with a discussion of BNL's compliance status with regard to each requirement.

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, which are briefly described below.

- State Pollutant Discharge Elimination System permit
- Major Petroleum Facility license
- Resource Conservation and Recovery Act permit for the Waste Management Facility
- Registration certificate from the New York State Department of Environmental Conservation (NYSDEC) for tanks storing bulk quantities of hazardous substances
- Seven radiological emission authorizations issued under the National Emission Standards for Hazardous Air Pollutants by the U.S. Environmental Protection Agency
- Air emissions permit issued by NYSDEC under Title V of the Clean Air Act Amendments authorizing the operation of 14 emissions units
- Four permits for construction activities within the Peconic River corridor
- Underground Injection Control (UIC) Area permit for the operation of 90 UIC wells
- Permit for the operation of six domestic water supply wells
- Ten equivalency permits for the operation of seven groundwater remediation systems installed under the Inter-Agency Agreement (Federal Facility Agreement under the Com-

prehensive Environmental Response, Compensation and Liability Act [CERCLA] 120, Admin. Docket No. II-CERCLA-FFA-00201)

3.2.2 New or Modified Permits and Requests

3.2.2.1 State Pollutant Discharge Permits

A permit from the State Pollution Discharge Elimination System (SPDES) authorizes discharges from the BNL Sewage Treatment Plant (STP) to the Peconic River, and discharges of cooling water and stormwater to recharge basins, including discharges from Relativistic Heavy Ion Collider (RHIC) facilities. In November 2001, BNL submitted a request to revise its SPDES permit. The revisions included deleting Outfalls 002A and 004 because the operations contributing to these releases either ceased or were redirected to another point source; constructing two new recharge basins for increased drainage capacity to prevent overloading of existing basins; increasing the monitoring of three existing discharges (Outfalls 002, 008, and 010) to include metals analyses; decreasing monitoring of Outfall 007 because evaluation of iron releases from the Water Treatment Plant has shown no detrimental impact on the environment; and decreasing monitoring of corrosion control chemical residuals for Outfall 003 because cooling tower discharges have ceased. These requested modifications were approved in February 2002.

3.2.2.2 Air Emissions Permits

Air emissions permits are granted by the New York State Department of Environmental Conservation. Permits are issued either as "equivalency" permits for restoration projects conducted under CERCLA, or as changes to the BNL Title V draft operating permit, which was issued in final form in January 2002. Permitting activities for 2002 are discussed below.

CERCLA. In March 2002, BNL submitted an equivalency permit application to NYSDEC for a newly constructed air stripping treatment system in Operable Unit III. The treatment system was designed to remediate groundwater contaminated with volatile organic compounds (VOCs). The application stated that anticipated

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Reference 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 of inactive hazardous waste disposal sites.	In 1989, BNL entered into a tri-party agreement among EPA, NYSDEC, and DOE. Remediation of the BNL site is conducted by the Environmental Restoration Program in accordance with milestones established under this agreement.	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 evaluate 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 the NEPA requirements. The Laboratory has established sitewide procedures for the implementation of NEPA requirements.	3.3
Advisory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800 43 CFR 7	The National Historic Preservation Act identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places. Historic properties can be archeological sites, historic structures, or historic documents, records, or objects.	The High Flux Beam Reactor, Brookhaven Graphite Research Reactor (BGRR) complex, and World War I trenches in the area of the Relativistic Heavy Ion Collider project have been determined to be eligible for inclusion in the National Register of Historic Places. The former Cosmotron building was identified as being potentially eligible in an April 1991 letter from the New York State Historic Preservation Officer (NYSHPO). Any activities involving these facilities are identified through the NEPA process and an evaluation is initiated to determine if the proposed action would impact the features that extend eligibility to these facilities. Some activities associated with the decontamination and decommissioning of the BGRR were determined to impact its eligibility, and mitigative actions are proceeding according to a Memorandum of Agreement between DOE and NYSHPO. BNL is currently developing a Cultural Resource Management Plan to ensure compliance with applicable cultural resource regulations.	3.4
EPA: 40 CFR 50 – 80 40 CFR 82 NYSDEC: 6 NYCRR 200 – 258 6 NYCRR 307	The Clean Air Act (CAA) and the New York State Environmental Conservation Laws regulate the release of air pollutants through permits and air quality limits. Emissions of radionuclides are regulated by the EPA, via the National Emission Standards for Hazardous Air Pollutants (NESHAPs) authorizations.	All air emission sources have permits or have been exempted under the New York State air program.	3.5
EPA: 40 CFR 109 –140 40 CFR 230 – 231 40 CFR 401 40 CFR 403 NYSDEC: 6 NYCRR 700 – 703 6 NYCRR 750 – 758	The Clean Water Act (CWA) and corresponding New York State Environmental Conservation Laws seek to improve the quality of surface waters by implementing a permitting program and establishing water quality standards. Wastewater discharges are permitted by NYSDEC.	Permitted discharges include treated sanitary waste, and cooling tower and stormwater discharges. With the exception of five excursions, these discharges met the State Pollutant Discharge Elimination System permit limits in 2002.	3.6
EPA: 40 CFR 141 – 149 NYSDOH: 10 NYCRR 5	The Safe Drinking Water Act (SDWA) and New York State Department of Health 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.	BNL maintains a sitewide public water supply. This water supply met all primary drinking water standards as well as operational and maintenance requirements.	3.7
EPA: 40 CFR 112 40 CFR 328 40 CFR 355 40 CFR 370 40 CFR 372	The Oil Pollution Act , Emergency Planning and Community Right-to-Know Act (EPCRA), and the Superfund Amendment Reauthorization Act (SARA) require that facilities storing large quantities of petroleum products and/or chemicals prepare emergency planning documents and report the inventory of such chemicals to EPA, the state, and local emergency planning groups.	Since facilities at BNL store or use chemicals or petroleum in quantities exceeding threshold planning quantities, BNL is subject to these requirements. BNL is in full compliance with all emergency planning requirements.	3.8.1 3.8.2 3.8.3

(continued on next page)

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

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Reference Sections
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.	BNL is subject to a vast set of regulations governing storage of chemicals, petroleum products, and wastes. 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 is working toward achieving full conformance to county codes.	3.8.4 3.8.5 3.8.6
EPA: 40 CFR 260 – 280 NYSDEC: 6 NYCRR 360 – 374	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. While almost all wastes are handled and disposed in accordance with federal and state requirements, audits identified several concerns. These were immediately addressed by corrective actions.	3.9
EPA: 40 CFR 700 – 766	The Toxic Substances Control Act (TSCA) regulates the manufacture, use, and distribution of all chemicals.	BNL manages all TSCA-regulated materials, including PCBs, in compliance with all requirements.	3.10
EPA: 40 CFR 162 – 171 NYSDEC: 6 NYCRR 320 – 329	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and corresponding New York State regulations govern the manufacture, use, storage, and disposal of pesticides and herbicides, as well as pesticide containers and residuals.	BNL employs New York State-certified pesticide applicators for the application of pesticides and herbicides on the site. Each applicator attends training as needed to maintain all certifications current. Annual reports detailing the types and quantity of pesticides applied are filed by each applicator each year by February 1st.	3.11
DOE: 10 CFR 1022 NYSDEC: 6 NYCRR 662 6 NYCRR 663 6 NYCRR 666	DOE regulations govern compliance with floodplain/wetland review requirements. The New York State Fresh Water Wetlands and Wild, Scenic, and Recreational Rivers regulations govern development in natural waterways. Development or projects occurring within ½ mile of regulated waters are subject to permitting by NYSDEC.	BNL is located within the Peconic River watershed and has several jurisdictional wetlands; consequently, development of locations in the north and east is subject to permitting by NYSDEC and review for compliance under DOE wetland/floodplain regulations. During 2002, two new projects were permitted under New York State programs.	3.12
U.S. Fish and Wildlife Service: 50 CFR 11 NYSDEC: 6 NYCRR 182	The Endangered Species Act and corresponding New York State regulation prohibit activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat.	One New York State endangered species (the tiger salamander), three threatened (the banded sunfish, the swamp darter, and the stiff goldenrod), and eight species of special concern have been identified on site. The Laboratory has prepared a Wildlife Resource Management Plan that outlines activities to protect species and enhance their habitats.	3.13

Notes:

CFR = Code of Federal Regulations
 DOE = Department of Energy
 EPA = Environmental Protection Agency
 NYCRR = New York Codes, Rules, and Regulations

NYSDEC = New York State Department of Environmental Conservation
 NYSDOH = New York State Department of Health
 SCDHS = Suffolk County Department of Health Services
 SCSC = Suffolk County Sanitary Code

airborne emissions associated with the system would be properly controlled in conformance with 6 NYCRR 212 air pollution control requirements. NYSDEC approved the application in April and the treatment system began operating in May.

Clean Air Act Title V. Under the Clean Air Act Amendments of 1990 (CAAA), BNL is defined as a major emission source of criteria pollutants (NO_x and SO₂). As a major emission source, BNL was required to obtain a Title V operating permit. The process to obtain a Title V permit began in December 1998, when BNL filed a permit application with NYSDEC. After

NYSDEC completed their application review, they prepared a draft permit and released a notice of complete application in August 2001. The notice was subsequently published in local newspapers and the public was given an opportunity to comment on the draft permit through September 21, 2001. BNL requested several minor revisions; there were no comments from the public, and the EPA offered no objections to the terms and conditions of the draft permit. Following the comment period, NYSDEC issued a Title V operating permit to BNL on January 11, 2002.

Table 3-2. BNL Environmental Permits.

Issuing Agency	Bldg or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emmision Unit ID	Source ID
EPA	510	Calorimeter enclosure	BNL-689-01	None	NA	NA
EPA	705	Building ventilation	BNL-288-01	None	NA	NA
EPA	820	Accelerator test facility	BNL-589-01	None	NA	NA
EPA	AGS	AGS Booster - Accelerator	BNL-188-01	None	NA	NA
EPA	BNL	Underground Injection Control	NYU500001	11-Feb-11	NA	NA
EPA	RHIC	Accelerator	BNL-389-01	None	NA	NA
NYSDEC	517	Middle Road./S. Bndry. SPDES equiv.	1-51-009	30-Mar-02	NA	NA
NYSDEC	517	Middle Road./S. Bndry. Air equiv.	1-51-009	30-Mar-02	NA	NA
NYSDEC	521	OUIV Air Sparge - Air equiv.	NA	None	NA	NA
NYSDEC	539	W. South Bndry. - SPDES equiv.	1-52-009	31-Oct-06	NA	NA
NYSDEC	539	W. South Bndry. - Air equiv.	1-52-009	31-Oct-06	NA	NA
NYSDEC	598	OUI Remediation - SPDES equiv.	1-52-009	30-Mar-02	NA	NA
NYSDEC	598	OUI Remediation - Air equiv.	1-52-009	30-Mar-02	NA	NA
NYSDEC	598	Tritium Rem. - SPDES equiv.	1-52-009	30-Mar-02	NA	NA
NYSDEC	TR829	Carbon Tet. - SPDES equiv.	NA	None	NA	NA
NYSDEC	TR867	T-96 Remediation - Air equiv.	NA	None	NA	NA
NYSDEC	BNL	Hazardous Substance Bulk Storage Registration Certificate	1-000263	27-Jul-03	NA	NA
NYSDEC	BNL	Domestic Potable/Process Wells	1-4722-00032/00113	13-Sep-08	NA	NA
NYSDEC - Air Quality	197	Lithographic Printing Presses	1-4722-00032/00115	06-Jan-07	U-LITHO	19709-10
NYSDEC - Air Quality	423	Metal parts cleaning tanks	1-4722-00032/00115	06-Jan-07	U-METAL	42306-08
NYSDEC - Air Quality	423	Gasoline storage and fuel pumps	1-4722-00032/00115	06-Jan-07	U-FUELS	42309-10
NYSDEC - Air Quality	423	Motor vehicle A/C servicing	1-4722-00032/00115	06-Jan-07	U-MVACS	MVAC1&2
NYSDEC - Air Quality	458	Paint spray booth	1-4722-00032/00115	06-Jan-07	U-45801	45801
NYSDEC - Air Quality	458	Flammable Liquid Storage cabinet	1-4722-00032/00115	06-Jan-07	U-45801	458AA
NYSDEC - Air Quality	473	Metal parts cleaning tank	1-4722-00032/00115	06-Jan-07	U-METAL	47302
NYSDEC - Air Quality	479	Metal parts cleaning tank	1-4722-00032/00115	06-Jan-07	U-METAL	47906
NYSDEC - Air Quality	490	Milling machine/block cutter	1-4722-00032/00115	06-Jan-07	U-49003	49003
NYSDEC - Air Quality	490	Lead alloy melting	1-4722-00032/00115	06-Jan-07	U-49003	49004
NYSDEC - Air Quality	498	Aqueous cleaning facility	1-4722-00032/00115	06-Jan-07	U-METAL	49801
NYSDEC - Air Quality	535B	Plating Tanks	1-4722-00032/00115	06-Jan-07	U-INSIG	53501
NYSDEC - Air Quality	535B	Etching machine	1-4722-00032/00115	06-Jan-07	U-INSIG	53502
NYSDEC - Air Quality	535B	PC board process	1-4722-00032/00115	06-Jan-07	U-INSIG	53503
NYSDEC - Air Quality	610	Combustion unit	1-4722-00032/00115	06-Jan-07	U-61005	61005
NYSDEC - Air Quality	610	Combustion unit	1-4722-00032/00115	06-Jan-07	U-61006	61006
NYSDEC - Air Quality	610	Combustion unit	1-4722-00032/00115	06-Jan-07	U-61007	61007
NYSDEC - Air Quality	610	Metal parts cleaning tray	1-4722-00032/00115	06-Jan-07	U-METAL	61008
NYSDEC - Air Quality	610	Combustion unit	1-4722-00032/00115	06-Jan-07	U-61005	6101A
NYSDEC - Air Quality	630	Gasoline storage and fuel pumps	1-4722-00032/00115	06-Jan-07	U-FUELS	63001-03
NYSDEC - Air Quality	820	Metal parts cleaning tank	1-4722-00032/00115	06-Jan-07	U-METAL	82001
NYSDEC - Air Quality	903	Metal parts cleaning tank	1-4722-00032/00115	06-Jan-07	U-METAL	90304
NYSDEC - Air Quality	919B	Electroplating operation	1-4722-00032/00115	06-Jan-07	U-INSIG	91904
NYSDEC - Air Quality	922	Metal parts cleaning tank	1-4722-00032/00115	06-Jan-07	U-Metal	92202-03
NYSDEC - Air Quality	922	Electroplating operation	1-4722-00032/00115	06-Jan-07	U-INSIG	92204
NYSDEC - Air Quality	923	Electronic equipment cleaning	1-4722-00032/00115	06-Jan-07	U-METAL	9231A
NYSDEC - Air Quality	923	Parts drying oven	1-4722-00032/00115	06-Jan-07	U-METAL	9231B
NYSDEC - Air Quality	924	Magnet Coil Production Press	1-4722-00032/00115	06-Jan-07	U-INSIG	92402
NYSDEC - Air Quality	924	Vapor/ultrasonic degreasing unit	1-4722-00032/00115	06-Jan-07	U-METAL	92404
NYSDEC - Air Quality	902	Epoxy coating/curing exhaust	1-4722-00032/00115	06-Jan-07	U-COILS	90206
NYSDEC - Air Quality	Site	Halon 1211 portable extinguishers	1-4722-00032/00115	06-Jan-07	U-HALON	H1211
NYSDEC - Air Quality	Site	Halon 1301 fire suppression systems	1-4722-00032/00115	06-Jan-07	U-HALON	H1301

(continued on next page)

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	Site	Packaged A/C Units	1-4722-00032/00115	06-Jan-07	U-RFRIG	PKG01-02
NYSDEC - Air Quality	Site	Reciprocating chillers	1-4722-00032/00115	06-Jan-07	U-RFRIG	REC01-41
NYSDEC - Air Quality	Site	Rotary screw chillers	1-4722-00032/00115	06-Jan-07	U-RFRIG	ROTO1-07
NYSDEC - Air Quality	Site	Split A/C units	1-4722-00032/00115	06-Jan-07	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal chillers	1-4722-00032/00115	06-Jan-07	U-RFRIG	CEN01-22
NYSDEC - Haz Waste	WMF	Waste Management	1-4722-00032/00102	12-Jul-05	NA	NA
NYSDEC - Nat. Res.	AGS	Construction of AGS storage facility	1-4722-00032/00133	03-Jun-06	NA	NA
NYSDEC - Nat. Res.	RHIC	Liner installation at Bldg. 1010	1-4722-00032/00131	25-Apr-06	NA	NA
NYSDEC - Nat. Res.	RHIC	Construction of new recharge basin	1-4722-00032/00129	17-May-04	NA	NA
NYSDEC - Nat. Res.	STP	Sanitary Phase III Construction	1-4722-00032/00127	14-Mar-02	NA	NA
NYSDEC - NESHAPs	490	Asbestos test facility	1-4722-00032/00115	06-Jan-07	U-49001	4901A-1D
NYSDEC - NESHAPs	865	Lead smelting pot	1-4722-00032/00115	06-Jan-07	U-LEADM	86501
NYSDEC - NESHAPs	REF	Radiation Effects/Neutral Beam	BNL-789-01	None	NA	NA
NYSDEC - NESHAPs	RTF	Radiation Therapy Facility	BNL-489-01	None	NA	NA
NYSDEC - Water Quality	CSF	Major Petroleum Facility	1-1700	31-Mar-07	NA	NA
NYSDEC - Water Quality	STP	Sewage Plant and Recharge Basins	NY-0005835	01-Mar-05	NA	NA

Notes:

AGS = Alternating Gradient Synchrotron

CSF = Central Steam Facility

EPA = Environmental Protection Agency

NYSDEC = New York State Department of Environmental Conservation

NA = Not Applicable

REF = Radiation Effects Facility

RTF = Radiation Therapy Facility

RHIC = Relativistic Heavy Ion Collider

STP = Sewage Treatment Plant

WMF = Waste Management Facility

This permit consolidates all applicable federal and state requirements for BNL's regulated emission sources into a single document. BNL has a variety of nonradioactive air emission sources covered under the permit that are subject to federal or state regulations. Section 3.5 describes the most significant sources and the methods used by BNL to comply with the applicable regulatory requirements.

3.2.2.3 Underground Injection Control Permit

Under the Safe Drinking Water Act (SDWA), BNL is required to maintain an Area Permit for Underground Injection Control wells (e.g., drywells, cesspools, and leaching pools). BNL received a final permit in January 2001. This permit authorizes the operation of 90 UICs, including 86 stormwater drywells and four small sanitary systems. Several changes to the permit occurred in 2002, essentially due to a change in the number of active UICs. During 2002, two UICs were closed and applications were filed for the installation of 12 new devices (see Section 3.7.3 for more details).

3.3 NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the effects of proposed major federal activities on the environment. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made. During 2002, environmental evaluations were completed for 114 proposed projects. Of these projects, 101 were considered minor actions requiring no additional documentation. The remaining 13 projects were addressed through the submission of Environmental Evaluation Notification Forms to the Department of Energy. Evaluation of these projects resulted in the determination that they were covered by existing Categorical Exclusions, as defined by 10 CFR 1021.

3.4 HISTORIC PRESERVATION AND ARCHAEOLOGY

BNL is subject to several cultural resource laws, most notably the National Historic Preservation Act (NHPA) and the Archeological Resource Protection Act (ARPA). These acts

require federal agencies to identify, evaluate, and consider the effects of federal actions on historical and archeological sites eligible for listing or inclusion on the National Register of Historic Places. The sites may include historic structures, objects, documents, and Native American Indian lands.

BNL has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I training trenches associated with Camp Upton. In 2002, the New York State Historic Preservation Officer (SHPO) concurred with BNL's determination that the following WW II era buildings were *not* eligible for listing on the National Register of Historic Places:

- Buildings 89, 90, and 91 – Warehouses
- Buildings 93 and 168 – Well houses
- Building 194 – Storage/laboratories/offices
- Building 318 – Laboratories/offices
- Building 324 – Apartments
- Building 426 – Laboratories/offices
- Building 428 – Incinerator

The annual Department of Interior questionnaire regarding historic and cultural resources was completed and submitted as required.

Additional activities in 2002 associated with NHPA and ARPA compliance are identified in Chapter 6, Section 6.9, Cultural Resource Activities.

3.5 CLEAN AIR ACT

The objectives of the Clean Air Act (CAA) that 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

BNL has a variety of conventional, nonradioactive air emission sources that are subject to federal or state regulations. The following subsections describe the most 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 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 2002, natural gas was the predominant fuel burned in Boiler 6, whereas Boilers 5 and 7 burned mostly low nitrogen residual fuel oil.

For boilers with maximum operating heat inputs greater than or equal to 50 MMBtu/hr (14.6 MW), RACT requirements establish emission standards for oxides of nitrogen (NO_x). Boilers with a maximum operating heat input between 50 and 250 MMBtu/hr (14.6 and 73.2 MW) can demonstrate compliance using periodic emission tests or by using continuous emission monitoring equipment. Emission tests conducted in 1995 confirmed that BNL Boilers 1A and 5, both of which are in this size category, met the NO_x emission standards when burning low nitrogen and sulfur content residual fuel oil (below 0.3 percent). To ensure continued compliance, an outside contractor laboratory analyzed composite samples of fuel deliveries (collected quarterly) and confirmed that the fuel-bound nitrogen and sulfur content met these requirements. Compliance with the 0.30 lbs/MMBtu NO_x emission standards for Boilers 6 and 7 was demonstrated by continuous emission monitoring of the flue gas. For the year 2002, NO_x emissions from Boilers 6 and 7 averaged 0.083 lbs/MMBtu and 0.224 lbs/MMBtu, respectively, and there were no known exceedances of the NO_x emission standard for either boiler.

3.5.1.2 Ozone-Depleting Substances

Refrigerants. All refrigerant recovery and recycling equipment used by refrigerant service technicians is certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. Under the preventative maintenance program, refrigeration and air conditioning equipment containing ozone-depleting substances, such as R-12 and R-22, is regularly inspected and maintained. As a matter of standard practice at BNL, if a refrigerant leak is found, technicians

will either immediately repair the leak or isolate it and prepare a work order for the needed repairs. This practice exceeds the leak repair provisions of 40 CFR 82.156.

Approximately 1 pound of R-12 and 671 pounds of R-22 were recovered and reclaimed for future use from equipment that was serviced during 2002.

Halon. Halon 1211 and 1301 are extremely efficient fire suppressants but are no longer acceptable, due to their effect on the Earth's ozone layer. In 1998, BNL purchased equipment to comply with the halon recovery and recycling requirements of the CAA, 40 CFR 82 Subpart H. Halon recovery and recycling devices are used when portable fire extinguishers or fixed systems are removed from service and during periodic hydrostatic testing of halon cylinders. In 2002, cylinders containing 360 pounds of Halon 1301 from two fixed fire suppression systems deactivated during the year were transferred to BNL's static inventory.

3.5.2 Hazardous Air Pollutants

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

3.5.2.1 Maximum Available Control Technology

During preparation of the Title V Phase II application, BNL reviewed existing state and federal regulations administered under the CAA to determine applicability to BNL activities and operations. Based on this review, it was concluded that no proposed or promulgated Maximum Available Control Technology (MACT) standards apply to BNL operations. Additional evaluation

conducted in 2002 determined that no MACT standards apply to anticipated emissions from proposed activities or operations.

3.5.2.2 Asbestos

As required, BNL provided notice to the EPA Region II office regarding the removal of materials that contained asbestos. During 2002, 5,100 linear feet of asbestos-containing pipe insulation and 62,370 square feet of asbestos-containing surface material (principally roofing and vinyl asbestos floor tile) were removed and disposed of in accordance with EPA requirements.

3.5.2.3 Radioactive Airborne Emissions

Emissions of radiological contaminants are evaluated and, if necessary, monitored to ensure that they do not affect the environment. A full description of the monitoring conducted by BNL in 2002 is provided in Chapter 4. BNL transmitted all data pertaining to radioactive air emissions and dose calculations to EPA on schedule, in fulfillment of the June 30 annual reporting requirement. In 2002, the maximum off-site dose due to airborne radioactive emissions from BNL continued to be far below the 10 mrem (100 μ Sv) annual dose limit specified in 40 CFR 61 Subpart H. (See Chapter 4 for more information on the estimated air dose.) The dose to the maximally exposed individual resulting from airborne emissions, calculated using EPA's modeling software was 0.086 mrem (0.8 μ Sv). See Chapter 8 for more information.

3.6 CLEAN WATER ACT

The disposal of wastewater generated by BNL operations is regulated under the Clean Water Act (CWA), as implemented by NYSDEC and under DOE Order 5400.5 (1990). The goals of the CWA are to achieve a level of water quality that promotes the propagation of fish, shellfish, and wildlife; to provide waters suitable for recreational purposes; and to eliminate the discharge of pollutants into surface waters. New York State was delegated CWA authority in 1975. NYSDEC has issued a SPDES permit to regulate wastewater effluents at BNL. This permit establishes release concentration limits and specifies monitoring requirements.

The BNL SPDES permit was renewed in September 1999 with an effective date of March 1, 2000 and an expiration date of March 1, 2005. This permit provides monitoring requirements and specifies effluent limits for nine of 12 outfalls, as described below.

- Outfall 001 is the discharge of treated effluent from the STP to the Peconic River.
- Outfalls 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. No monitoring requirements are imposed for Outfalls 003, 011, and 012.
- Outfall 007 receives backwash water from the potable Water Treatment Plant filter building.
- Outfall 009 consists of numerous subsurface and surface wastewater disposal systems that receive predominantly sanitary waste, and steam- and air-compressor condensate discharges. There are no monitoring requirements imposed for this outfall.

See Figure 5-6 in Chapter 5 for the locations of BNL outfalls.

Each month, BNL prepares a Discharge Monitoring Report that details monitoring data, evaluates compliance with permit limitations, and identifies corrective measures taken to address permit excursions. This report is submitted directly to the NYSDEC central and regional offices and the Suffolk County Department of Health Services.

3.6.1 Sewage Treatment Plant

Sanitary and process wastewater generated by BNL operations is conveyed to the Sewage Treatment Plant (STP) for processing before being discharged to the Peconic River. The STP provides tertiary treatment of sanitary and process wastewater (i.e., biological reduction of organic matter and reduction of nitrogen). This treatment process became fully functional in 1998. Chapter 5 provides a detailed description of the treatment process. In 2002, BNL completed the third phase of sanitary upgrades, which included construction of a new aerobic solids digester, replacing or relining 16,000 linear feet of piping, relining holdup ponds used to hold wastewater suspected of containing

contaminants at concentrations that could jeopardize the STP effluent quality, and repairing or replacing piping that serves the sand filtration system.

A summary of the SPDES monitoring results for the STP discharge at Outfall 001 is provided in Table 3-3. The relevant SPDES permit limits are also shown. BNL monitors the STP discharge for more than 100 parameters monthly and well over 200 parameters quarterly. BNL's compliance with effluent limits was greater than 99 percent overall, but there were two exceedances of SPDES permit limits in 2002: one each for total suspended solids removal and fecal coliform. Figures 3-1 through 3-7 plot five-year trends (four years for mercury) for the maximum monthly concentrations of copper, iron, lead, mercury, silver, nickel, and zinc in the STP discharge. There were no exceedances for metals at the STP in 2002.

3.6.1.1 Total Suspended Solids Removal

BNL is required to measure the influent and effluent concentrations of total suspended solids (TSS) twice monthly and to calculate and report the overall percent removal of TSS achieved by the treatment process. BNL is required to achieve an 85 percent removal of TSS as per the SPDES permit. While the concentration of TSS in the sewage treatment plant effluent was always well below the monthly maximum of 20 mg/L, the very low level of TSS entering the plant and the relative high limit of detection (i.e., 4 mg/L) for the effluent prevents accurate calculation of removal. The percent removal achieved in August was reported as greater than 82 percent, which did not meet the SPDES requirement of 85 percent. BNL did not report this as a permit violation because the effluent concentration was well below the permit limit and the excursion was the result of an inaccurate calculation. However, EPA and NYSDEC listed this incident as a permit violation.

3.6.1.2 Fecal Coliform

A sample of STP effluent collected in July 2002 exhibited a fecal coliform concentration of 800 organisms per 100 milliliters, which exceeded the SPDES maximum limit of 400

CHAPTER 3: COMPLIANCE STATUS

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

Analyte	Min.	Max.	Min. Monitoring Frequency	SPDES Limit	No. of Exceedances	% Compliance*
Max. Temperature (°F)	48	79	Daily	90	0	100
pH (SU)	6.0	7.0	Continuous Recorder	Min. 5.8 Max. 9.0	0	100
Avg. 5-Day Biological Oxygen Demand (BOD) (mg/L)	< 2	2	Twice Monthly	10	0	100
Max. 5-Day BOD (mg/L)	< 2	2	Twice Monthly	20	0	100
% BOD Removal	> 89	> 98	Monthly	85	0	100
Avg. Total Suspended Solids (TSS) (mg/L)	< 4	< 6	Twice Monthly	10	0	100
Max. TSS (mg/L)	< 4	< 8	Twice Monthly	20	0	100
% TSS Removal	> 82	> 98	Monthly	85	1 ^(a)	92
Settleable Solids (ml/L)	0.0	0.0	Daily	0.1	0	100
Ammonia Nitrogen (mg/L)	< 0.1	0.47	Twice Monthly	2	0	100
Total Nitrogen (mg/L)	3.9	8.5	Twice Monthly	10	0	100
Total Phosphorus (mg/L)	1.1	2.0	Twice Monthly	NA	0	100
Cyanide (µg/L)	< 10	< 10	Twice Monthly	100	0	100
Copper (mg/L)	0.03	0.07	Twice Monthly	0.15	0	100
Iron (mg/L)	0.16	0.31	Twice Monthly	0.37	0	100
Lead (mg/L)	< 0.0008	0.004	Twice Monthly	0.019	0	100
Nickel (mg/L)	0.003	0.01	Twice Monthly	0.11	0	100
Silver (mg/L)	< 0.001	0.005	Twice Monthly	0.015	0	100
Zinc (mg/L)	0.02	0.1	Twice Monthly	0.1	0	100
Mercury (mg/L)	0.0001	0.0003	Twice Monthly	0.0008	0	100
Toluene (µg/L)	< 1	< 1	Twice Monthly	5	0	100
Methylene Chloride (µg/L)	< 1	1	Twice Monthly	5	0	100
1,1,1-Trichloroethane (µg/L)	< 1	< 1	Twice Monthly	5	0	100
2-Butanone (µg/L)	< 5	< 5	Twice Monthly	50	0	100
PCBs (µg/L)	< 0.065	< 0.065	Quarterly	NA	0	100
Max. Flow (MGD)	0.4	0.8	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.3	0.6	Continuous Recorder	NA	0	100
Avg. Fecal Coliform (MPN/100 ml)	< 2	146	Twice Monthly	200	0	100
Max Fecal Coliform (MPN/100 ml)	< 2	800	Twice Monthly	400	1 ^(b)	97

Notes:

See Chapter 5, Figure 5-6 for location of Outfall 001.

*% Compliance = [(Total No. Samples – Total No. Exceedances) / Total No. of Samples] x 100

MGD = Million Gallons per Day

MPN = Most Probable Number

NA = Not Applicable

SU = Standard Unit

^(a)The calculated % TSS removal was greater than 82 percent in August. The TSS results were below the analytical detection limit and therefore the actual percent removal cannot be precisely determined.

^(b)A permit exceedance of daily maximum fecal coliform concentration occurred in July of 2002. The sample was collected during cleaning of the UV disinfection system, which resulted in elevated coliform concentrations in the effluent for a very short period. The cleaning procedure has been modified to prevent future excursions.

Figure 3-1. Maximum Concentration of Copper Discharged from the BNL Sewage Treatment Plant, 1998–2002.

Figure 3-2. Maximum Concentration of Iron Discharged from the BNL Sewage Treatment Plant, 1998–2002.

Figure 3-3. Maximum Concentration of Lead Discharged from the BNL Sewage Treatment Plant, 1998–2002.

Figure 3-4. Maximum Concentration of Silver Discharged from the BNL Sewage Treatment Plant, 1998–2002.

Figure 3-5. Maximum Concentration of Nickel Discharged from the BNL Sewage Treatment Plant, 1998–2002.

organisms per 100 milliliters. Investigation of the incident showed that the wastewater sample was collected immediately after the UV disinfection system light bulbs were cleaned. Although every effort is taken to ensure that at least one bank of UV disinfection lights is functional, a slug of water lying between the two banks could have elevated levels of coliform. Changes to the cleaning sequence were implemented to prevent this from recurring. There were no other excursions of coliform found in subsequent samples.

3.6.1.3 Chronic Toxicity Testing

BNL's SPDES permit requires that "whole effluent toxicity" tests be conducted to ensure that

chemicals present in the STP effluent are not toxic to aquatic organisms. BNL's chronic toxicity testing program began in 1993 and continued through 2002. Samples are collected and tested quarterly. The program consists of performing seven-day chronic toxicity tests on two freshwater organisms: water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*). Sets of 10 animals are exposed to varying concentrations of the STP effluent (100, 50, 25, 12.5, and 6.25 percent) for seven days in each test. During testing, the size of fish and/or rate of reproduction for the water flea were measured and compared to untreated organisms (i.e., controls). The test results are submitted to NYSDEC for review.

Figure 3-6. Maximum Concentration of Zinc Discharged from the BNL Sewage Treatment Plant, 1998–2002.

Figure 3-7. Maximum Concentration of Mercury Discharged from the BNL Sewage Treatment Plant, 1998–2002.

In 2002, two of the five tests for water flea reproduction and three of the five tests for the minnow (i.e., two growth and one survival) revealed toxicity. Comparison of chemical data to the toxicity data gave no indication of any single element or compound that would have contributed to these observations. In August 2002, NYSDEC notified BNL that because BNL was unable to document that the STP effluent had no toxicity on the test organisms, a toxicity reduction evaluation (TRE) had to be performed. A TRE is a series of toxicity tests performed using samples of the STP effluent after treatment. Treatments may include pH adjustment, treatment with a chelating agent, or treatment with activated

carbon. The TRE sequence that BNL and NYSDEC developed includes treatment with carbon, with EDTA (a chelating agent), and with thiosulfate (another chelating agent). Due to the intermittent nature of toxicity, the TRE only needs to be performed if toxicity is found in concentrations less than 50 percent. Tests conducted in September and December did not fail this criterion, so TREs were not performed in 2002.

3.6.2 Recharge Basins and Stormwater

Outfalls 002 through 008 and Outfalls 010 through 012 discharge to groundwater, replenishing the underlying aquifer. Monitoring requirements for each of these discharges vary, depend-

ing on the type of wastewater received and the type of cooling water treatment reagents used. In 2002, there were many changes to the monitoring requirements for several of the recharge basins resulting from the change to the BNL SPDES permit. These changes include no monitoring of Outfalls 003 and 012, deletion of Outfalls 002A and 004, reduced monitoring at Outfall 007, and increased monitoring for Outfalls 002, 008, and 010. No monitoring requirements are imposed for Outfalls 009 and 011. Table 3-4 summarizes the monitoring requirements and performance results for 2002.

There were three permit excursions at these outfalls in 2002. Two were for exceedances of effluent limits for lead at Outfall 010. As reported in the 2000 and 2001 SERs, an area of lead-contaminated soil was discovered at Outfall 010. Resuspension of the sediment due to scouring causes elevated lead levels in water samples collected during rain events. To prevent further violation of the SPDES permit limits, a geotextile liner was installed at Outfall 010 in October. Subsequent sampling showed all lead levels to be within permit limits. A draft remedial action workplan has been prepared to remediate the contaminated soils. The third exceedance was for pH measured at Outfall 002. Investigation attributed the elevated pH to stormwater runoff from a construction site. Water samples collected immediately downstream of the site measured approximately 10 SU. The most probable cause was contact with freshly poured concrete and a new, crushed concrete parking lot base. Benchtop pH measurements of water mixed with crushed concrete were similar to those measured in the runoff. Improved erosion control measures should minimize future excursions of this nature.

3.7 SAFE DRINKING WATER ACT

The distribution and supply of drinking water is regulated under the federal SDWA. In New York State, implementation of the SDWA is delegated to the New York State Department of Health (NYSDOH) and administered by the Suffolk County Department of Health Services (SCDHS). Because BNL provides potable water to “more than 25 full-time residents,” it is subject to the same requirements as a public water

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

Analyte		Outfall 002	Outfall 002B	Outfall 003	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007 ^(a)	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Comp.
Flow (MGD)	N	CR	CR	CR	CR	CR	CR	CR	11	10	NA	NA	NA
	Min. Max.	0.007 0.51	0.00001 0.006	0.5 0.5	0.047 0.30	0.037 0.10	0.12 0.71	0.16 0.36	0.0008 0.54	0.00007 0.21	NA	NA	NA
pH (SU)	Min. Max.	6.3 9.4 ^(b)	7.2 8.6	6.7 7.8	6.2 8.4	7.2 8.2	7 8.3	6.7 7.8	6.5 8.1	6.5 8.0	NA 8.5, 9.0 ^(c)	1	>99
	N	12	10	2	12	12	12	NR	11	10	NA	0	100
Oil and Grease (mg/L)	Min. Max.	<5 <5	<5 <5	<5 <5	<5 <5	<5 <5	<1 <5	NR	<5 <5	<5 <5	NA 15	0	100
	N	NR	NR	NR	4	NR	NR	NR	NR	4	NA	0	100
Copper (mg/L)	Min. Max.	NR	NR	NR	0.004 0.008	NR	NR	NR	NR	0.006 0.04	NA 1.0	0	100
	N	4	NR	NR	NR	NR	NR	NR	4	4	NA	0	100
Aluminum (mg/L)	Min. Max.	0.03 0.067	NR	NR	NR	NR	NR	NR	0.1 1	0.6 1.8	NA 2.0	0	100
	N	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0	100

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

Analyte	Outfall 002	Outfall 002B	Outfall 003 ^(a)	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007 ^(a)	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Comp.
Lead (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4	NA	2	50
	Min.	NR	NR	NR	NR	NR	NR	NR	0.01	0.05		
	Max.	NR	NR	NR	NR	NR	NR	NR	0.1 ^(b)	0.05		
Vanadium (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4	NA	NA	NA
	Min.	NR	NR	NR	NR	NR	NR	NR	0.01	NA		
	Max.	NR	NR	NR	NR	NR	NR	NR	0.04	NPL		
Iron (total) (mg/L)	N	NR	NR	NR	NR	NR	2	NR	NR	NA	NA	100
	Min.	NR	NR	NR	NR	NR	53.4	NR	NR	NA		
	Max.	NR	NR	NR	NR	NR	160	NR	NR	NA		
Iron (dissolved) (mg/L)	N	NR	NR	NR	NR	NR	2	NR	NR	NA	NA	100
	Min.	NR	NR	NR	NR	NR	0.16	NR	NR	NA		
	Max.	NR	NR	NR	NR	NR	2.32	NR	NR	NA		
Chloroform (µg/L)	N	NR	NR	NR	NR	NR	NR	NR	NR	NA	NA	100
	Min.	4	NR	NR	NR	NR	NR	NR	NR	7		
	Max.	<0.5	NR	NR	NR	NR	NR	NR	NR	7		
Bromo- dichloromethane (µg/L)	N	NR	NR	NR	NR	NR	NR	NR	NR	NA	NA	100
	Min.	<0.5	NR	NR	NR	NR	NR	NR	NR	5		
	Max.	<1	NR	NR	NR	NR	NR	NR	NR	5		
1,1,1-trichloroethane (µg/L)	N	NR	4	NR	NR	NR	NR	11	NR	NA	NA	100
	Min.	<1	<1	NR	NR	NR	NR	<1	NR	NA		
	Max.	<1	<1	NR	NR	NR	NR	<1	NR	5		
1,1-dichloroethylene (µg/L)	N	NR	NR	NR	NR	NR	NR	NR	NR	NA	NA	100
	Min.	NR	NR	NR	NR	NR	NR	NR	NR	5		
	Max.	NR	NR	NR	NR	NR	NR	NR	NR	5		
Hydroxyethylene- diphosphonic Acid (mg/L)	N	4	4	4	4	4	NR	NR	NR	NA	NA	100
	Min.	<0.05	<0.05	<0.05	<0.05	<0.05	NR	NR	NR	NA		
	Max.	0.1	0.13	<0.05	0.0	0.3	NR	NR	NR	0.5		
Tolyltriazole (mg/L)	N	4	4	4	4	4	NR	NR	NR	NA	NA	100
	Min.	<0.005	<0.005	<0.005	<0.005	<0.005	NR	NR	NR	0.2		
	Max.	<0.005	<0.005	<0.005	<0.005	<0.005	NR	NR	NR	0.2		

Notes:

See Chapter 5, Figure 5-6 for locations of outfalls.

There are no monitoring requirements for Outfall 009, 011, and 012.

CR = Continuous Recorder

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

^(a) All monitoring at Outfall 003 and the total and dissolved iron monitoring at Outfall 007 was removed from the BNL SPDES permit with the February 2002 permit modification.^(b) The pH at Outfall 002 on 12/20/02 was 9.4 due to interaction of crushed concrete and newly poured concrete with stormwater at a construction site within the drainage area for this recharge basin.^(c) pH limit is 8.5 for Outfalls 005, 008, and 010. pH limit is 9.0 for Outfalls 002, 002B, 003, 006A, 006B, and 007.^(d) The total lead concentration exceeded permit limits in March and September due to resuspension of contaminated sediments at the outfall. Filtered samples were below the permit limit.

supplier. Monitoring requirements are prescribed annually by SCDHS, and a *Potable Water Sampling and Analysis Plan* (Chaloupka 2002) is prepared to comply with these requirements. The 1996 amendments to the SDWA required preparation of a source water assessment for all sources of public drinking water. In December 2000, the *BNL Source Water Assessment for Drinking Water Supply Wells* was prepared in satisfaction of this requirement (Bennett et al. 2000). The assessment is designed as a management tool to further protect the sole-source aquifer system underlying the BNL site.

3.7.1 Potable Water

BNL maintains six groundwater wells for on-site distribution of potable water. To meet drinking water standards, groundwater is treated with activated carbon or air stripping to remove VOCs. Groundwater from three of the six wells is also treated to reduce naturally occurring iron. As required by NYSDOH regulations, BNL monitors the potable wells regularly for bacteria, inorganics, organics, and pesticides. BNL also voluntarily monitors drinking water supplies for radiological contaminants. Tables 3-5 and 3-6 provide the potable water supply monitoring data for 2002. Color and iron exceeded drinking water standards in samples collected from three of the wells prior to distribution. Treatment at the water treatment plant effectively reduced these levels to below drinking water standards. Bacteria were detected in several samples collected from the wells. The presence of bacteria was determined to be contamination of the sample collection tap. Heating the tap effectively exterminated the bacterial source and all subsequent samples tested negative for bacteria. At the point of consumption, all drinking water complied with primary drinking water standards during 2002. Chapter 7 provides additional data on environmental surveillance tests performed on potable wells. This additional testing goes beyond the minimum SDWA testing requirements.

3.7.2 Cross-Connection Control

The SDWA requires that public water suppliers implement practices to protect the

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

BNL has installed and maintains approximately 200 cross-connection control devices at interfaces to the potable water main, and secondary control devices at the point of use. Approximately 190 cross-connection control units were tested in 2002, including primary and secondary devices. If a problem is encountered during testing, the device is repaired and re-tested to ensure proper function.

3.7.3 Underground Injection Control

Underground injection control wells are regulated under the SDWA. UICs at BNL 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, since NYSDEC did not adopt UIC regulatory requirements. (New York State regulates discharges of pollutants to cesspools under the SPDES program.) Under the EPA’s UIC program, all Class V injection wells must be included in an inventory maintained with the agency.

During 2002, BNL closed one UIC at Building 318 and one at Building 960. BNL installed 12 new UICs for management of stormwater due to the unavailability of storm water management systems. Applications were filed to install new UICs at Bldg. 974 (nine

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

Analyte	Well No. 4 ^a	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Well No. 12	Potable Distribution Sample	NYS DWS
Water Quality Indicators								
Total Coliform	ND	POS ¹	POS ¹	NA	POS ²	POS ²	ND	Negative
Color (Units)	NA	20 ^b	20 ^b	NA	< 5	< 5	< 5	15
Odor (Units)	NA	0	0	NA	0	0	0	3
Cyanide (µg/L)	NA	< 10	< 10	NA	< 10	< 10	< 10	NS
Conductivity (µmhos/cm)	NA	101	93	NA	298	301	229	SNS
Chlorides (mg/L)	NA	24.4	18.6	NA	21.6	14.6	14.1	250
Sulfates (mg/L)	NA	10.2	10.8	NA	9.3	8.5	12.7	250
Nitrates (mg/L)	NA	0.34	0.31	NA	0.43	0.47	0.48	10
Nitrites (mg/L)	NA	< 0.10	< 0.10	NA	< 0.10	< 0.10	< 0.10	1.0
Ammonia (mg/L)	NA	< 0.10	< 0.10	NA	< 0.10	< 0.10	< 0.10	SNS
pH (Standard Units)	NA	7.1	5.8	NA	5.8	5.7	5.7	SNS
MBAS (mg/L)	NA	< 0.08	< 0.08	NA	< 0.08	< 0.08	< 0.08	SNS
Metals								
Antimony (µg/L)	NA	< 5.9	< 5.9	NA	< 5.9	< 5.9	< 5.9	6.0
Arsenic (µg/L)	NA	< 3.0	< 3.0	NA	< 3.0	< 3.0	< 3.0	50
Barium (mg/L)	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2	< 0.2	2.0
Beryllium (µg/L)	NA	< 3.0	< 3.0	NA	< 3.0	< 3.0	< 3.0	4.0
Cadmium (µg/L)	NA	< 5.0	< 5.0	NA	< 5.0	< 5.0	< 5.0	5.0
Chromium (mg/L)	NA	< 0.01	< 0.01	NA	< 0.01	< 0.01	< 0.01	0.1
Fluoride (mg/L)	NA	< 0.10	< 0.10	NA	< 0.10	< 0.10	< 0.10	2.2
Iron (mg/L)	NA	1.83 ^b	0.77 ^b	NA	0.35 ^c	< 0.02	0.03	0.3
Lead (µg/L)	NA	< 1.0	1.5	NA	< 1.0	< 1.0	1.0	15
Manganese (mg/L)	NA	0.04	0.02	NA	0.01	< 0.01	0.01	0.3
Mercury (µg/L)	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2	< 0.2	2.0
Nickel (mg/L)	NA	0.39	< 0.04	NA	< 0.04	< 0.04	< 0.04	SNS
Selenium (µg/L)	NA	< 5.0	< 5.0	NA	< 5.0	< 5.0	< 5.0	50.0
Sodium (mg/L)	NA	19.1	21.5	NA	15.2	12.9	25.6	SNS
Silver (µg/L)	NA	< 10	< 10	NA	< 10	< 10	< 10	100
Thallium (µg/L)	NA	< 1.9	< 1.9	NA	< 1.9	< 1.9	< 1.9	2.0
Zinc (mg/L)	NA	< 0.02	< 0.02	NA	< 0.02	< 0.02	< 0.02	5.0
Radioactivity								
Gross Alpha Activity (pCi/L)	< 0.58	1.03	2.86	NA	0.87	0.94	NR	15.0
Beta (pCi/L)	< 1.69	< 2.15	1.86	NA	1.79	< 2.15	NR	50.0
Tritium (pCi/L)	< 286	< 353	< 353	NA	< 353	< 353	NR	20,000
Strontium-90 (pCi/L)	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	NR	8.0
Other								
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	NR	< 0.18	7
Calcium (mg/L)	NR	NR	NR	NR	NR	NR	9.6	SNS
Alkalinity (mg/L)	NR	NR	NR	NR	NR	NR	52.3	SNS

Notes:

See Figure 7-2 for well locations.

MBAS = Methylene Blue Active Substances

NA = Not Analyzed due to well shutdown

ND = Not Detected

NR = Analysis Not Required

POS = Positive for total coliform

SNS = Drinking Water Standard Not Specified

NYS DWS = New York State Drinking Water Standard

^a Well #4 was not operational during the annual sampling for water quality and metals.^b Water is treated at the WTP for color and iron before distribution.^c Potable well #11 tested above the NYS DWS for iron on 7/11/02.

Subsequent sampling and analysis resulted in an iron concentration of 0.01 mg/L. The 7/11/02 analysis is therefore considered a false positive.

¹ Potable wells #6 and #7 tested positive for total coliform when sampled on 7/11 and 7/17/02. The wells tested negative for total coliform on 7/17/02 after sterilization of the sampling port.² The treated (granulated activated carbon) systems for potable wells #11 and #12 tested positive for total coliform on 7/1/02 and 10/10/02 respectively. The systems tested negative for total coliform after sterilization of the sampling ports on 7/15/02 and 10/14/02 respectively.

CHAPTER 3: COMPLIANCE STATUS

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 μg/L	Well No. 10	Well No. 11	Well No. 12	NYS DWS
Dichlorodifluoromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Vinyl Chloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2
Bromomethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Fluorotrichloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Methylene Chloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
trans-1,2-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
cis-1,2-dichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
2,2-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Bromochloromethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,1-trichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Carbon Tetrachloride	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Trichloroethene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Dibromomethane	< MDL	< MDL	< MDL	1.5	< MDL	< MDL	< MDL	5
trans-1,3-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
cis-1,3-dichloropropene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,2-trichloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Trihalomethanes	< MDL	7.0	17.1	12.4	< MDL	< MDL	< MDL	100
1,3-dichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Chlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,1,1,2-tetrachloroethane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Bromobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,3-trichloropropane	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
2-chlorotoluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
4-chlorotoluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,3-dichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,4-dichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2-dichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,4-trichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Hexachlorobutadiene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
1,2,3-trichlorobenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Benzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Toluene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5
Ethylbenzene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	5

(continued on next page)

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 µg/L	Well No. 10	Well No. 11	Well No. 12	NYS DWS
m,p-xylene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
o-xylene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
Styrene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
Isopropylbenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
n-propylbenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
1,3,5-trimethylbenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
tert-butylbenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
1,2,4-trimethylbenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
sec-butylbenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
4-Isopropyltoluene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
n-butylbenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
methyl tert. Butylether	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Lindane	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.2
Heptachlor	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.4
Aldrin	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
Heptachlor Epoxide	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.2
Dieldrin	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
Endrin	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.2
Methoxychlor	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	40
Toxaphene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	3
Chlordane	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	2
Total PCB's	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.5
2,4,5,-TP (Silvex)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	10
Dinoseb	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Dalapon	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Pichloram	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Dicamba	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Pentachlorophenol	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	1
Hexachlorocyclopentadiene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
Bis(2-ethylhexyl)Phthalate	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Bis(2-ethylhexyl)Adipate	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Hexachlorobenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	5
Benzo(A)Pyrene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Aldicarb Sulfone	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	SNS
Aldicarb Sulfoxide	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	SNS
Aldicarb	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	SNS
Oxamyl	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
3-Hydroxycarbofuran	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Carbofuran	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	40

(continued on next page)

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 µg/L	Well No. 10	Well No. 11	Well No. 12	NYS DWS
Carbaryl	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Methonmyl	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	SNS
Glyphosate	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Diquat	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
1,2-dibromomethane	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.05
1,2-dibromoethane	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.05
1,2-dibromo-3-chloropropane	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.2
2,4,-D	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Alachor	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	2
Simazine	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Atrazine	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	3
Metolachor	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Metribuzin	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Butachlor	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50
Endothall	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	100
Propachlor	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	50

Notes:

See Chapter 7, Figure 7-2 for well locations.

For compliance determination with New York State Department of Health standards, potable water samples were analyzed quarterly during the year by H2M Labs Inc., a New York State-certified contractor laboratory.

The minimum detection limits for principal organic compound analytes are 0.5 µg/L. Minimum detection limits for synthetic organic chemicals and micro-extractables are compound-specific, and in all cases are less than the New York State Department of Health drinking water standards.

All values are the maximum observed concentration for all samples collected.

<MDL = Less than the minimum detection limit for the analyte in question

SNS = Drinking Water Standard not specified

NYS DWS = New York State Drinking Water Standard

WTP = Water Treatment Plant

devices) and Buildings 634, 635, and 637 (one device each). The UIC inventory on file with EPA will be updated as these devices are installed.

3.8 SPILL PREVENTION, EMERGENCY PLANNING, AND REPORTING

Several federal, state, and local regulations address the management of storage facilities containing chemicals, petroleum, and other hazardous materials. These regulations include specifications for storage facilities, requirements for release planning documentation, and release reporting. The following subsections describe BNL's compliance with these regulations.

3.8.1 Preventing Oil Pollution and Spills

BNL must maintain a Spill Prevention Control and Countermeasures (SPCC) Plan as a

condition of its Major Petroleum Facility License and as required by the Oil Pollution Act. This plan is part of BNL's emergency preparedness program and outlines mitigating and remedial actions that would be taken in the event of a major petroleum release. The plan also provides information regarding release prevention measures, the design of storage facilities, and maps detailing their locations. The SPCC Plan is filed with NYSDEC, EPA, and DOE. The plan is updated triennially and was last updated in December 2000 (Chaloupka 2000). BNL remained in full compliance with the SPCC requirements in 2002.

Revisions to the SPCC rules were issued in July 2002 to reduce the reporting burden on some facilities while making the rule language easier to understand. One benefit for BNL is the

reduced frequency of updating the SPCC plan. The revised rule calls for updates every five years as compared with the old rule of every three years. Since BNL will have to update its plan to address issues such as a revised cross-reference and an updated training section, BNL will update the plan in 2003, then modify the review cycle to five years.

BNL also maintains a facility response plan that outlines emergency response procedures to be implemented in the event of a worst-case discharge of oil. EPA again reviewed this plan in 2002 and identified several technical deficiencies and formatting issues. The EPA comments were reviewed and a revised plan was transmitted to the EPA in September 2002. Due to the time needed to revise several maps, these were transmitted to the EPA in November 2002.

3.8.2 Local and State Reporting Requirements

The Emergency Planning and Community Right-to-Know Act (EPCRA) (42 USC 11001) and Title III of the Superfund Amendments and Reauthorization Act (SARA) require that facilities report inventories and releases of certain chemicals that exceed specific storage thresholds to the local emergency planning committee and the state emergency response commission. Community Right-to-Know requirements are codified under 40 CFR Parts 355, 370, and 372. BNL complied with these requirements in 2002 through the submittal of the required reports under EPCRA Sections 302, 303, 311, and 312. During 2000 and 2001, the Part 313 Toxic Release Inventory thresholds were significantly lowered for mercury, polychlorinated biphenyls (PCBs), and lead. Mercury and PCB thresholds were lowered from 10,000 pounds to just 10 pounds, and lead from 10,000 to 100 pounds. In 2002, BNL was required to submit reports for these three classes of chemicals. In total, 600 pounds of mercury and 30,668 pounds of lead were reported in the Form R Toxic Release Inventory Report, which was submitted in June 2002. However, due to an oversight, PCB releases were not reported with the 2002 Form R. Approximately 14 pounds of PCBs were disposed in 2002, mainly from restoration

activities and disposal of spill residuals from leaks from old fluorescent light ballasts. A revised report will be submitted in early 2003 to correct this omission. Additionally, the total weight of lead disposed in 2002 will be revised to 48,302 pounds.

There were no releases of extremely hazardous substances reported under Part 304 during 2002.

3.8.3 Spills and Releases

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

During 2002, there were 52 spills, of which 19 met external agency reporting criteria. These 19 reports are summarized in Table 3-7. The remaining releases were either small-volume releases to containment areas or other impermeable surfaces, or were gaseous releases that did not exceed a reportable quantity. Seventeen of the 19 reported releases involved very small volumes (< 10 gallons) of petroleum products that reached soils. New York State has a “zero tolerance” level for releases of oils to soil or water; consequently, spills of any amount to soil are reportable. Of the 17 spills, eight were releases from hydraulic systems on earth-moving equipment, four were associated with diesel fuel releases, two were for gasoline

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

BNL Spill Number and Date	Material and Quantity	ORPS Report*	Source/Cause and Corrective Actions
02-02 1/16/02	Hydraulic fluid 9 gallons	No	The hydraulic line on a BNL Load Lugger being used in the Plant Engineering (EP) Transfer Yard failed, resulting in a spill to soil. The operator immediately put plastic bins under the vehicle to capture the leak and put absorbent pads on the affected soil. BNL personnel removed the soil and absorbent material and containerized them for off-site disposal. The initial report to regulatory agencies estimated that 15 gal of oil had been spilled, based on the capacity of the Load Lugger and the amount captured in the plastic bins. However, later calculations indicated a smaller spill, of 7 to 9 gallons.
02-04 1/28/02	Hydraulic fluid 2 quarts	No	The hydraulic line failed on a backhoe being used to chop concrete at the Brookhaven Graphite Research Reactor (BGRR) remediation project at Bldg. 701. The operator immediately put a plastic container under the backhoe, collecting most of the hydraulic fluid, but about 2 quarts went onto the ground. BNL personnel removed the impacted road base material and containerized it for off-site disposal.
02-08 3/1/02	Fuel oil (No.2) 2-5 gallons	No	During the planned removal of a 1,000-gal UST at Bldg. 575, three pin-size holes were seen in the side of the tank and the underlying soil looked dark. With a Suffolk County Sanitary Engineer present, oily soil was removed until clean soil was encountered, resulting in a hole extending about 11 ft from grade in the area below the tank. About 6 cubic yards of oily soil were collected for off-site disposal. Samples taken after excavation was complete did not show any residual contamination.
02-09 3/5/02	Gasoline 2-4 gallons	No	The operator of a BNL pickup truck noticed gasoline spilling from one of the two gas tanks on board. Investigation revealed that during installation, the rear return line had been crimped so fuel could move from one tank to the other without an equalizing return. This resulted in overfill of one of the tanks while driving. The spill impacted the asphalt road surface and nearby soil. BNL personnel removed the soil and absorbent material and containerized them for off-site disposal.
02-11 3/7/02	Hydraulic fluid 1 gallon	No	While a BNL front-end loader was clearing the area behind Bldg. 650, a hydraulic line failed and spilled less than 1 gal of fluid onto the soil. BNL spill personnel removed the soil and containerized it for off-site disposal.
02-13 3/18/02	Hydraulic fluid ~ 1 quart	No	The hydraulic line for the bucket of a contractor's excavator failed while the old storm drain system at Building 650 was being removed. Hydraulic fluid leaked onto a concrete pad and soil. A tray was put under the leak and absorbent material was put on the ground. BNL personnel removed the soil and the absorbent material, containerizing them for off-site disposal.
02-14 3/29/02	Diesel fuel > 10 gallons	Yes (CH-BH- BNL-PE- 2002-0001)	During the planned removal of a 275-gal UST at Bldg. 423, rust and holes were seen in the side of the tank and the underlying soil was darker than normal. With a Suffolk County Sanitary Engineer present, contaminated soil was removed until the 12-foot limit of the backhoe was reached, resulting in a hole 11 ft deep and 7 ft wide. Samples taken at this point did not show any contamination. A sheet of plastic was placed to prevent rainwater intrusion and the hole was backfilled. Approximately 15 cubic yards of contaminated soil were removed for off-site disposal.
02-30 7/1/02	Fuel oil (No. 2) < 5 gallons	No	During the planned removal of a 4,000-gal UST at Bldg. T-91, two pin-size holes were seen in the top and bottom of the tank and the soil underneath looked dark. With a Suffolk County Sanitary Engineer present, soil was removed until clean soil was encountered. Nine cubic yards of soil were collected for off-site disposal. The SCDHS engineer was confident all contaminated soil had been removed and no end-point samples were required.
02-32 7/2/02	Fuel oil (No. 2) 100 gallons	Yes (CH-BH- BNL-PE- 2002-0006)	During the planned removal of a 1,000-gal UST on the north side of Building T-90, several holes were seen in the tank. With a Suffolk County Sanitary Engineer present, soil was removed until clean soil was encountered at about 13 ft. The SCDHS engineer was confident all contaminated soil had been removed and no end point samples were required. Thirty cubic yards of soil were containerized for off-site disposal.
02-33 7/11/02	Hydraulic Fluid 2 gallons	No	A seal failed on the lifting arm of a power-screen being used at the glass holes remediation area, releasing 2 gal of hydraulic fluid onto the soil. BNL personnel removed the soil and absorbent material for off-site disposal. Because there is a geotextile under that soil, this was considered a release in a contained area rather than to the environment, so regulatory reporting was unnecessary. However, after the report was written, the geotextile material was discovered to be permeable (i.e., not a geomembrane); therefore, a spill to the environment had occurred and regulatory reporting was necessary.

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Table 3-7. Summary of Chemical and Oil Spill Reports *(concluded)*.

BNL Spill Number and Date	Material and Quantity	ORPS Report*	Source/Cause and Corrective Actions
02-34 7/15/02	Gasoline 2-3 gallons	No	BNL personnel accidentally ran over a fence post behind Bldg. 463, piercing the gasoline tank on their utility vehicle. Approximately 2 to 3 gallons of gasoline were released to the asphalt road and adjoining soil. BNL personnel removed the soil and absorbent material and containerized them for off-site disposal.
02-35 8/1/02	Diesel fuel 2 gallons	No	A portable trailer-mounted emergency generator leaked diesel fuel from a fitting on the fuel ejector line. Diesel fuel leaked into the tray below and onto the asphalt and nearby grass and soil. BNL personnel removed the soil and absorbent material, containerizing them for off-site disposal.
02-36 8/7/02	Hydraulic fluid <1 pint	No	A Payloader at the glass hole remediation area experienced a failure in the hydraulic system, resulting in a spill to the soil. The vehicle was moved onto plastic and BNL personnel removed the soil and containerized it for off-site disposal.
02-38 8/12/02	Hydraulic fluid 2 gallons	No	A BNL Payloader working in the tree recycling area drove over a tree stump that sheared the fitting off the hydraulic line for the front bucket, releasing hydraulic fluid to the cab of the Payloader and soil beneath it. BNL personnel performed on-site repairs to move the Payloader and initiate cleanup. They removed the affected soil and trees and containerized them for off-site disposal.
02/39 8/22/02	Hydraulic fluid 1 quart	No	A hydraulic fitting failed on a BNL forklift during outdoor use near Bldg. 244. The spill created a 20- to 30-ft line of hydraulic fluid along the building's asphalt parking lot, concrete, and across a 4-ft section of deteriorated asphalt where soil was exposed. BNL personnel removed the affected soil and absorbent material and containerized them for off-site disposal.
02-41 8/29/02	Diesel fuel < 1 quart	No	A 5-gal bucket containing used diesel fuel filters in the back of a BNL pickup truck tipped over during a heavy rainstorm, spilling diesel fuel on the truckbed and the asphalt behind Bldg. 452. Rainwater carried petroleum sheen to the nearby stormwater catch basin. Absorbent pigs and pads were put around the catch basin and a section of the road was closed to traffic, to eliminate spread of the material to other areas. Additional absorbent pigs were placed at the cross section of this leg of the stormwater system and the main channel to prevent diesel fuel from reaching the HS recharge basin that collects storm water from this area of the site. The recharge basin was inspected for visual signs of petroleum sheen but none were found. Corrective actions resulting from the spill included a twist-on lid for the bucket and securing the bucket in the truckbed with bungee cords.
02/45 10/9/02	Diesel fuel 2 pints	No	During an asphalt repaving project on Railroad Ave. and associated parking lots/areas, contractor personnel released diesel fuel to the adjacent grass when refueling an asphalt roller truck with their truckbed-mounted fuel tank delivery hose. BNL personnel removed the impacted soil and grass and containerized them for off-site disposal.
02-48 11/7/02	Fuel oil (No. 2) Unknown	Yes (CH-BH- BNL-BNL- 2002-0012)	The Environmental Restoration Division is characterizing the former Hazardous Waste Management Facility in preparation for remediation. A portion of the investigation includes collecting soil samples near a UST formerly used for fuel. Analysis of the samples showed petroleum products above NY State soil action levels. Additional soil samples will be collected to delineate the area of contamination and estimate the amount of fuel oil represented.
02-49 11/19/02	Diesel fuel 4 gallons	No	The fuel line on a BNL tractor-trailer failed near Bldg. 938, resulting in a spill to soil. Cleanup was begun immediately and the impacted soil was excavated based on odor. Nine 55-gal drums of contaminated soil were removed from an area approximately 17 ft in diameter and 2 in. deep. One area in the center of the circle was excavated to approximately 8 in. An SCDHS engineer inspected the remediation on 11/20/02 and agreed that the spill had been satisfactorily remediated; therefore, soil sampling was not needed.

*ORPS Report: Release is reportable to the Department of Energy under the requirements of DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information.

releases, and three were associated with underground tank removals.

There were two larger spills reported during 2002, each exceeding 10 gallons. Both spills were associated with leaks from underground storage tanks that were discovered during tank removal; one tank stored diesel fuel and the second tank stored fuel oil. Table 3-7 provides information on the reportable spills, including the date of the spill, material involved, and quantity released. It also includes a summary of the cause and corrective actions taken, and notes whether the spill was reportable to DOE through the Occurrence Reporting and Processing System (ORPS).

Five other incidents that were environmental in nature were reported to DOE through ORPS. These incidents are summarized in Table 3-8. All incidents were addressed through the identification and implementation of corrective actions geared toward the root cause. No off-site or on-site environmental consequences arose from the ORPS incidents.

3.8.4 MAJOR PETROLEUM FACILITY LICENSE

The storage of 2.3 million gallons of petroleum products (principally No. 6 fuel oil) subjects BNL to Major Petroleum Facility (MPF) licensing by NYSDEC. BNL maintains an MPF License for storing and transferring oil at the Central Steam Facility. During 2002, BNL remained in full compliance with license requirements. The license requires BNL to monitor groundwater in the vicinity of the seven active, aboveground storage tanks that range in size from 60,000 to 600,000 gallons. The license also requires that BNL inspect storage facilities monthly and test the systems for leak detection, high level monitoring, and secondary containment. Tank integrity is also checked periodically. Groundwater monitoring consists of monthly checks for floating products and twice-yearly tests for volatile and semivolatile organic compounds. In 2002, no contaminants or floating products were found in groundwater wells attributable to MPF activities. See Chapter 7 for additional information on groundwater monitoring results.

The petroleum facility is inspected annually by NYSDEC. The 2002 annual inspection was conducted in April. The inspection noted six

conditions that required corrective action, one related to the operations at the MPF and four related to diesel fuel storage at Bldg. 326. At the MPF, the inspection noted that a modification was needed to the rectifiers that provide cathodic protection of the aboveground storage tanks. At Bldg. 326, noted issues included color-coding of fill ports, accumulation of precipitation, repair to rusting tank saddles on one of three tanks, and testing of the secondary containment system. All issues were closed by the end of the year. In followup to issues raised during the 2001 inspection, a meeting was held with NYSDEC in March to discuss the path forward to repairing the secondary containment serving Tank No. 12. As previously documented, the containment for this tank did not meet the permeability rate recommended in New York State guidelines. BNL and NYSDEC agreed to an 18-month repair schedule. A new containment basin will be constructed by September 30, 2003.

3.8.5 Chemical Bulk Storage

All underground tanks, and all aboveground tanks larger than 185 gallons that store specific chemical substances listed in 6 NYCRR 597, must be registered with NYSDEC. BNL holds a Hazardous Substance Bulk Storage Registration Certificate. At the start of 2002, BNL had 14 registered tanks: 13 aboveground tanks storing water treatment chemicals (for cooling towers, wastewater, or potable water treatment), and one tank for storing gallium trichloride formerly used in neutrino experiments. The tanks range in size from 200 to 2,000 gallons. During 2002, there were numerous changes to the inventory of tanks storing chemicals. Six of nine 200-gallon tanks storing sodium hypochlorite for potable water disinfection were replaced with tanks storing only 150 gallons, thereby deregulating them under the Chemical Bulk Storage program. These tanks are still regulated under Suffolk County Sanitary Code Article 12 and are managed in accordance with BNL procedures designed to conform to Suffolk County requirements. One of the 200-gallon tanks was removed from service, and a 1,000-gallon hypochlorite storage tank was replaced by two 500-gallon tanks to address fire protection requirements.

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

<p>ORPS* ID: CH-BH-BNL-BNL-2002-0001</p> <p>On the weekend of Dec. 8-9, 2001, approximately 8,000 gal of rainwater flooded Bldg. 801's basement. This was caused by excavation damage to the stormwater piping from the Brookhaven Graphite Research Reactor (BGRR) and surrounding areas, coupled with $\frac{3}{4}$" of rain. Rainwater collected in the F and D waste cells, designated as radiological areas. Samples of water on the floor of these cells just after the flood showed Cs-137 levels between 167 and 219 pCi/L. (The drinking water standard for Cs-137 is 200 pCi/L.) Although the walls and floor in this area are coated with an epoxy-based material to prevent liquids from escaping, it had failed in some areas of the floor. As plans were being developed to manage the water, its level in the waste cells was seen to be decreasing. This was first attributed to evaporation, but investigations showed that up to 3,000 gal of slightly contaminated water might have seeped through the basement floor and walls into the surrounding soil. The contents of the waste tanks were pumped to a tanker trailer on 3/8/02, for off-site disposal as radioactive waste. Analysis of the combined rain- and wastewater found a Cs-137 level of 724 pCi/L and a Sr-90 level of 560 pCi/L. A technical team was formed which processed the data associated with the contaminated rainwater and developed recommendations for assessing the environmental impact and preventing a recurrence. This team determined that the groundwater threat from Cs-137 was unlikely, because Cs-137 is attracted to soil. The Sr-90 does threaten the groundwater, but because Sr-90 migrates slowly, it should be remediated by a groundwater cleanup system to be installed in FY 2004. The potential groundwater contamination from this release will be evaluated as part of the OU III characterization study.</p>	<p>Date: 12/14/01 Status: Open: While DOE has accepted the ORPS report, one corrective action remains open: the evaluation of potential groundwater contamination as part of the Operable Unit III characterization study.</p>
<p>ORPS* ID: CH-BH-BNL-BNL-2002-0002</p> <p>BNL routinely samples meat from deer killed in vehicular accidents both on and off site. Samples are analyzed for Cs-137 and results are reported in the annual Site Environmental Report. A deer sample from the William Floyd parkway near the laboratory was found to have a Cs-137 concentration of 21.1 pCi/g after confirmatory analysis—twice the highest concentration found to date, from a sample in 1996. Using the New York State Department of Health (NYSDOH) assumptions for annual deer meat consumption, this sample would result in a dose of 30 millirems, exceeding the New York State limit of 10 millirems per year. The Community Advisory Council was informed of this at its monthly meeting on 2/14/02. The sample was submitted to NYSDOH for analysis, where it showed only 8.0 to 8.7 pCi/g of Cs-137. A BNL investigation team was formed and found that the sample had been recounted three times on the same detector at the BNL Analytical Services Laboratory (ASL) using an inappropriate calibration standard. The sample was recounted using a different detector and the results confirmed the lower Cs-137 result obtained by NYSDOH. Corrective actions focused on reducing the potential for deer access to contaminated areas and improving data analysis and quality assurance measures.</p>	<p>Date: 1/31/02 Status: Closed: All corrective actions have been completed.</p>
<p>ORPS* ID: CH-BH-BNL-BNL-2002-0003</p> <p>Elevated stormwater lead concentrations reported in the 1999 and 2000 Site Environmental Reports, which were above the New York State Groundwater discharge standard of 50 µg/L, prompted an investigation. Soil sampling conducted by BNL and the Suffolk County Department of Health in the Fall of 2001 found soil lead levels as high as 55,000 mg/kg. Historical burning of waste oils and discharge of boiler wash water from the Central Steam Facility to this outfall is thought to be the most likely direct and root cause of the soil contamination. A remedial action plan and cost analysis were developed; the remediation of this area will proceed once funding is obtained.</p>	<p>Date: 3/5/02 Status: Closed: All corrective actions have been completed.</p>
<p>ORPS* ID: CH-BH-BNL-PE-2002-0002</p> <p>The BNL garbage truck alarmed the vehicle radiation monitor as it drove through. Facility Support technicians surveyed the contents after they were emptied and found that several 24" x 24" x 2" air filters were radiologically contaminated. An investigation revealed that the filters came from air handlers in Bldg. 914. The filter replacement was completed on a general radiation work permit and the technicians did not notice the Activation Check Required exit requirement on the Radiation Area posting outside of Bldg. 914. Future work planning will ensure that location-specific hazards and necessary controls are explicitly conveyed to workers.</p>	<p>Date: 4/29/02 Status: Closed: All corrective actions have been completed.</p>
<p>ORPS* ID: CH-BH-BNL-BNL-2002-0008</p> <p>A commercial driver making a routine delivery noticed a wet container in the truck. He contacted the material during his inspection. When notifying BNL personnel of the incident, he mentioned numbness in his hands and arms and was taken to a local hospital for observation and treatment. The shipping manifest listed four bottles of dichloromethane, one of which had broken during transit. The shipping company (New Penn) evaluated the incident and found that their loading and bracing procedures had not been followed precisely. New Penn provided BNL with the measures taken to prevent recurrence.</p>	<p>Date: 7/1/02 Status: Closed: All corrective actions have been completed.</p>

* Occurrence Report: Release is reportable to the Department of Energy under the requirements of DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information.

NYSDEC did not inspect the Chemical Bulk Storage facilities in 2002. In followup to open items from the 2001 Chemical Bulk Storage inspection, BNL constructed chemical off-loading pads at four facilities. These pads are constructed of concrete and are designed to contain spillage should it occur from delivery vehicles or transfer hoses. At the end of 2002, all conventional construction was complete, but due to cold weather, coating the containment areas to ensure impermeability was deferred to the spring of 2003.

3.8.6 County Storage Requirements

Article 12 of the Suffolk County Sanitary Code, administered by SCDHS, 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. It also specifies administrative requirements, such as identification, registration, and spill reporting procedures. In 1987, BNL entered into a voluntary Memorandum of Agreement with SCDHS in which DOE and BNL agreed to conform to the environmental requirements of Article 12.

BNL has approximately 411 active storage facilities listed in the Suffolk County Tanks Database. Also included in the county database are another 41 storage facilities associated with environmental restoration activities conducted under the CERCLA program; these facilities are not regulated under Article 12. BNL storage facilities listed in the database include those storing fuel (some of which are also regulated under the MPF license), wastewater, and chemicals, as well as storage facilities used to support laboratory research.

At the close of 2002, 175 of the active tanks listed in the Suffolk County database fully conformed with all Article 12 administrative, maintenance, and technical requirements. Approximately 141 active tanks require administrative corrective actions (e.g., corrected registrations, submittal of as-built design plans to SCDHS, proper labeling, etc.) or maintenance (e.g., replacement of light bulbs). Fewer than 5 percent of the active facilities were found to be in

technical nonconformance with Article 12 requirements (e.g., no secondary containment, no high-level detection).

BNL has an ongoing program to upgrade or replace existing storage facilities and to meet with representatives of SCDHS regularly to discuss storage issues. In September 2000, BNL initiated a project plan to achieve full conformance with Article 12 requirements by the end of calendar year 2003. This Article 12 Improvements Project is primarily divided into two major tasks. The first task involves designing and constructing modifications to storage facilities that require technical upgrades to bring them into conformance with Article 12. The second task involves preparing as-built design plans for many other existing on-site storage facilities that already conform to Article 12 standards. At the close of 2002, construction activities for those tanks requiring upgrades were completed and final as-built plans for approximately 50 registered storage facilities had been prepared. In 2003, BNL will arrange for final inspections of all storage facilities included in the upgrade project and will prepare various as-built packages for transmittal to SCDHS for review and final approval.

Revisions to the *Storage and Transfer of Toxic or Hazardous Materials* laboratory procedure, which primarily addresses SCDHS Article 12 regulations, were completed in April 2002. In an effort to continuously improve BNL operations and minimize impacts to the environment, the procedure was revised to include measures for handling surface water runoff from outdoor storage or work areas (e.g., excess material storage yards, welding areas, shielding storage areas). In addition, design guidelines and requirements for planning, operating, and dismantling an outdoor storage or work area were included in these revisions.

3.9 RESOURCE CONSERVATION AND RECOVERY ACT

The Resource Conservation and Recovery Act (RCRA) regulates hazardous wastes that could present risks to human health or the environment if mismanaged. 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. BNL is considered a large-quantity generator and has a RCRA permit to store hazardous wastes for one year prior to off-site shipment for treatment and disposal. As noted in Chapter 2, BNL has a number of 90-day storage and satellite accumulation areas.

On August 28, 2002, NYSDEC conducted its annual inspection of the BNL hazardous waste management operations and issued a Preliminary Finding and Administrative Complaint for three administrative deficiencies. One item, a missing label, was corrected during the inspection. The two remaining issues deal with the management of CERCLA-derived wastes and preparation of a Land Disposal Restriction for intra-laboratory shipments of waste. These deficiencies are being reviewed by BNL management and counsel to determine the validity of the issues and their applicability to BNL.

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

BNL updates the *BNL Site Treatment Plan* annually and submits it to NYSDEC. The update documents the current mixed waste inventory and describes efforts undertaken to seek new commercial treatment and disposal outlets for various waste streams. Treatment options for most of the mixed waste now in storage have been identified, and most of the current inventory will be shipped off site for treatment and disposal in 2003. BNL will continue to update the treatment plan for wastes that have no identified disposal pathway.

3.10 POLYCHLORINATED BYPHENYLS

The storage, handling, and use of PCBs are regulated under the Toxic Substance and

Control Act (TSCA). Capacitors manufactured prior to 1970 that are believed to be oil-filled are handled as if they contain PCBs, even when the existence of PCBs cannot be verified through an investigation of the manufacturer's records. All equipment containing PCBs must be inventoried, except for capacitors containing less than 3 pounds of dielectric fluid and items with a concentration of PCB source material of less than 50 parts per million. The PCB inventory is updated by July 1 of each year. All PCB-containing articles or PCB-contaminated equipment must be labeled. BNL responds to any PCB spill in accordance with standard emergency response procedures. BNL was in compliance with TSCA requirements in 2002.

3.11 PESTICIDES

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

3.12 WETLANDS AND RIVER PERMITS

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

Activities that could require review under the Natural Resource Protection Program are identi-

fied 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, BNL must comply with the permit conditions.

In 2002, four projects were permitted under this program, two ongoing and two new. The first ongoing project was continuation of the Sewage Treatment Plant upgrades project. This project was completed in early 2002 and the permit closed in July. The second ongoing project was construction of a new recharge basin within the RHIC area. Construction commenced in October 2002 and will be continued in 2003. Due to potential impacts on the tiger salamander, a NYS endangered species, work can only be completed from August through November. The two new projects involved modifications to a liner covering sections of the RHIC tunnel and construction of a new material storage facility. Additionally, an equivalency permit for Peconic River pilot studies was issued by NYSDEC in January 2002. This permit authorizes the demonstration of two techniques being studied for the remediation of contaminated sediments: vacuum guzzling and excavation and wetland restoration. All work under this equivalency permit was completed in summer 2002. A separate permit will be obtained for full-scale remediation of the Peconic River, which is expected to commence in 2003.

3.13 ENDANGERED SPECIES ACT

In 1999, NYSDEC revised its list of endangered, threatened, and “species of special concern.” The tiger salamander (*Ambystoma t. tigrinum*) is the only state endangered species found at BNL. Tiger salamanders are listed in New York State as endangered 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. BNL

has prepared a *Wildlife Management Plan* (Naidu 1999) that formalizes the strategy and actions needed to protect 14 confirmed tiger salamander breeding locations identified on site. The strategy includes identifying and mapping habitats, monitoring breeding conditions, improving breeding sites, and controlling activities that could negatively affect breeding.

The banded sunfish (*Enneacanthus obesus*) and swamp darter (*Etheostoma fusiforme*) are found in the Peconic River drainage areas on site at BNL. Both are listed as threatened species within New York State. The reason for this status is that the only remaining populations of these fish in New York are on eastern Long Island. Measures taken or being taken by BNL to protect the banded sunfish and swamp darter and their habitat include the following:

- Eliminating, reducing, or controlling pollutant discharges
- Upgrading the STP to reduce nitrogen loading in the Peconic River (completed in 1998)
- Monitoring populations and water quality
- Maintaining adequate flow to the river to enable the fish to survive drought
- Minimizing disturbances to the river and adjacent banks

The frosted elfin (*Callophrys irus*) is a small, amber-colored butterfly that depends on lupine, a wildflower in the pea family. In the past, a population has utilized an area of lupine on BNL grounds. This habitat still exists and it is assumed that the butterfly is still present. Management of this habitat and surveys for this butterfly have been added to BNL’s Natural and Cultural Resource Management Program.

BNL also has eight species on site 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. The species of special concern found at BNL include the marbled salamander (*Ambystoma opacum*), the spotted turtle

(*Clemmys guttata*), the eastern box turtle (*Terrapene carolina*), the eastern hognosed snake (*Heterodon platyrhinos*), the horned lark (*Eremophila alpestris*), the whip-poor-will (*Caprimulgus vociferus*), the vesper sparrow (*Poocetes gramineus*), and the grasshopper sparrow (*Ammodramus savannarum*). Management efforts taken for the tiger salamander also benefit the marbled salamander. At present, no additional protective measures are planned for the eastern box turtle or spotted turtle, as little activity occurs within their known habitat on site. Observations of the eastern hognosed snake were reported on five different occasions in 2002. The only other time this snake has been reported on site was in 1994 (LMS 1995). BNL will be evaluating bird populations as part of the management strategy outlined in the *Wildlife Management Plan*. (Naidu 1999). Data concerning species of special concern are used appropriately in making management decisions regarding those species. In addition to the bird species mentioned above, 19 other bird species listed as species of special concern and two federally threatened species have been observed on site or flying over the site during spring and fall migrations.

BNL has 17 plant species protected under state law. One is a threatened plant, stiff goldenrod (*Solidago rigida*), and one is a rare plant, the narrow-leafed bush clover (*Lespedeza angustifolia*). The other 15 species are considered to be “exploitably vulnerable,” which means that they may become threatened or endangered if factors that result in population declines continue. These plants are currently sheltered at BNL due to the large areas of undeveloped pine barren habitat on site. Locations of these rare plants must be determined, populations estimated, and management requirements established. Management of protected plants will be included in the Natural Resource Management Plan currently under development. See Chapter 6 for more information.

3.14 EXTERNAL AUDITS AND OVERSIGHT

A number of federal, state, and local agencies oversee BNL activities. BNL was inspected by federal, state, or local regulators on 12 occasions in 2002. These inspections are summa-

rized in Section 3.14.1. In 2002, the Suffolk County Department of Health Services maintained a full-time on-site staffer who provided day-to-day oversight of BNL activities. In addition to external audits and oversight, BNL has a comprehensive self-assessment program, as described in Chapter 2.

3.14.1 Inspections by Regulatory Agencies

- *Hazardous Waste.* NYSDEC conducted a RCRA/hazardous waste compliance inspection in August 2002. See Section 3.9 for information regarding this inspection.
- *Air Compliance.* NYSDEC conducted an annual inspection of the Central Steam Facility in March. No issues were identified during this inspection.
- *Potable Water.* SCDHS conducts annual inspections of the BNL potable water system to collect samples and ensure that facilities are maintained. There were no issues in 2002. All sample results were within drinking water standards, except for iron, which occurs naturally. As noted in Section 3.7.1, BNL treats the drinking water supply to remove iron prior to distribution.
- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the BNL STP. In 2002, no performance or operational issues were identified during these inspections. Additionally, in January and October, NYSDEC conducted routine inspections of SPDES-permitted outfalls, especially the Sewage Treatment Plant. During these inspections, facility operations were evaluated and effluent samples were collected. No issues were identified.
- *Recharge Basins.* As part of SCDHS oversight, two inspections are conducted annually of recharge basins and other SPDES outfalls. In 2002, SCDHS completed their scheduled inspections and collected samples during the assessments. No issues were identified.
- *Major Petroleum Facility.* The MPF is inspected annually by NYSDEC. This inspection was conducted in April 2002. See Section 3.8.4 for a discussion of this inspection.

3.14.2 Inspections by DOE

Neither DOE Headquarters (EH-10) nor the Chicago Operations Office conducted assessments of the Laboratory's environmental programs in 2002. The DOE Brookhaven Area Office (BAO) continued to provide oversight of BNL programs during 2002 and conducted one environmental assessment and observed two environmental assessments conducted by BNL staff. The BAO reviewed the Radioactive Waste Management Program and observed the Air and PCB programmatic assessments. The results of each assessment are summarized below.

3.14.2.1 Air Emissions Programmatic Self-Assessment

The Environmental Services Division (ESD) programmatic assessment of the air emissions program was observed by BAO staff. This assessment was started during the last quarter of 2001 and continued into 2002 and reviewed the Labwide compliance with air regulations or Laboratory requirements. The assessment identified five noteworthy practices, one potential noncompliance, one nonconformance dealing with missing or inadequate review documentation for twelve new or modified emissions sources, and numerous observations dealing with recommended improvements for process-specific operations. A corrective action plan was prepared and all issues but one were closed. The remaining issue deals with missing information on the vendor-supplied bills of lading that should specify detergent content and Reid vapor pressure.

3.14.2.2 Polychlorinated Biphenyls Programmatic Self-Assessment

The BAO observed the ESD self-assessment of the PCB Management Program, which occurred during March and April 2002. The purpose of the assessment was to evaluate the Labwide PCB management program and assess compliance with applicable regulations and guidance. Operations in the following departments or divisions were assessed: Biology, Chemistry, Collider-Accelerator, Energy Environment & National Security, National Synchrotron Light Source, Instrumentation, Medical, Physics, Plant Engineering, Radiological Control Division,

and Waste Management Division. The DOE observer gave the assessment an Outstanding rating for all phases (approach, deployment, and results). The assessment found that all PCB wastes were being properly handled, and identified five noteworthy practices. The assessment also identified four minor noncompliances, which included too-small labels on large capacitors, missing or incorrect out-of-service dates on manifests or containers, handling of PCB Ballasts as Bulk PCB waste in one case, and federal requirements not clearly reflected in the procedural documentation (the PCB Subject Area). In addition, one nonconformance and six "observations" were noted. A corrective action plan was prepared and all issues were closed.

3.14.2.2 Radioactive Waste Management BAO Assessment

The assessment of five BNL organizations was conducted by evaluating one or two radioactive waste streams or treatment processes from each. Four noteworthy practices, four concerns, five findings, and three observations were noted. Program strengths were identified in the areas of program planning documentation for remediation activities, development of an electronic Radioactive Waste Control Form and tracking system, and proactive radioactive waste minimization and decay-in-storage practices in the Life Sciences Directorate. In all programmatic areas and organizations reviewed, opportunities for improvement were identified, including: waste characterization and certification based on indirect methods, program validation or verification, integrated contingency storage program for liquid waste, 90-day staging limit, noncompliance with Suffolk County Sanitary Code-Article 12, sitewide inconsistencies with BNL's approved Radioactive Waste Management Basis Document, inconsistent implementation of BNL's Subject Areas, and noncompliance with 10 CFR 830 Subpart A. BNL issued ORPS Report No. NTS-CH-BH-BNL-BNL-2002-0003 to report these issues. Corrective actions are in progress.

3.14.3 Enforcement Actions and Memos

No new consent orders were issued to BNL in 2002. A notice of violation for administrative

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

Title	Parties	Effective Date	Status
Action			
Preliminary Finding and Administrative Complaint	NYSDEC	1/14/03	A preliminary Finding and Administrative Complaint was issued for three administrative deficiencies identified during the 2002 annual hazardous waste compliance inspection conducted by NYSDEC. One deficiency, a missing label, was corrected at the time. The two remaining issues deal with the management of CERCLA-derived wastes and preparation of a Land Disposal Restriction for intra-laboratory waste shipments. These deficiencies are being reviewed by BNL management and counsel.
Agreements			
Suffolk County Agreement	SCDHS, DOE, and BNL	Originally signed on 9/23/87	This Agreement was developed to ensure that the storage and handling of toxic and hazardous materials at BNL conform with the environmental and technical requirements of Suffolk County codes.
Federal Facilities Compliance Agreement (FFCA) on Mixed Wastes	NYSDEC and DOE	1992 (Updated annually)	The FFCA requires that a site treatment plan to manage mixed wastes be written and updated annually. BNL is in compliance with this requirement.
II-CERCLA-FFA-00201: Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section 120 (also known as the Interagency Agreement or "IAG")	EPA, DOE, and NYSDEC	05/26/92	Provides the framework, including schedules, for assessing the extent of contamination and conducting the BNL cleanup. Work is performed either as an Operable Unit or a Removal Action. The IAG integrates the requirements of CERCLA, RCRA, and the National Environmental Policy Act. All IAG-scheduled milestones were met in 2002.
Memorandum of Agreement (MOA) by and between the Environmental Protection Agency and the Department of Energy	EPA and DOE	03/23/98	In 1998, BNL, DOE, and EPA entered into an MOA requiring the implementation of an EMS. All conditions of the MOA were satisfied in 2002.

Notes:

EPA = Environmental Protection Agency

DOE = Department of Energy

NYSDEC = New York State Department of Environmental Conservation

SCDHS = Suffolk County Department of Health Services

deficiencies was issued by NYSDEC as a result of the annual RCRA inspection (see discussion in Section 3.9). On March 23, 1998, EPA and DOE signed a voluntary Memorandum of Agreement (MOA). During 2002, BNL continued to be in full compliance with and completed all the terms of the MOA. All existing enforcement actions and MOAs are listed in Table 3-9, along with a summary of their status. BNL believes that it has fully complied with the terms and conditions listed in these actions and has submitted supporting documentation to the regulatory agencies. The Laboratory continues to work with the regulators to close these actions as expeditiously as possible.

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CHAPTER 3: COMPLIANCE STATUS

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Air Quality

Brookhaven National Laboratory monitors both radioactive and nonradioactive emissions at several facilities to ensure compliance with the requirements of the Clean Air Act. In addition to a facility emissions monitoring program, ambient air monitoring is conducted to verify local air quality and to assess environmental impacts from the Laboratory's operations.

During 2002, BNL facilities released a total of 5,682 curies of short-lived radioactive gases. Oxygen-15 (half-life: 122 seconds) and carbon-11 (half-life: 20.48 minutes) released from the Brookhaven Linac Isotope Producer constituted more than 99.9 percent of the site's radiological air emissions.

Continuing a pattern observed in 2000 and 2001, natural gas prices were higher than residual fuel prices through much of 2002, causing the Central Steam Facility to rely more on residual fuel to meet the heating and cooling needs of BNL's major facilities than in 1999. As a result, annual facility emissions of particulate matter, nitrogen oxides, and sulfur dioxide were considerably higher in 2002 than in 1999, when natural gas was the predominant fuel used at the Central Steam Facility. Compared to 2001, however, when natural gas prices spiked, residual fuel use and emissions declined significantly in 2002.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and DOE regulations governing the release of airborne radioactive material include 40 CFR 61 Subpart H, the *National Emission Standards for Hazardous Air Pollutants* (NESHAPs)—part of the Clean Air Act, and DOE Order 5400.5 (1993), *Radiation Protection of the Public and the Environment*. Under NESHAPs Subpart H, facilities that have the potential to deliver a radiation dose of greater than 0.1 mrem/year (1 μ Sv/year) to a member of the public must be continuously monitored for emissions. Also, facilities capable of delivering a radiation dose below 0.1 mrem/year (1 μ Sv/year) require periodic, confirmatory monitoring. BNL has one facility that requires continuous monitoring, the Brookhaven Linac Isotope Producer (BLIP), and three active facilities where periodic moni-

toring is conducted. Figure 4-1 indicates the locations of the monitored facilities, and Table 4-1 presents the airborne release data from each of these facilities during 2002. Annual emissions from monitored facilities are discussed in the following sections. A fourth inactive facility, the Evaporator facility, which was periodically monitored in past years, is also discussed. The associated radiation dose calculations are presented in Chapter 8.

4.1.1 Brookhaven Medical Research Reactor

In August 2000, DOE announced that the Brookhaven Medical Research Reactor (BMRR) would be permanently shut down. Until it stopped operating in late December 2000, the BMRR was fueled with enriched uranium, moderated and cooled by light water, and was operated intermittently at power levels up to 3 megawatts (ther-

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

mal). Air from the interior of the containment building was used to cool the neutron reflector surrounding the core of the reactor vessel. As air was drawn through the reflector it was exposed to a neutron field, resulting in activation of the argon fraction of the air and producing argon-41, an inert, radioactive gas with a short half-life of 1.8 hours. After passage through the reflector, the air was routed through a roughing filter and a high efficiency particulate air (HEPA) filter to remove any particulate matter. Charcoal filters were also used to remove radioiodines produced during the fission process. Following filtration, the air was exhausted to the atmosphere through a 150-foot stack adjacent to the reactor containment building.

After the BMRR stopped operating, continuous monitoring to track argon-41 air emissions was reduced to periodic semi-annual monitoring, because the emissions were very low. January and September 2002 sampling showed there were no quantifiable emissions of argon-41 or nonargon radionuclides at zero power level with building ventilation on and the BMRR core unchanged.

4.1.2 High Flux Beam Reactor

Following the discovery of an underground plume of tritiated groundwater emanating from a leak in the spent fuel storage pool, the High Flux Beam Reactor (HFBR) was kept in a standby mode from January 1997 until November 1999,

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

Facility	Nuclide	Half-life	Ci Released
BMRR	Argon-41	1.8 hours	None
HFBR	Tritium	12.3 years	1.93E + 00
BLIP	Carbon-11	20.5 minutes	1.41E + 03
	Germanium-69	1.6 days	9.20E - 05
	Oxygen-15	122 seconds	4.27E + 03
	Rubidium-86	18.7 days	4.99E - 05
	Tritium	12.3 years	1.80E - 01
Target Processing Laboratory	Arsenic-74	17.8 days	1.85E - 06
	Bromine-77	56 hours	6.94E - 05
	Cesium-137	30 years	6.19E - 07
	Rubidium-86	18.7 days	2.78E - 05
	Selenium-75	119.8 days	9.77E - 09
	Thallium-202	12.2 days	6.37E - 07
	Tin-113	115.1 days	3.59E - 05
	Zirconium-88	83.4 days	8.63E - 07
Total			5.682E + 03

Notes:

Ci = 3.7×10^4 Bq.

BMRR = Brookhaven Medical Research Reactor

HFBR = High Flux Beam Reactor

BLIP = Brookhaven Linac Isotope Producer

The BMRR stopped operating in December 2000.

when DOE announced that it would be permanently shut down. The storage pool was drained in December 1997 to prevent additional leakage as well as to facilitate repairs and double lining of the pool to conform to Suffolk County Article 12. When the HFBR operated, it used heavy water as a neutron moderator and fuel coolant. Heavy water, or D_2O , is water composed of a nonradioactive isotope of hydrogen known as deuterium. When exposed to the neutron fields generated inside the reactor vessel, the deuterium became activated, producing radioactive tritium (half-life = 12.3 years). Although heavy water has been removed from the vessel, residual tritium still remains in the vessel and cooling loops. Tritiated water vapor (HTO) is released from the vessel and associated piping systems (via diffusion at valve seals and other system penetrations) to building air, where it is routed to the facility's 328-foot stack. Concentrations of HTO in air are assessed using a silica gel absorbent material. In 2002, 1.93 curies (Ci) of airborne HTO were released from the HFBR. Figure 4-2 illustrates the declining trend of tritium emissions from the HFBR since 1993. In 2002, sampling was reduced to one week per month.

Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1993–2002).

4.1.3 Brookhaven Linac Isotope Producer

Protons from the Linear Accelerator are sent via an underground beam tunnel to the BLIP, where they strike various metal targets. The proton beam activates these metal targets to produce new radionuclides for diagnostic use. The activated metal targets are transferred to the Target Processing Laboratory (TPL), Building 801, for separation and are later shipped 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 are oxygen-15 and carbon-11 (radionuclides with short half-lives of 122 seconds and 20.48 minutes, respectively). Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-foot stack.

In 2002, the BLIP operated over a period of 21 weeks; during this period, 1,410 Ci of carbon-11 and 4,270 Ci of oxygen-15 were released. Tritium produced from activation of the target cooling water was also released, but in a much smaller quantity. Emissions of carbon-11 and oxygen-15 declined by more than 40 percent from 2001, primarily due to a decreased period of operations (35 weeks in 2001 compared to 21 weeks in 2002). See Table 4-1 for a complete listing of the radionuclides released from the BLIP facility during 2002.

4.1.4 Evaporator Facility

In the past, liquid waste generated on site that contained residual radioactivity was accumulated at the Waste Concentration Facility (WCF) in Building 811. At the WCF, suspended solids and a high percentage of radionuclides were removed from the liquid, using reverse osmosis. However, because tritium is an isotope of hydrogen, it could not be removed from aqueous wastes. The tritiated water that remained following waste concentration was transferred to the Evaporator Facility in Building 802B, where it was converted to steam and released as an airborne emission. The Evaporator Facility was constructed primarily to reduce the amount of tritiated water released to the Peconic River

through the BNL Sewage Treatment Plant. Emissions were directed to the same stack used by the HFBR to exhaust building air. This method was preferable to release via surface water because there was virtually no potential for the airborne emissions to influence groundwater (the primary drinking water source on Long Island), and the potential for the released tritium to contribute to an off-site dose was minimized by atmospheric dispersion.

Since no aqueous waste was processed at the WCF in 2002, there were no emissions of tritiated water vapor from the Evaporator Facility. Because generation rates of aqueous wastes containing residual radioactivity are expected to remain low, it is no longer economical to process the waste in the same manner. As a result, plans are to decommission the WCF reverse osmosis process and the Evaporator Facility.

4.1.5 Target Processing Laboratory

As mentioned in Section 4.1.3, the metal targets irradiated at the BLIP facility are transported to the TPL in Building 801, where isotopes are chemically extracted for radiopharmaceutical production. Airborne radionuclides released during the extraction process are drawn through multistage HEPA and charcoal filters and then vented to the HFBR stack (see Table 4-1 for isotopes and quantities). The types of radionuclides that are released depends on the isotopes that are chemically extracted from the irradiated metal targets, which can change from year to year. Annual radionuclide quantities released from this facility are very small, typically in the millicurie (mCi) range. In 2002, the total release from the TPL was 0.14 mCi.

4.1.6 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves very small quantities of radioactive materials (in the microcurie to millicurie range). The work done using fume hoods typically involves transferring material between containers, using pipettes, and labeling chemical compounds. Due to the use of HEPA filters, the nature of the work conducted, and the small quantities involved, these operations have a very low

potential for atmospheric releases of any significant quantities of radioactive materials. Compliance with NESHAPs Subpart H is demonstrated through the use of an inventory system that allows an upper estimate of potential releases to be calculated. Facilities that demonstrate compliance in this way include Buildings 463, 490, 490A, 510, 555, 725, and 801, where research is conducted in the fields of biology, medicine, high energy physics, chemistry, applied and materials science, and advanced technology. See Table 8-4 for the calculated dose from the emissions from these facilities.

4.1.7 Uncharacterized Radiological Emission Sources Evaluated in 2002

Uncharacterized radiological emissions (diffuse or area sources) were evaluated for compliance with NESHAPs, Subpart H. The EPA-approved CAP88-PC dose modeling program (see Chapter 8 for more details) was used to calculate the dose to members of the public from planned research, environmental restoration, and waste management activities. These evaluations determined whether NESHAPs permitting and continuous monitoring requirements are applicable or whether periodic confirmatory sampling is needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of the research, environmental restoration, and waste management activities that occurred in 2002.

One of the projects evaluated as a diffuse source was the Chemistry Department's use of radiotracers for neuroimaging research in Building 901. The radiotracers are fabricated in the form of ^{11}C (half-life: 20.48 minutes) labeled compounds. The procedure is initiated by trapping the $^{11}\text{CO}_2$ in a molecular sieve and reacting it with hydrogen to convert it into $^{11}\text{CH}_4$. The $^{11}\text{CH}_4$ is converted to ^{11}CN by reacting it with NH_3 . The complete procedure is performed under a laboratory hood and the waste gases are collected in an 8-foot weather balloon encased in a secondary polyethylene bag. The ^{11}C collected in the weather balloon is decayed for ten half-lives and then vented to the outside. Another

tracer the Chemistry Department uses is fluorine-18 (half-life: 109.77 minutes), which is produced by irradiating ^{18}O water. The potential emissions from this operation, ^{11}C and ^{18}F , were evaluated for NESHAPs compliance. By decaying the emission gases for ten half-lives before discharging them to the environment, the effective dose to members of the public and impacts to the environment are minimized in accordance with BNL's commitment to the ALARA (as low as reasonably achievable) policy.

The CAPP88-PC model conservatively overestimated an effective dose equivalent of $1.33\text{E-}02$ mrem/annual to the maximally exposed individual with a worst-case scenario, 100 percent release of the source term to the environment. This value is well under the annual 0.1 mrem threshold that triggers the NESHAPs Subpart H requirements for continuous monitoring. Chapter 8 discusses in greater detail this and other activities that were evaluated.

4.2 FACILITY MONITORING

In the past, potential sources of radioactive particulate emissions that have been monitored included the BMRR, the HFBR, the Evaporator Facility, the TPL (Building 801), and the BLIP. Since the BMRR and HFBR are permanently shut down and the Evaporator Facility did not process any aqueous wastes in 2002, no particulate sampling was conducted at these facilities.

The samplers in the exhaust duct for the TPL and the exhaust stack for the BLIP are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-3 for locations). The filters are collected and analyzed weekly for gross alpha and beta activity. Particulate filter analytical results for gross alpha and beta activity are reported in Table 4-2. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.036 pCi/m^3 and 0.219 pCi/m^3 , respectively. The annual average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were -0.043 pCi/m^3 and -0.460 pCi/m^3 , respectively. (For a discussion of negative values associated with radioactivity monitoring, see Appendix B.)

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

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

Facility Monitor		Gross Alpha		Gross Beta	
		(pCi/m ³)			
TPL - Bldg. 801	N	51		51	
	Max.	2.200 ± 3.740		14.400 ± 12.200	
	Avg.	0.036 ± 0.143		0.219 ± 0.466	
	MDL	0.168		0.510	
BLIP	N	51		51	
	Max.	0.120 ± 0.101		0.660 ± 0.332	
	Avg.	-0.043 ± 0.023		-0.460 ± 0.054	
	MDL	0.231		0.667	

Notes:

See Figure 4-3 for sample station locations.

All values shown with a 95% confidence interval.

Negative values occur when the measured value is less than background.

BLIP = Brookhaven Linac Isotope Producer

N = Number of samples collected

MDL = Average Minimum Detection Limit

TPL = Target Processing Laboratory

4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, an array of air monitoring stations is in place around the perimeter of the BNL site. Samplers are housed within six blockhouse stations (see Figure 4-3 for locations). The blockhouses are fenced to control access and protect costly sampling equipment. In addition to the blockhouses, 16 pole-mounted, battery-powered silica-gel samplers (used for tritium monitoring) are located throughout the site, primarily near the site boundary.

At each blockhouse, particulate matter is captured on a glass-fiber filter and water vapor for tritium analysis is collected on silica-gel absorbent material. (Note that Station S5 does

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

Sample Station		Gross Alpha (pCi/m ³)	Gross Beta (pCi/m ³)
P2	N	52	52
	Max	0.0038 ± 0.0008	0.0201 ± 0.0019
	Avg.	0.0007 ± 0.0001	0.0111 ± 0.0002
	MDL	0.0008	0.0024
P4	N	52	52
	Max	0.0054 ± 0.0010	0.0189 ± 0.0026
	Avg.	0.0006 ± 0.0002	0.0104 ± 0.0005
	MDL	0.0008	0.0025
P7	N	52	52
	Max	0.0048 ± 0.0009	0.0178 ± 0.0017
	Avg.	0.0006 ± 0.0001	0.0082 ± 0.0004
	MDL	0.0006	0.0019
P9	N	52	52
	Max	0.0056 ± 0.0010	0.0186 ± 0.0024
	Avg.	0.0009 ± 0.0001	0.0107 ± 0.0003
	MDL	0.0008	0.0025
S5	N	52	52
	Max	0.0039 ± 0.0008	0.0238 ± 0.0029
	Avg.	0.0008 ± 0.0001	0.0125 ± 0.0002
	MDL	0.0009	0.0027
S6	N	52	52
	Max	0.0056 ± 0.0010	0.0201 ± 0.0027
	Avg.	0.0008 ± 0.0001	0.0124 ± 0.0003
	MDL	0.0009	0.0027
Grand Average		0.0007 ± 0.0001	0.0109 ± 0.0005

Notes:

See Figure 4-3 for sample station locations.
 All values shown with a 95% confidence interval.
 N = Number of samples collected
 MDL = Average Minimum Detection Limit

not contain a tritium sampler.) Particulate filters are collected weekly and are analyzed for gross alpha and beta activity using a gas-flow proportional counter. Silica-gel samples are collected for one week per month for processing by liquid scintillation analysis. Before April 1999, silica-gel samples were collected weekly, but multiple years' worth of results below the minimum detection limit (MDL) were the basis for reducing the sampling frequency.

4.3.1 Gross Alpha and Beta Activity

Particulate filter analytical results for gross alpha and beta activity are reported in Table 4-3. The annual average gross alpha and beta airborne activity levels for the six monitoring stations were 0.0007 pCi/m³ and 0.0109 pCi/m³, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-4. The results at this location are typical for the site. The trend shows seasonal variation in activity within a range that is representative of natural background levels. The gross alpha activity is not plotted because the vast majority of results were below the MDL.

The New York State Department of Health (NYSDOH) received duplicate filter samples that were collected at Station P7 using a sampler they provided. These samples were collected weekly

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

and analyzed by the NYSDOH laboratory for gross beta activity. The analytical results received were comparable to the Station P7 samples analyzed by the BNL Analytical Services Laboratory. Analytical results for gross beta activity reported by the NYSDOH laboratory were between 0.010 and 0.027 pCi/m³, with an average concentration of 0.016 pCi/m³, whereas the BNL results ranged from - 0.001 to 0.062 pCi/m³ with an average concentration of 0.011 pCi/m³. 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. NYSDOH reported in 2002 that airborne gross beta activity at that location varied between 0.00003 and 0.037 pCi/m³. The average concentration at this control location was 0.015 pCi/m³. Sample results measured at BNL generally fall within this range, demonstrating that on-site radiological air quality is consistent with that observed at locations in New York State not located near radiological facilities.

4.3.2 Airborne Tritium

Airborne tritium in the form of HTO is monitored throughout the BNL site. In addition to the five blockhouses containing tritium samplers, fourteen pole-mounted monitors are located at or near the property boundary (see Figure 4-3 for locations). Two additional pole-mounted monitors are centrally located on site. Airborne tritium is collected by using a pump to draw air through a column of silica gel, a water-absorbent medium. The absorbed HTO is recovered by distillation and analyzed using liquid scintillation counting techniques.

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 super-saturated silica gel, or the loss of sample during laboratory preparation). Airborne tritium samples were collected from each sampling station over a one-week period during each calendar month. While one location (S6) showed the maximum and average values to be above the

Table 4-4. Ambient Airborne Tritium Measurements in 2002.

Sample Station	Wind Sector	Validated Samples	Maximum —— (pCi/m ³) ——	Average
P9	NE	12	3.6 ± 1.8	0.6 ± 1.0
011	NNE	12	2.4 ± 1.7	0.7 ± 0.6
012	NNE	11	<6.3	0.7 ± 0.7
P2	NNW	12	<2.8	0.7 ± 0.8
030	ENE	12	<4.5	0.8 ± 0.8
034	NNW	12	<21.1	1.5 ± 1.3
049	E	12	8.2 ± 4.3	0.6 ± 0.8
053	NW	12	<4.1	0.5 ± 0.6
063	W	12	<4.6	0.5 ± 0.7
075	SW	12	<5.2	1.0 ± 0.7
076-302	ESE	11	<3.5	-1.5 ± 3.4
080	ESE	12	<5.0	0.8 ± 0.
082	W	12	<5.1	-0.2 ± 1.0
S6	SE	12	97.0 ± 4.9	45.6 ± 19.3
P7	ESE	12	<2.5	0.3 ± 0.7
105	S	12	<7.2	0.9 ± 0.9
108	SE	12	<4.9	0.1 ± 1.3
P4	WSW	12	4.5 ± 2.5	0.4 ± 1.0
111	SW	12	<6.8	1.1 ± 0.8
122	SSE	12	<3.8	0.2 ± 0.7
126	SSW	12	<4.4	-0.2 ± 1.1
Grand Average				2.6 ± 1.5

Notes:

See Figure 4-3 for station locations.

Wind sector is the downwind direction of the sample station from the BNL facilities noted in Section 4.1 that are subject to NESHAPs Subpart H monitoring requirements.

All values reported with a 95% confidence interval.

Typical minimum detection limit for tritium is between 1 and 6 pCi/m³.

DOE Order 5400.5 Air Derived Concentration Guide is 100,000 pCi/m³.

typical MDL range of 1 to 6 pCi/m³, the remaining sample results were below the MDL. The collected data demonstrate that there were no significant differences in ambient tritium concentrations on site or at the site boundary. All annual average concentrations were below the MDL, except at Station S6, which is adjacent to the Former Waste Management Facility (FWMF). The maximum concentration recorded at Station S6 was 97 pCi/m³ ± 4.9. BNL intends to investigate the FWMF and the Current Landfill as potential contributing sources for the elevated tritium concentrations at Station S6. To put Station S6's maximum value of 97 pCi/m³ into perspective, the concentration guide for tritium in

air is 100,000 pCi/m³ (DOE Order 5400.5). This is the amount of an airborne radionuclide, which, if inhaled at that concentration for one year, would result in an effective dose equivalent of 100 mrem (1 mSv) to the maximally exposed individual. Therefore, all BNL station measurements of ambient tritium are less than 0.1 percent of the DOE-derived concentration guide value. Observed concentrations of tritium at the sampling stations in 2002 were comparable to concentrations observed in 2001, but were considerably lower than measured station concentrations in 1996, when the HFBR was last operational and released 48 Ci of HTO to the atmosphere.

The three pole-mounted air samplers located near the Removal Action V Recharge Basin that were used to monitor ambient tritium concentrations in prior years have been dismantled because the potential source of emissions, the tritiated groundwater pump and recharge system, is no longer operational.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emissions monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that is required to monitor nonradiological emissions. BNL has several other emission sources subject to state and federal regulatory requirements that do not require emissions monitoring (see Chapter 3 for more details). The CSF supplies steam for heating and cooling to BNL major 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 MMBtu/hr). 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, respectively. Each of these boilers has a heat input of 42.6 MW (147 MMBtu/hr). For perspective, Keyspan's Northport, New York power station has four utility-sized turbine/generator boilers, each with a nominal heat input of 385 MW (1,330 MMBtu/hr).

Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are subject to Title 6 of the New York Code, Rules, and Regulations (NYCRR) Part 227-2, and the federal *New Source Performance Standard*, 40 CFR 60 Subpart Db. As such, these boilers are equipped with continuous emission monitors for nitrogen oxides (NO_x). Boiler 7 emissions are also continuously monitored for opacity. To measure combustion efficiency, both boilers are also monitored for carbon dioxide (CO₂). Continuous emissions monitoring results from the two boilers are reported on a quarterly basis to EPA and NYSDEC.

From May 1 to September 15 (the peak ozone period), compliance with the 0.30 lbs/MMBtu (129 ng/J) NO_x emissions standard is demonstrated by calculating the 24-hour average emission rate from continuous emission monitoring system readings and comparing the value to the emission standard. The remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Boiler 7 opacity levels are recorded as 6-minute averages. Measured opacity levels cannot exceed 20 percent opacity, except for one 6-minute period per hour of not more than 27 percent opacity. In 2002, there were no measured exceedances of the NO_x emission standard for either boiler. Boiler 7 opacity measurements (recorded in the first, third, and fourth quarters) that exceeded the limit occurred during opacity monitoring system calibrations, boiler start-ups, or during routine boiler tube soot blowing operations. While there are no regulatory requirements for continuous monitoring of opacity for Boilers 1A, 5, and 6, surveillance monitoring of visible stack emissions is conducted daily by CSF on-duty personnel. Daily observations of stack gases recorded throughout the year in accordance with conditions of BNL's Title V operating permit showed no visible emissions with opacity levels exceeding regulatory limits established for these boilers.

In the spring of 1997, the Long Island Lighting Company completed work extending a natural gas main into the CSF. To accommodate the combustion of natural gas, new gas rings were added to the burners of Boiler 5, and

Table 4-5. Central Steam Facility Fuel Use and Emissions (1996 – 2002).

Year	Annual Fuel Use and Fuel Heating Values						Emissions			
	# 6 Oil (10 ³ gals)	Heating Value (MMBtu)	# 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)
1996	4,782.55	703,991	52.77	7,388	0.00	0	14.0	104.9	109.0	0.7
1997	3,303.43	484,613	10.23	1,432	190.65	26,691	13.7	83.5	75.1	1.0
1998	354.28	52,283	9.44	1,322	596.17	608,093	2.7	75.1	8.9	1.7
1999	682.76	78,335	2.77	388	614.98	627,280	5.1	53.5	16.7	1.8
2000	2,097.32	309,317	0.82	115	342.40	349,248	9.5	81.6	45.0	1.2
2001	3,645.10	538,847	3.40	476	103.96	106,039	17.5	80.4	77.8	0
2002	2,785.04	407,518	0.29	41	220.62	225,030	15.4	62.4	53.8	1.0

Notes:
TSP = Total Suspended Particulates

natural gas trains were installed to connect the gas main to Boilers 5 and 7. In 1998, existing steam-atomized oil burners on Boiler No. 6 were replaced with two dual-fuel low NO_x burners, and a natural gas train was added to connect the boiler to the gas main.

Through much of 2002, natural gas prices exceeded those for residual fuel (No. 6 oil). During these periods of higher natural gas prices, the CSF burned residual fuel. As a result, residual fuel supplied approximately 64 percent of the heating and cooling needs of BNL's major facilities in 2002 (see Table 4-5). By comparison, in 1999 natural gas satisfied more than 88 percent of the major facility heating and cooling needs but only 16 percent of these heating and cooling needs in 2001. Consequently, annual emissions of particulates NO_x, and SO₂ were 10.3 tons, 8.9 tons, and 37.1 tons higher than the respective totals for 1999 but were 2.1 tons, 18

tons, and 24 tons lower than the respective emission totals for 2001.

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Water Quality

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

Analytical data for 2002 showed that the average gross alpha and beta activity levels in the STP discharge were within the range typical of historical levels and were well below drinking water standards. Tritium releases to the Peconic River continued to decline and were the lowest since monitoring began in 1966. Cesium-137 and strontium-90 were detected infrequently in the effluent and at levels significantly less than the drinking water standard. No other gamma-emitting nuclides attributable to BNL operations were detected in the effluent. Nonradiological monitoring of the effluent showed that, with the exception of isolated incidents of noncompliance, organic and inorganic parameters were within State Pollutant Discharge Elimination System effluent limitations or other applicable standards.

Inorganic data from the upstream, downstream, and control locations demonstrated that elevated amounts of aluminum, iron, and zinc detected within the Peconic River are a result of natural geology. In addition, the low pH of water samples collected at several sections of the river was also due to natural causes. Very low concentrations of tritium were detected at the STP outfall, but there were no detections above the minimum detection limit at all downstream monitoring stations. The maximum tritium concentration at the STP outfall was approximately 3 percent of the drinking water standard. Based on the 2002 nonradiological and radiological data, the Peconic River water quality is comparable to other local freshwater rivers and is of consistent quality both upstream and downstream of BNL.

5.1 SURFACE WATER MONITORING PROGRAM

Treated wastewater from the BNL Sewage Treatment Plant (STP) is discharged into the headwaters of the Peconic River. This discharge is permitted by the New York State Department of Environmental Conservation (NYSDEC) point source discharge program. Effluent limits are based on the water quality standards established by NYSDEC, as well as historical opera-

tional data. To assess the impact of this discharge on the quality of the river, surface water monitoring is conducted at several locations upstream and downstream of the point of discharge. Monitoring Station HY, located on site but upstream of all BNL operations, provides information on the background water quality of the Peconic River. The Carmans River is monitored as a geographic control

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

location for comparative purposes, as it is not affected by BNL operations.

On the BNL site, the Peconic River is an intermittent stream. Off-site flow only occurs during periods of sustained precipitation, typically in the spring. Due to severe drought conditions in the spring and summer of 2002, there was no off-site flow recorded.

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 operated under a State Pollutant Discharge Elimination System (SPDES) permit. Figure 5-1 shows a schematic of the STP and the STP sampling locations. The BNL STP treatment system includes: 1) primary clarification to remove settleable solids and floatable materials, 2) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 3) secondary clarification, 4) sand filtration for final solids removal, and 5) ultraviolet disinfection for bacterial control prior to discharge to the Peconic River.

Tertiary treatment for nitrogen removal is also provided by controlling the oxygen levels in the aeration tanks. During the aeration process (i.e., Step 2), the oxygen levels are allowed to drop to the point where microorganisms use nitrate-bound oxygen for respiration; this liberates nitrogen gas and consequently reduces the concentration of nitrogen in the STP discharge. Nitrogen is an essential nutrient in biological systems that, in high concentrations, can cause excessive aquatic vegetation growth. Since vegetation utilizes oxygen during nighttime hours, too much aquatic plant life can deprive a water system of oxygen needed by fish and other aquatic organisms for survival. Reducing the concentration of nitrogen in the STP discharge allows plant growth within the Peconic River to remain in balance with the nutrients provided by natural sources. During 2002, the STP discharge continuously met the nitrogen limit of 10 mg/L specified in the SPDES permit.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity takes place at two locations. The first site is approximately 1.1 miles upstream of the STP,

providing at least 30 minutes warning to the STP operator that wastewater is en route that may exceed SPDES limits or BNL effluent release criteria (which are much more stringent than DOE-specified levels). The second site is at the point where the influent enters the primary clarifier. In addition to the two full monitoring stations, effluent leaving the primary clarifier is also monitored for radioactivity.

Any influent to the clarifier that does not meet SPDES limits or BNL effluent release criteria is diverted to lined holding ponds. The total combined capacity of the two holding ponds exceeds 7,000,000 gallons, or approximately 14 days of flow. Diversion continues until the effluent's water quality meets the permit limits or release criteria. If wastewater is diverted to the holding ponds, it is tested and evaluated against the requirements for release. If necessary, the wastewater is treated, then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits or BNL effluent release criteria. No diversions were necessary in 2002.

Solids separated in the clarifiers are pumped to a new digester, where they are reduced in volume by aerobic bacteria. Periodically, a fraction of the sludge is emptied into a drying bed. The drying bed uses solar energy to dry the watery sludge to a semisolid cake. Since the dried sludge contains very low levels of radioactivity (e.g., Co-60 < 0.1 to 2 pCi/g), it is put into containers for off-site disposal at an authorized facility.

In 2002, BNL completed the third and final phase of STP upgrades. These upgrades included completion of the new aerobic digester, upgrades to the pipe distribution system within the sand filters, relining of the holding ponds, and replacement, repair, or relining of approximately 16,000 linear feet of sewer collection and conveyance piping.

5.2.1 Sanitary System Effluent – Radiological Analyses

Wastewater at the STP is sampled at the output of the primary clarifier (Station DA) and at the Peconic River Outfall (Station EA). At each location, samples are collected on a flow-proportional basis; that is, for every 1,000 gallons

of water treated, approximately 4 fluid ounces of sample are collected and composited into a 5-gallon collection container. These samples are analyzed for gross alpha and gross beta activity and tritium concentrations. During 2002, samples were collected three times weekly. Samples collected from these locations are also composited and analyzed monthly for gamma-emitting radionuclides and strontium-90.

Although the Peconic River is not used as a direct source of potable water, BNL applies the stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of DOE wastewater criteria. The SDWA specifies that no individual may receive an annual dose greater than 4 mrem (40 mSv) in a year from radionuclides present in drinking water. The SDWA annual average gross alpha activity limit is 15 pCi/L (0.6 Bq/L) (including radium-226, but excluding radon and uranium). The SDWA also stipulates a 50 pCi/L (1.85 Bq/L) gross beta activity screening level, above which radionuclide-specific analysis is required. BNL goes beyond this basic screening requirement by performing radionuclide-specific gamma analysis, regardless of the gross beta activity. Other SDWA-specified drinking water limits are 20,000 pCi/L (740 Bq/L) for tritium and 8 pCi/L (0.3 Bq/L) for strontium-90. For all other radionuclides, Derived Concentration Guides (DCGs) found in DOE Order 5400.5 (DOE 1993) are used to determine the concentration of the nuclide, which, if continuously ingested over a calendar year, would produce an effective dose equivalent (EDE) of 4 mrem (40 mSv).

Gross activity (alpha and beta) measurements were 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 2002. Annual average gross alpha and beta activity of the STP effluent was 2.25 ± 0.25 pCi/L (0.08 ± 0.009 Bq/L) and 8.24 ± 0.5 pCi/L (0.31 ± 0.02 Bq/L), respectively. These concentrations are well below the New York State Drinking Water Standard (DWS) of 15 and 50 pCi/L, respectively. Control location data (Carman's River Station HH) show average gross alpha and beta levels of 0.49 ± 0.73 pCi/L

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

	Monthly Flow (Liters)	Tritium Maximum	Tritium Average	Gross Alpha Maximum	Gross Alpha Average (pCi/L)	Gross Beta Maximum	Gross Beta Average
STP Influent							
January	3.97E+ 07	< 355	-19 ± 80	6.25 ± 2.81	1.25 ± 0.99	12.10 ± 5.35	7.78 ± 1.32
February	2.98E+ 07	< 313	24 ± 41	5.38 ± 2.49	1.53 ± 0.98	13.80 ± 5.82	8.85 ± 1.37
March	3.85E+ 07	<386	33 ± 91	6.01 ± 3.05	2.27 ± 1.17	13.10 ± 6.05	8.18 ± 1.66
April	4.44E+ 07	< 268	31 ± 48	4.17 ± 2.20	1.95 ± 0.61	12.20 ± 5.66	9.29 ± 0.91
May	5.19E+ 07	381 ± 221	57 ± 73	6.16 ± 2.32	3.51 ± 0.88	24.80 ± 5.62	11.85 ± 2.87
June	5.34E+ 07	< 357	74 ± 84	4.54 ± 1.99	3.23 ± 0.63	15.00 ± 4.83	9.55 ± 1.83
July	7.39E+ 07	508 ± 197	189 ± 78	5.05 ± 2.48	2.70 ± 0.80	11.80 ± 4.29	7.23 ± 1.40
August	6.16E+ 07	444 ± 254	137 ± 80	2.96 ± 1.60	1.96 ± 0.53	11.10 ± 4.07	7.35 ± 1.28
September	5.54E+ 07	< 398	150 ± 53	6.05 ± 2.23	3.01 ± 0.91	11.80 ± 4.30	7.80 ± 1.61
October	4.46E+ 07	342 ± 203	78 ± 103	3.76 ± 1.81	2.39 ± 0.64	12.60 ± 4.56	9.33 ± 1.04
November	3.43E+ 07	< 331	22 ± 72	3.98 ± 2.24	2.33 ± 0.59	16.80 ± 5.05	10.40 ± 1.54
December	3.50E+ 07	351 ± 248	52 ± 80	4.62 ± 2.44	2.74 ± 0.68	14.90 ± 4.61	9.02 ± 1.89
Annual Average		70 ± 23			2.41 ± 0.25		8.89 ± 0.51
STP Effluent							
January	3.47E+ 07	< 355	19 ± 68	< 3.49	1.27 ± 0.68	8.90 ± 5.44	5.77 ± 1.15
February	2.80E+ 07	< 383	43 ± 38	5.11 ± 3.15	1.47 ± 0.95	13.00 ± 6.03	7.86 ± 1.60
March	3.41E+ 07	640 ± 216	43 ± 125	5.07 ± 2.62	1.75 ± 1.21	10.70 ± 6.19	7.88 ± 0.94
April	3.94E+ 07	< 299	-2 ± 61	4.71 ± 2.16	2.06 ± 0.90	18.10 ± 6.06	8.92 ± 2.16
May	4.53E+ 07	< 314	41 ± 79	4.09 ± 2.23	2.28 ± 0.59	15.50 ± 4.72	9.37 ± 1.30
June	4.73E+ 07	554 ± 279	155 ± 109	4.16 ± 2.08	2.44 ± 0.70	27.60 ± 5.90	9.86 ± 3.66
July	6.64E+ 07	563 ± 199	170 ± 101	6.40 ± 2.31	2.67 ± 1.12	11.60 ± 4.51	7.85 ± 1.33
August	6.17E+ 07	< 413	127 ± 73	4.37 ± 2.17	2.27 ± 0.67	13.10 ± 4.87	8.15 ± 1.44
September	4.33E+ 07	525 ± 242	166 ± 83	3.90 ± 1.90	2.27 ± 0.49	12.70 ± 4.55	8.01 ± 1.22
October	3.86E+ 07	398 ± 217	117 ± 71	6.15 ± 2.70	2.87 ± 0.83	12.50 ± 4.61	9.04 ± 1.44
November	3.75E+ 07	< 334	16 ± 61	4.81 ± 2.32	3.26 ± 0.61	13.30 ± 4.78	9.48 ± 1.47
December	3.60E+ 07	< 317	3 ± 73	5.35 ± 2.31	2.46 ± 0.93	11.20 ± 4.28	6.82 ± 1.24
Annual Average			75 ± 25		2.25 ± 0.25		8.24 ± 0.50
Total Release	5.12E+ 08		56.8 mCi		1.2 mCi		4.2 mCi
SDWA Limit			20,000 (pCi/L)		15.0 (pCi/L)		50.0 (pCi/L)
Average MDL			343 (pCi/L)		2.28 (pCi/L)		6.93 (pCi/L)

Notes:

All values shown with a 95% confidence interval.

Negative numbers occur when the measured value is lower than background.

To convert values from pCi to Bq, divide by 27.03.

MDL = Minimum Detection Limit

SDWA = Safe Drinking Water Act

(0.02 ± 0.03 Bq/L) and 0.85 ± 2.37 pCi/L (0.03 ± 0.09 Bq/L), respectively (see Table 5-7).

Tritium detected at the STP originates from either HFBR sanitary system releases or 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 evaporative losses of residual tritium remaining in the reactor coolant and from off-gassing of the facility. Once tritium is in the air stream, it condenses as a component of water vapor in the air conditioning or air compressor

units and is discharged in these wastewater streams. To minimize the quantity of tritium released to the STP, efforts have been made to capture most of the air conditioning condensate collected on the equipment level of the HFBR. A plot of the 2002 tritium concentrations recorded in the STP effluent is presented in Figure 5-2. A 15-year trend plot of annual average tritium concentrations measured in the STP discharge is shown in Figure 5-3. Annual average concentrations have been declining since 1995.

In 2002, the annual average tritium concentration as measured in the STP effluent (EA,

Outfall 001) was 75 ± 25 pCi/L (2.8 ± 0.9 Bq/L), down from 136 pCi/L (5.0 Bq/L) in 2001. This value is less than one-quarter the average minimum detection limit (MDL) for the BNL Analytical Services Laboratory of 343 pCi/L (13.0 Bq/L),

and well below the DWS of 20,000 pCi/L. A total of 0.057 Ci (2.1 billion Bq) of tritium was released during the year. This level is 22 percent less than the discharge recorded for 2001, is the lowest annual release of tritium to the Peconic River

Figure 5-2. Tritium Concentration in Effluent from the Sewage Treatment Plant.

Figure 5-3. Sewage Treatment Plant/Peconic River Annual Tritium Concentrations (1988 – 2002).

observed since routine measurements began in 1966, and is less than 2 percent of the peak values released in the late 1980s (see Figure 5-4). Tritium was detected above the MDL in less than 10 percent of the samples collected at the STP discharge to the Peconic River. The maximum concentration of tritium was 640 pCi/L (23.7 Bq/L), detected in March. Reduced concentrations of tritium are primarily the result of operations readying the HFBR for permanent closure. In 2000, most of the primary coolant, which had very high concentrations of tritium, was drained from the reactor and shipped off site. The reactor was subsequently partially filled with tap water. The level of tritium released from the HFBR has decreased more than 20 percent from 2001 levels and will continue to drop as the HFBR moves into permanent decommissioning.

Table 5-2 presents the gamma spectroscopy analytical data for the monthly STP composite samples. During 2002, the samples showed the presence of cesium-137 once in the STP effluent and not in the influent. The concentration of cesium-137 detected in the effluent was less than 1 percent of the SDWA drinking water standard. The presence of cesium-137 in the STP effluent is due to the continued leaching of very small amounts of cesium-137 from the STP sand filter

beds and from sludge residuals in the piping systems. This radionuclide was deposited during pre-1990 releases to the site sanitary system. The cesium-137 concentrations in the STP influent and effluent have been steadily decreasing since 1990, as shown in Figure 5-5. Although the total release of cesium-137 in 2002 (0.06 mCi) was approximately twice that for 2001 (0.03 mCi), the concentration in the discharge was essentially the same in both years (1.4 versus 1.2 pCi/L). In 2002, the Environmental Restoration Program began a cleanup of the residual radionuclides in the sand filter beds and associated berms. Approximately 1,320 cubic yards of sand and debris containing low levels of radioactivity and heavy metals were removed and staged for off-site disposal. Soil disposal will continue into 2003.

Strontium-90 was detected at very low levels in the STP effluent monthly composite samples on two occasions in 2002. Strontium-90 was detected in January at 3.92 ± 0.52 pCi/L (0.15 ± 0.02 Bq/L), and in March at 0.25 ± 0.13 pCi/L (0.01 ± 0.005 Bq/L). All subsequent monthly data showed levels to be nondetectable. Strontium-90 was discharged from BNL facilities in the 1950s and 1960s and has remained in the sludge within the sanitary piping system. All levels are less than the DWS of 8.0 pCi/L (0.3 Bq/L).

Figure 5-4. Tritium Released to the Peconic River, 15-Year Trend (1988 – 2002).

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

	Flow — L —	Co-60	Cs-137	Be-7 pCi/L	Na-22	Sr-90
STP Influent						
January	3.97E + 07	ND	ND	ND	ND	< 0.34
February	2.98E + 07	ND	ND	ND	ND	< 0.14
March	3.85E + 07	ND	ND	ND	ND	< 0.28
April	4.44E + 07	ND	ND	ND	ND	< 0.17
May	5.19E + 07	ND	ND	ND	ND	< 0.39
June	5.34E + 07	ND	ND	ND	ND	< 0.46
July	7.39E + 07	ND	ND	ND	ND	< 0.64
August	6.16E + 07	ND	ND	ND	ND	< 1.01
September	5.54E + 07	ND	ND	ND	ND	< 0.51
October	4.46E + 07	ND	ND	ND	ND	< 0.42
November	3.43E + 07	ND	ND	ND	ND	< 0.51
December	3.50E + 07	ND	ND	ND	ND	< 0.20
STP Effluent						
January	3.47E + 07	ND	ND	ND	ND	3.92 ± 0.52 ⁽¹⁾
February	2.80E + 07	ND	ND	ND	ND	< 0.24
March	3.41E + 07	ND	ND	ND	ND	0.25 ± 0.13 ⁽¹⁾
April	3.94E + 07	ND	1.40 ± 0.85	ND	ND	< 0.30
May	4.53E + 07	ND	ND	ND	ND	< 0.14
June	4.73E + 07	ND	ND	ND	ND	< 0.34
July	6.64E + 07	ND	ND	ND	ND	< 0.45
August	6.17E + 07	ND	ND	ND	ND	< 0.60
September	4.33E + 07	ND	ND	ND	ND	< 0.31
October	3.86E + 07	ND	ND	ND	ND	< 0.58
November	3.75E + 07	ND	ND	ND	ND	< 0.37
December	3.60E + 07	ND	ND	ND	ND	< 0.16
Total Release		0	0.06 mCi	0	0	0.15 mCi
DOE Order 5400.5 DCG		5,000	3,000	50,000	10,000	1,000
Dose Limit of 4 mrem EDE		100	200	6,000	400	8

Notes:

All values shown with a 95% confidence interval.

DCG = Derived Concentration Guide

EDE = Effective Dose Equivalent

ND = Not Detected

⁽¹⁾ This is an estimated value.**5.2.2 Sanitary System Effluent – Nonradiological Analyses**

In addition to the compliance monitoring discussed in Chapter 3, effluent from the STP is also monitored for nonradiological contaminants under the BNL Environmental Surveillance Program. Data are collected for field-measured parameters, such as temperature, specific conductivity, pH, and dissolved oxygen, as well as inorganic parameters such as chlorides, nitrates, sulfates, and metals measured in the BNL Analytical Services Laboratory. Composite samples of the STP effluent are collected using

a flow-proportional refrigerated sampling device (ISCO Model 3700RF). The BNL Analytical Services Laboratory analyzes these composite samples for 21 inorganic compounds. In addition, grab samples are collected monthly from the STP effluent and analyzed for 38 different volatile organic compounds (VOCs). Daily influent and effluent logs are maintained by the STP operators for flow, pH, temperature, and settleable solids as part of routine monitoring of STP operations.

Table 5-3 summarizes the inorganic analytical results for the STP samples. Comparing the

Figure 5-5. Cesium-137 in the Sewage Treatment Plant Influent and Effluent (1990 – 2002).

effluent data to the SPDES effluent limits (or other applicable standard) shows that the majority of the analytical parameters were within SPDES effluent permit limits (see also the compliance data in Chapter 3). Copper and iron were detected once and twice respectively at concentrations exceeding SPDES limits. There were no detections of these elements above SPDES limits during routine compliance monitoring (see Chapter 3). There are no defined sources that would explain these three elevated readings. Aluminum was also detected periodically at levels exceeding the ambient water quality standard of 100 µg/L. Aluminum is a component of native soils and is most likely attributable to fine particles of sand media carried over in the effluent. There are no other defined sources that would explain the elevated readings for aluminum.

Except for a single detection of diethyl ether (4.5 µg/L), no organic compounds were detected above the MDL throughout 2002. Although there are no SPDES limits or ambient water quality standards specified for diethyl ether, NYSDEC imposes a generic limit of 50 µg/L for unlisted organic compounds. The diethyl ether reading was less than 10 percent of NYSDEC's generic limit.

5.3 PROCESS-SPECIFIC WASTEWATER

Wastewater that may contain constituents above SPDES permit limits or groundwater discharge standards is held by the generating facility and characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate discharge limit, and the wastewater is released to the sanitary system only if the volume and concentration of contaminants in the discharge would not jeopardize the quality of the STP effluent and subsequently the Peconic River.

The BNL SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from the photographic developing operations in Building 197B, the printed-circuit-board fabrication operations conducted in Building 535B, the metal cleaning operations in Building 498, cooling tower discharges from Building 902, and boiler blowdown from satellite boilers at Buildings 244 and 423. These operations were monitored for contaminants such as metals, cyanide, VOCs (EPA Method 624), and semiVOCs (EPA Method 625). Analyses of these waste streams showed that, although several operations contributed contaminants to the STP in concentrations exceeding SPDES-

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

	STP Influent				STP Effluent				SPDES Limit or Ambient Water Quality Standard ⁽¹⁾
	No. of Samples	Min.	Max.	Avg.	No. of Samples	Min.	Max.	Avg.	
pH (SU) ⁽²⁾	139	6.1	7.2	NA	152	6	8	NA	5.8–9.0
Conductivity (µS/cm) ⁽²⁾	NA	NA	NA	NA	152	220	396	300.60	SNS
Temperature (°C) ^(2,3)	NA	NA	NA	NA	152	5.2	26.1	15.70	SNS
Dissolved Oxygen (mg/L)	NA	NA	NA	NA	152	6.6	15.1	9.60	SNS
Chlorides (mg/L)	11	24.1	73.4	47.3	12	23	66.8	42.90	SNS
Nitrate* (as N) (mg/L)	11	< 1	4.6	2.9	12	< 1	7.3	4.40	10 (Total N)
Sulfates (mg/L)	11	13.9	23.3	17.2	12	14.5	21.7	17.00	250 (GA)
Aluminum (µg/L)	12	39.2	1600	743.79	12	14.7	796	126.80	100 (Ionic)
Antimony (µg/L)	12	< 0.88	4.1	< 0.88	12	< 0.9	< 3.5	< 3.5	3 (GA)
Arsenic (µg/L)	12	< 3.0	< 12	< 12	12	< 3	< 12	< 12	150 (Dissolved)
Barium (µg/L)	12	28.3	63.1	39.34	12	14.8	31.3	21.02	1,000 (GA)
Beryllium (µg/L)	12	< 0.66	4.46	< 1.3	12	< 0.66	< 2.64	< 2.64	11 (Acid Soluble)
Cadmium (µg/L)	12	< 1.1	< 4.4	< 4.4	12	< 1.1	< 4.4	< 4.4	1.1 (Dissolved)
Chromium (µg/L)	12	< 1.0	10.9	3.4	12	1.28	6.6	2.40	34.4 (Dissolved)
Cobalt (µg/L)	12	0.31	4.87	1.35	12	0.26	2.4	0.86	5 (Acid Soluble)
Copper (µg/L)	12	35.2	285	125.17	12	33.7	206.6	58.56	150 (SPDES)
Iron (mg/L)	12	0.426	1.3	0.85	12	0.117	0.422	0.25	0.37 (SPDES)
Mercury (µg/L)	12	< 0.1	0.99	0.11	12	< 0.1	0.23	< 0.1	0.8 (SPDES)
Manganese (µg/L)	12	11.5	70.6	36.2	12	3.4	28.5	10.86	300 (GA)
Molybdenum (µg/L)	12	< 5.0	116	23.8	12	< 5	143	30.24	SNS
Nickel (µg/L)	12	2.71	15	7.69	12	2.57	8.7	4.61	110 (SPDES)
Lead (µg/L)	12	4.18	58	18.6	12	< 1.32	16.7	3.36	19 (SPDES)
Selenium (µg/L)	12	< 5.0	< 20	< 20	12	< 5	< 20	< 20	4.6 (Dissolved)
Silver (µg/L)	12	< 1.0	6.4	< 4.0	12	< 1	7.7	2.30	15 (SPDES)
Sodium (mg/L)	12	26.2	48.8	40.75	12	25.8	56.4	39.06	SNS
Thallium (µg/L)	12	< 0.7	4.3	< 1.3	12	< 0.66	2.6	< 0.66	8 (Acid Soluble)
Vanadium (µg/L)	12	< 5.5	< 22	< 22	12	< 5.5	< 22	< 22	14 (Acid Soluble)
Zinc (µg/L)	12	31.4	132	65.88	12	18.9	94.7	46.03	100 (SPDES)

Notes:

See Figure 5-1 for locations of the STP influent and effluent monitoring locations.
 All analytical results were generated using total recoverable analytical techniques.
 For Class C standards, the solubility state for the metal is provided.
 GA = Class GA (groundwater) Ambient Water Quality Standard
 NA = Not Applicable
 SNS = Standard Not Specified
 SPDES = State Pollutant Discharge Elimination System

SU = Standard Units

* Holding times for nitrate analyses are routinely exceeded.

⁽¹⁾ Unless otherwise provided, the reference standard is 6 NYCRR Part 703.5 Class C Surface Water.

⁽²⁾ The pH and temperature values reported are based on analysis of daily grab samples.

⁽³⁾ Continuously monitored by STP operators.

permitted levels, the concentration did not affect the quality of the STP effluent.

Process wastewaters that were not expected to be of consistent quality because they were not routinely generated were held for characterization before release to the site sewer system. The process wastewaters typically included ion-exchange column regeneration wastes, primary closed-loop cooling water, and other industrial

wastewaters. To determine the appropriate disposal method, samples were analyzed for contaminants specific to the process. The analyses were then reviewed and the concentrations were compared to the SPDES effluent limits and BNL effluent criteria. If the concentrations were within limits, authorization for sewer disposal was granted; if not, alternate means of disposal were pursued. Any waste that contained

Figure 5-6. BNL Outfall Locations.

elevated levels of hazardous or radiological contaminants in concentrations that exceed BNL effluent criteria was sent to the BNL Waste Management Facility for proper disposal.

5.4 RECHARGE BASINS

Recharge basins are used for the discharge of “clean” wastewater streams, including once-through cooling water, storm water runoff, and cooling tower blowdown. With the exception of elevated temperature and increased natural sediment content, these wastewaters are suitable for direct replenishment of the groundwater aquifer. Figure 5-6 shows the locations of BNL’s discharges to recharge basins. An overall

schematic of water use at BNL is presented in Figure 5-7. Nine recharge basins are used for managing once-through cooling water, cooling tower blowdown, and stormwater runoff, as described below.

- Basins HN, HT-W, and HT-E receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS) and Relativistic Heavy Ion Collider (RHIC), as well as cooling tower blowdown and stormwater runoff.
- Basin HS receives predominantly stormwater runoff, once-through cooling water from Building 555 (Chemistry Department), and minimal cooling tower

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

blowdown from the National Synchrotron Light Source.

- 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.
- Several other recharge areas are used exclusively for discharging stormwater runoff, including Basin HW in the warehouse area, Basin CSF at the Central Steam Facility, Basin H-WM at the Former Waste Management Facility, and a newly constructed Basin HZ, which receives stormwater from the area around Building 902.

Each of the recharge basins is a permitted point source discharge under BNL's SPDES permit. Where required by the permit, the discharge to the basin is equipped with a flow monitoring station, and weekly recordings of flow are collected, with measurements of pH. The specifics of the SPDES compliance monitoring program are provided in Chapter 3. To supplement that monitoring program, samples also are routinely collected and analyzed under BNL's Environmental Monitoring Program for radioactivity, VOCs, metals, and anions. During 2002,

water samples were collected from Basins HN, HO, HS, HT-E, HT-W, HW, and the CSF.

5.4.1 Recharge Basins - Radiological Analyses

Discharges to the recharge basins were sampled throughout the year to measure concentrations of gross alpha and beta activity, gamma-emitting radionuclides, and tritium. Radiological results for water samples that were collected at the recharge basins are presented in Table 5-4. The data show there were extremely low levels of beta activity detected in most of the basins, with Basin HW exhibiting higher concentrations than the others. The maximum concentration of beta activity detected in Basin HW was 21.6 ± 1.7 pCi/L (0.8 ± 0.06 Bq/L), which is less than 45 percent of the drinking water standard. With the exception of low level detections of cesium-137 in Basin HW, the accompanying gamma analysis of water samples collected from all basins showed that only potassium-40, lead-212, thallium-208, and beryllium-7 were detectable in these water samples. These gamma-emitting nuclides are attributed to natural terrestrial/geological or cosmic sources. With regard to Basin HW, cesium-137 was detected in two of four sampling events at concentrations of 2.12 ± 1.27 pCi/L (0.08 ± 0.05 Bq/L) and 1.31 ± 1.00

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

Basin		Gross Alpha	Gross Beta (pCi/L)	Tritium	Sr-90
HN	N	4	4	4	NS
	Max.	2.40 ± 0.65	3.45 ± 0.94	<386	
	Avg.	1.18 ± 0.93	2.17 ± 1.31	131 ± 89	
HO	N	4	4	4	NS
	Max.	5.06 ± 0.75	2.99 ± 1.07	<347	
	Avg.	1.25 ± 2.53	1.40 ± 1.62	79 ± 41	
HS	N	4	4	4	NS
	Max.	0.84 ± 0.51	3.21 ± 1.39	<386	
	Avg.	0.68 ± 0.11	2.34 ± 0.95	191 ± 74	
HT-E	N	4	4	4	NS
	Max.	4.21 ± 0.73	5.03 ± 1.02	<386	
	Avg.	1.76 ± 2.13	1.54 ± 2.33	175 ± 123	
HT-W	N	4	4	4	NS
	Max.	1.96 ± 0.63	3.60 ± 1.41	<386	
	Avg.	0.70 ± 1.08	1.79 ± 1.75	182 ± 197	
HW	N	3	3	4	NS
	Max.	4.75 ± 0.85	21.60 ± 1.66	<336	
	Avg.	2.15 ± 2.57	6.21 ± 15.40	26 ± 64	
SDWA Limit		15	50	20,000	8

Notes:

Figure 5-6 provides the locations of outfall/recharge basins.

All values reported with a 95% confidence interval.

N = Number of samples collected for analysis

NA = Not Applicable

NS = Samples not collected for this analysis

SWDA = Safe Drinking Water Act

pCi/L (0.05 ± 0.04 Bq/L). Due to the high error (i.e., > 50 percent) associated with these detections, the concentrations are at best estimates. Cesium-137 is present in natural sediments at very low levels (i.e., < 1 pCi/g). Carryover of sediment in the storm water could explain these low levels of detection. Tritium was not detected in any basin above minimum detection limits during 2002.

5.4.2 Recharge Basins - Nonradiological Analyses

To determine the overall impact of the recharge basin discharges on the environment, the nonradiological analytical results were compared to groundwater discharge standards promulgated under Title 6 of the New York Codes, Rules, and Regulations, Part 703.6. Samples were collected quarterly for water quality parameters, metals, and VOCs, and analyzed by the BNL Analytical Services Laboratory. Field-measured parameters (pH, conductiv-

ity, and temperature) were routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 5-5 and 5-6, respectively.

Low concentrations of disinfection byproducts were routinely detected in several discharges. These VOCs included bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. Concentrations ranged from nondetectable to a maximum of 4.7 µg/L. Sodium hypochlorite and bromine, used to control algae in cooling towers, are responsible for the formation of these compounds. Acetone was detected in several samples collected from Recharge Basin HW at concentrations up to 13 µg/L. Acetone is commonly found as a contaminant in analytical laboratories and may be present due to its ability to evaporate in one area and then redissolve in water in another area of the Laboratory.

The analytical data in Tables 5-5 and 5-6 show that most parameters, except for aluminum and iron, complied with the respective groundwater discharge or water quality standards. Chlorides were found to be very high in a sample collected in January from Basin HW. Since this basin receives runoff from paved roads, the most likely contributor to this observation is salt from deicing of roadways. Aluminum and iron are natural components of soil and readily dissolve when water samples are acidified for preservation. Iron is present naturally in Long Island groundwater at concentrations that exceed the New York State groundwater effluent limit. Selenium was also detected in several samples approaching or slightly exceeding the groundwater discharge standard. However, these values were estimated and are suspect, due to the presence of selenium in the laboratory blank.

Investigation of lead concentrations in soil samples collected at the Central Steam Facility (CSF) outfall continued in 2002. A significant area of soil containing lead in concentrations greater than 10,000 mg/Kg is still under investigation. Historical operations of the CSF, specifically the combustion of waste oils and the washing of boiler ash to this outfall, are the most likely cause. Investigation activities in 2002 included the collection of more than 100 soil

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

Recharge Basin		pH (SU)	Conductivity (μS/cm)	Temperature (°C)	Dissolved Oxygen (mg/L)	Chlorides (mg/L)	Sulfates (mg/L)	Nitrate as N* (mg/L)
HN (RHIC)	N = 4							
	Min.	7.7	99	5.6	9.1	17.6	11.9	< 1
	Max.	7.9	280	15.3	12.1	27.6	20.1	< 1
	Avg.	NA	148	8.8	10.9	21.8	14.4	< 1
HO (AGS/HFBR)	N = 4							
	Min.	7.5	165	13.6	8.7	15.2	11.5	< 1
	Max.	7.8	221	22.2	10.3	25.4	13.3	< 1
	Avg.	NA	182	17.8	9.5	20.7	12.2	< 1
HS (stormwater)	N = 4							
	Min.	6.6	25	5.1	9.8	< 4	< 4	< 1
	Max.	7.8	267	16.6	12.3	42.5	18.9	1.8
	Avg.	NA	155	10.1	10.9	30.3	13.9	1.2
HT-E (AGS)	N = 4							
	Min.	6.6	93	6.6	9.0	15.1	11.2	< 1
	Max.	8.0	181	14.1	11.7	23.7	13.0	< 1
	Avg.	NA	137	9.4	10.8	18.5	11.7	< 1
HT-W (Linac)	N = 4							
	Min.	7.6	120	7.2	8.5	15.9	10.7	< 1
	Max.	8.1	177	18.7	13.0	28.0	13.3	< 1
	Avg.	NA	142	12.3	10.8	22.4	12.0	< 1
HW (Weaver Rd)	N = 3							
	Min.	6.5	31	5.8	8.3	< 4	< 4	< 1
	Max.	7.3	325	24.2	12.9	2,230	35.8	3.9
	Avg.	NA	129	14.1	10.5	743	11.8	1.3
CSF (stormwater)	N = 3							
	Min.	6.5	47	13.7	7.7	< 4	11.5	< 1
	Max.	7.2	89	23.2	8.9	5.4	13.3	1.4
	Avg.	NA	67.7	18.8	8.3	< 4.0	12.2	< 1
NYSDEC Effluent Standard		6.5–8.5	SNS	SNS	SNS	500	500	10
Typical MDL		NA	10	NA	NA	4	4	1

Notes:

* Holding times for nitrate analyses are routinely exceeded.

See Figure 5-6 for the locations of recharge basins.

There was no discharge to basin HP in 2002. This basin no longer receives cooling water from the BMRR.

AGS/HFBR = Alternating Gradient Synchrotron/High Flux Beam Reactor

BMRR = Brookhaven Medical Research Reactor

CSF = Central Steam Facility

Linac = Linear Accelerator

MDL = Minimum Detection Limit

N = Number of Samples

SU = Standard Units

NA = Not Applicable

NS = Not Sampled

NYSDEC = New York State Department of Environmental Conservation

RHIC = Relativistic Heavy Ion Collider

SNS = Effluent Standard Not Specified

samples that were used to delineate the area of contamination. A draft remedial work plan has been prepared and is currently under regulatory review. As discussed in Chapter 3, the SPDES permit now requires quarterly sampling for lead. On two occasions the lead concentration in the sample exceeded the SPDES permit limit of 50 μg/L when analyzed by the total recoverable method (i.e., acid preservation immediately after sample collection). However, samples that were filtered prior to acid preservation were well within the standard. To mitigate future permit

excursions, a geotextile fabric was installed at the outfall to prevent the resuspension of sediments. Since installation of the geotextile, there have been no further SPDES violations.

5.4.3 Stormwater Assessment

All recharge basins receive storm water runoff. At BNL, storm water is managed by collecting runoff from paved surfaces, roofs, and other impermeable surfaces and directing it to recharge basins via underground piping and abovegrade vegetated swales. Recharge Basin

Table 5-6. Metals Analytical Results for On-Site Recharge Basin Samples.

Recharge Basin	No. of Samples	Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
HN (RHIC, total)	N = 4																					
	Max.	<2.0	42.8	<6.0	30.2	<1.3	<2.2	1.2	<2.0	37.9	0.1	<0.1	22.9	<10.0	43.6	<2.2	<2.6	<1.8	<10.0	<1.3	<11.0	62.6
	Avg	<2.0	22.6	<6.0	20.9	<1.3	<1.1	0.4	<2.0	31.1	<0.075	<0.1	12.1	<10.0	33.1	<2.2	<2.6	<1.8	<10.0	<1.3	<11.0	39.1
HN (RHIC, filtered)	N = 2																					
	Min.	<1.0	5.5	<3.0	19.7	<0.7	<1.1	<0.12	<1.0	27.4	<0.075	<0.1	3.3	<5.0	30.2	<1.1	<1.3	<0.9	<5	<0.7	<5.5	19.3
	Max	<1.0	14.4	<3.0	26.4	<0.7	<1.1	0.3	<1.0	27.6	<0.075	<0.1	6.5	<5.0	41.3	<1.1	<1.3	<0.9	<5	<0.7	<5.5	19.3
HO (AGS, total)	N = 4																					
	Min.	<1.0	<2.2	<3.0	15.5	<0.7	<1.1	<0.12	<1.0	4.4	<0.075	<0.1	<2.0	<5.0	18.1	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
	Max.	<2.0	11.7	<6.0	19.4	<1.3	<2.2	0.4	<2.0	9.1	0.1	<0.1	13.9	<10.0	25.9	2.7	<2.6	<1.8	<10.0	<1.3	<11.0	8.7
	Avg.	<2.0	6.1	<3.0	17.0	<1.3	<2.2	<0.2	<2.0	6.6	<0.075	<0.1	6.1	<5.0	22.2	<2.2	<2.6	<1.8	<10.0	<1.3	<5.5	<8.0
HO (AGS, filtered)	N = 2																					
	Min.	<1.0	2.9	<3.0	15.0	<0.7	<1.1	0.2	<1.0	5.0	<0.075	<0.1	<2.0	<5.0	25.8	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
	Max.	<1.0	21.3	<3.0	18.9	<0.7	<1.1	0.4	<1.0	6.0	1.3	<0.1	<2.0	<5.0	35.6	<1.1	<1.3	<0.9	10.0	<0.7	<5.5	<4.0
HS (total stormwater)	N = 4																					
	Min.	<1.0	5.4	<3.0	31.0	<0.7	<1.1	<0.12	<1.0	4.4	<0.075	<0.1	5.3	<5.0	25.7	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	5.3
	Max.	<2.0	609.4	<6.0	41.4	<1.3	<2.2	0.2	2.2	62.6	0.1	<0.1	9.3	<10.0	30.1	<2.2	3.0	<1.8	22.4	<1.3	<11.0	23.8
	Avg.	<2.0	171.5	<6.0	34.3	<1.3	<2.2	<0.2	<2.0	20.0	<0.075	<0.1	7.1	<10.0	28.2	<2.2	<2.6	<1.8	<10.0	<1.3	<11.0	13.1
HS (filtered stormwater)	N = 2																					
	Min.	<1.0	18.6	<3.0	3.8	<0.7	<1.1	<0.12	<1.0	6.3	<0.075	<0.1	2.8	<5.0	1.1	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
	Max.	<1.0	120.0	<3.0	28.9	<0.7	<1.1	0.2	1.1	6.6	0.3	<0.1	5.4	15.3	27.0	1.3	4.1	<0.9	10.6	<0.7	<5.5	34.1
HT-E (AGS, total)	N = 4																					
	Min.	<1.0	2.7	<3.0	15.5	<0.7	<1.1	<0.12	<1.0	6.1	<0.075	<0.1	2.9	<5.0	17.9	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	4.0
	Max.	<2.0	30.2	<6.0	25.6	<1.3	<2.2	0.3	<2.0	34.5	0.1	<0.1	34.4	<10.0	27.1	<2.2	4.1	<1.8	<10.0	<1.3	<11.0	9.1
	Avg.	<2.0	12.3	<6.0	18.8	<1.3	<2.2	0.2	<2.0	16.6	<0.075	<0.1	14.3	<10.0	23.8	<2.2	<2.6	<1.8	<10.0	<1.3	<11.0	7.5
HT-E (AGS, filtered)	N = 2																					
	Min.	<1.0	16.9	<3.0	16.9	<0.7	<1.1	0.2	<1.0	6.7	<0.075	<0.1	<2.0	<5.0	22.9	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
	Max.	<1.0	18.6	<3.0	23.1	<0.7	<1.1	0.4	<1.0	14.5	<0.075	<0.1	4.9	<5.0	26.1	1.1	<1.3	<0.9	10.2	<0.7	<5.5	6.9
HT-W (Linac, filtered)	N = 2																					
	Min.	<1.0	22.1	<3.0	14.7	<0.7	<1.1	0.3	<1.0	10.8	<0.075	<0.1	<2.0	<5.0	23.4	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
	Max.	<1.0	36.6	<3.0	19.4	<0.7	<1.1	0.6	<1.0	15.7	<0.075	<0.1	6.1	<5.0	26.6	<1.1	<1.3	2.4	9.7	<0.7	<5.5	11.4
HT-W (Linac, total)	N = 4																					
	Min.	<1.0	15.8	<3.0	18.0	<0.7	<1.1	<0.12	<1.0	8.1	<0.075	<0.1	9.2	<5.0	16.1	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	12.5
	Max.	<2.0	1900.0	<6.0	31.2	<1.3	<2.2	1.1	5.5	139.0	0.7	<0.1	78.8	<10.0	32.1	3.1	4.1	<1.8	22.1	<1.3	<11.0	16.2
	Avg.	<2.0	504.3	<6.0	22.3	<1.3	<2.2	0.3	<2.0	48.9	0.2	<0.1	27.9	<10.0	26.4	<2.2	<2.6	<1.8	<10	<1.3	<11.0	15.1
HW (total stormwater)	N = 3																					
	Min.	<2.0	1600.0	<6.0	20.1	<1.3	<2.2	<0.5	5.7	70.7	0.5	<0.1	27.5	<10.0	3.6	5.9	16.6	<1.8	<5.0	<1.3	<11.0	31.7
	Max.	<4.0	2390.0	<12.0	69.9	<2.6	<4.4	1.4	10.4	186.1	1.9	<0.1	70.5	24.9	583.0	15.0	24.8	<3.5	21.4	<2.6	<22.0	95.9
	Avg.	<4.0	1915.2	<12.0	38.2	<2.6	<4.4	0.8	8.6	132.2	1.2	<0.1	49.1	<20.0	198.1	9.5	20.9	<3.5	<20.0	<2.6	<22.0	74.1
HW (filtered, stormwater)	N = 3																					
	Min.	<1.0	53.1	<3.0	5.2	<0.7	<1.1	0.2	<1.0	17.0	<0.075	<0.1	5.4	<5.0	2.1	1.3	<1.3	<0.9	<5.0	<0.7	<5.5	34.1
	Max.	15.3	119.6	3.8	56.0	<0.7	1.3	0.8	1.2	82.4	0.2	<0.1	43.3	21.5	587.0	4.5	4.1	<0.9	10.5	<0.7	<5.5	73.4
	Avg.	5.1	78.3	<3.0	21.7	<0.7	<1.1	0.6	<1.0	35.1	<0.075	<0.1	22.5	12.3	196.7	2.9	2.0	<0.9	<5.0	<0.7	<5.5	56.0

Table 5-6. Metals Analytical Results for On-Site Recharge Basin Samples (concluded).

Recharge Basin	No. of Samples	Ag μg/L	Al μg/L	As μg/L	Ba μg/L	Be μg/L	Cd μg/L	Co μg/L	Cr μg/L	Cu μg/L	Fe mg/L	Hg μg/L	Mn μg/L	Mo μg/L	Na mg/L	Ni μg/L	Pb μg/L	Sb μg/L	Se μg/L	Tl μg/L	V μg/L	Zn μg/L
CSF (total stormwater)	N = 4																					
	Min.	<2.0	2736.4	<6.0	17.5	<1.3	<2.2	0.4	2.9	37.8	1.4	<0.1	14.4	<10.0	3.1	6.2	11.9	<1.8	<10.0	<1.3	<11.0	24.0
	Max.	<4.0	3842.0	<12.0	57.3	<2.6	<4.4	2.4	10.1	201.4	2.6	<0.1	56.6	<20.0	36.4	26.6	44.3	<3.5	<20.0	<2.6	36.6	62.2
Avg. CSF (filtered stormwater)	N = 3																					
	Min.	<1.0	88.4	<3.0	14.8	<0.7	<1.1	0.4	<1.0	4.5	<0.06	<0.1	4.8	<5.0	3.9	5.4	2.5	<0.9	<5.0	<0.7	<5.5	14.6
	Max.	2.1	137.0	<3.0	34.4	<0.7	<1.1	0.8	<1.0	16.0	0.1	<0.1	14.8	<5.0	36.4	18.1	5.5	<0.9	9.4	<0.7	29.0	28.9
Avg.		<1.0	105.3	<3.0	17.6	<0.7	<1.1	0.6	<1.0	9.7	0.1	<0.1	10.8	<5.0	14.3	13.3	3.6	<0.9	<5.0	<0.7	13.0	23.5
NYSDEC		50.0	2000.0	50.0	2000.0	SNS	10.0	5.0	100.0	1000.0	0.6	1.4	600.0	SNS	SNS	200.0	50.0	6.0	20.0	SNS	SNS	5,000
Effluent Limitation or AWQS																						
Typical MDL		1.0	2.2	3.0	1.8	0.7	1.1	0.1	1.0	2.0	0.015	0.2	2.0	5.0	1.0	1.1	1.3	0.9	5.0	0.7	5.5	4.0

Notes:

See Figure 5-6 for locations of recharge basins.

Recharge basin HX was not sampled for metals during 2002.

AGS/HFBR = Alternating Gradient Synchrotron/High Flux Beam Reactor

AWQS = NYSDEC 6 NYCRR Part 703.5 Ambient Water Quality Standard

CSF = Central Steam Facility

MDL = Minimum Detection Limit

NYSDEC = New State Department of Environmental Conservation

RHIC = Relativistic Heavy Ion Collider

SNS = Effluent Standard Not Specified

HS receives most of the stormwater runoff from the central, developed portion of the BNL site (all properties south of Cornell Avenue and west of Railroad Avenue). Basins HN, HZ, HT-W, and HT-E receive runoff from the AGS and portions of the RHIC complex; Basin HO receives runoff from the BGRR and HFBR areas; Basin CSF receives runoff from the area around the Central Steam Facility, and areas along Cornell Avenue east of Railroad Avenue; Basin HW receives runoff from the warehouse area; and HW-M receives runoff from the fenced area at the waste management facility.

Stormwater runoff from the BNL site typically has elevated levels of inorganics and low pH. The inorganics are attributable to high sediment content and the natural occurrence of these elements in native soils. In an effort to further protect the quality of storm water runoff, BNL has finalized formal requirements for managing and maintaining outdoor work and storage areas. These requirements include covering areas to prevent contact with stormwater, an aggressive maintenance and inspection program, and formal restoration of these areas when operations cease. These requirements have become part of the revised *Storage and Transfer of Hazardous and Nonhazardous Materials* Subject Area.

5.5 PECONIC RIVER SURVEILLANCE

Several locations were monitored along the Peconic River to assess the overall water quality of the river and to assess any impact from BNL discharges. Sampling points along the Peconic River are identified in Figure 5-8. In total, 10 stations are monitored: three upstream and seven downstream of the STP outfall. In addition, a sampling station along the Carmans River (HH) is also monitored as a geographic control location that is not affected by BNL operations. All locations are monitored for

radiological and nonradiological parameters on a routine basis. In addition to the data reported here, water samples are also collected at locations where fish and aquatic vegetation samples are collected. The results for these data are reported in Chapter 6.

The sampling stations are located as follows.

Downstream sampling stations

- HM-N, on site, 0.5 mile downstream of the STP outfall
- HM-S, on site on a typically dry tributary of the Peconic River
- HQ, on site, 1.2 miles downstream of the STP outfall
- HA and HB, off site, 3.1 and 3.3 miles downstream of the STP outfall
- HC, off site, 4.3 miles downstream of the STP outfall
- HR, off site, 13 miles downstream of the STP outfall (in Riverhead)

Upstream locations

- HE, on site, approximately 20 feet upstream of the STP Outfall
- HV, on site, just east of the 10 o'clock Experimental Hall in the RHIC ring
- HY, on site, just east of the William Floyd Parkway

Control location

- HH, Carmans River

5.5.1 Peconic River - Radiological Analyses

Radionuclide measurements were performed on surface water samples collected from the Peconic River at nine of ten locations. As previously stated, low flow conditions within the Peconic due to drought prevented sample collection from HQ in 2002. Routine samples at Station HM-N were collected once per month. Station HE was collected quarterly in 2002. Since February 1995, Stations HE, HM-N, and HQ have been equipped with Parshall flumes that allow automated flow-proportional sampling and volume measurements. All other sites were sampled quarterly by collecting instantaneous grab samples, as flow allowed.

The radiological data from Peconic River surface water sampling in 2002 are summarized in Table 5-7. Radiological analysis of upstream water samples showed that gross alpha and beta

activities were occasionally detected at low levels at all three upstream locations. Samples collected downstream of the BNL STP discharge showed higher concentrations than upstream values. All detected levels were below the drinking water standard, with the exception of single gross alpha values at stations HB and HC. Resuspension of sediment that contains natural alpha emitters and possibly low levels of radionuclides discharged by BNL past operations is the most likely contributor to these detections. No gamma-emitting radionuclides attributable to BNL operations were detected either upstream or downstream of the STP.

Tritium analytical results of water samples collected upstream and downstream from the STP discharge were below detectable levels at all stations.

Monitoring for strontium-90 was performed at eight of the nine stations sampled in 2002. Trace levels were found at all locations, with the highest at Station HE. Strontium-90 was detected at Station HE at a maximum concentration of 1.09 ± 0.26 pCi/L (0.04 ± 0.01 Bq/L), which is approximately 14 percent of the drinking water standard and comparable to the levels detected at this location historically.

5.5.2 Peconic River - Nonradiological Analyses

Samples collected in 2002 were analyzed for water quality parameters (pH, temperature, conductivity, and dissolved oxygen), anions (chlorides, sulfates, and nitrates), metals, and VOCs. The inorganic analytical data for the Peconic River and Carmans River samples are summarized in Tables 5-8 (water quality) and 5-9 (metals).

No VOCs were routinely detected in river water samples above the minimum detection limits. Methyl tertiary butyl ether (MTBE) was detected at Stations HR and HH on several occasions. This compound was used as a gasoline oxygenating agent until 2002. The product was removed from formulated gasoline due to its recent nationwide detection in groundwater and very high aqueous mobility. The highest concentration, 17.6 mg/L, was detected at Station HR. Concentrations of MTBE at Station HH ranged from 3.8 to 10 mg/L. Trace levels of 1,1,1-

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

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

Sample Station	Geographic Location		Gross Alpha	Gross Beta	Tritium	Sr-90
			(pCi/L)			
HY	Peconic River (headwaters) on site, west of the RHIC ring	N	2	2	3	2
		Max.	1.52 ± 0.58	2.05 ± 1.10	<316	<0.59
		Avg.	0.83 ± 1.36	1.55 ± 0.98	-263 ± 216	0.23 ± 0.21
HV	Peconic River (headwaters) on site, inside the RHIC ring	N	2	2	2	NS
		Max.	1.24 ± 0.53	2.87 ± 1.14	<375	
		Avg.	0.90 ± 0.68	1.69 ± 2.31	-321 ± 266	
HE	Peconic River, upstream of STP outfall	N	4	4	4	4
		Max.	1.09 ± 0.46	2.72 ± 1.11	<294	1.09 ± 0.26
		Avg.	0.51 ± 0.38	1.07 ± 1.10	-111 ± 137	0.73 ± 0.34
HM-N	Peconic River, 0.4 mi from STP, on site	N	11	11	11	6
		Max.	3.17 ± 1.69	15.90 ± 6.19	<34	30.52 ± 0.16
		Avg.	1.60 ± 0.51	8.16 ± 2.26	78 ± 96	0.20 ± 0.15
HM-S	Peconic River tributary, on site	N	1	1	1	1
		Max.	<0.73	<1.96	<375	<0.23
HQ ⁽¹⁾	Peconic River, BNL boundary	N	NS	NS	NS	NS
HA	Peconic River, off site	N	4	4	4	2
		Max.	7.28 ± 0.99	6.72 ± 1.10	< 347	< 0.56
		Avg.	2.44 ± 3.20	2.12 ± 3.73	-27 ± 136	0.20 ± 0.25
HB	Peconic River, off site	N	4	4	4	2
		Max.	24.40 ± 1.83	7.21 ± 1.21	<347	<0.60
		Avg.	7.19 ± 11.38	4.42 ± 3.36	67 ± 121	0.06 ± 0.30
HC	Peconic River, off site	N	4	4	4	2
		Max.	20.30 ± 1.69	6.30 ± 1.17	<347	0.29 ± 0.15
		Avg.	5.60 ± 9.62	2.36 ± 3.21	-26 ± 144	0.28 ± 0.01
HR	Peconic River, Riverhead	N	4	4	4	2
		Max.	1.06 ± 0.42	2.66 ± 0.90	<347	<0.21
		Avg.	0.30 ± 0.53	1.69 ± 1.13	14 ± 129	0.04 ± 0.19
HH	Carmans River (control location)	N	4	4	4	2
		Max.	1.50 ± 0.49	3.71 ± 0.95	<347	<0.46
		Avg.	0.49 ± 0.73	0.85 ± 2.37	22 ± 115	0.01 ± 0.58
SDWA Limit			15	50	20,000	8

Notes:

See Figure 5-8 for sample station locations.

All values shown with 95% confidence interval.

Negative numbers occur when the measured value is lower than analytical laboratory background levels.

Avg. = Average value

Max. = Maximum value

N = Number of samples analyzed

NS = Not Sampled for this analyte

SDWA = Safe Drinking Water Act

⁽¹⁾There was no flow recorded at Station HQ throughout 2002.

trichloroethane were detected on one occasion at Station HR. Neither MTBE or 1,1,1 trichloroethane are the result of BNL operations, but may be the result of roadway runoff or other off-site sources.

Comparison of Peconic River water quality data collected upstream and downstream showed that water quality parameters were consistent

throughout the river system. These data were also consistent with data from the Carmans River control location (HH). Chlorides, sulfates, and nitrates tend to be slightly higher in samples collected immediately downstream of the STP discharge (Stations HM-N and HQ) and were consistent with the concentrations in the STP discharge. Chlorides were, however, highest at

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

Sample Station	Geographic Location		pH (SU)	Conductivity (μS/cm)	Temp. (°C)	Dissolved			Nitrates as N* (mg/L)
						Oxygen (mg/L)	Chlorides (mg/L)	Sulfates (mg/L)	
HY	Peconic River (headwaters) on site, east of Wm. Floyd Pkwy.	N	3	3	3	3	3	3	3
		Min.	4.1	69	3.4	8.5	6.6	< 4	< 1
		Max.	7.2	260	9.9	13.2	748.0	28.4	1.8
		Avg.	NA	155	6.2	11.5	313.0	9.5	< 1
HE	Peconic River, upstream of STP outfall	N	3	3	3	3	3	3	3
		Min.	6.3	43	7.6	9.1	5.8	8.5	< 1
		Max.	7.3	123	10.6	11.5	7.3	32.1	< 1
		Avg.	NA	88	8.6	10.2	6.6	21.5	< 1
HM-N	Peconic River, 0.4 mi from STP, on site	N	11	11	11	11	11	11	11
		Min.	6.4	216	3.6	6.2	23.0	13.7	1.2
		Max.	7.3	350	23.5	14.5	61.1	23.3	6.8
		Avg.	NA	274	13.3	10.3	40.1	17.0	4.4
HM-S	Peconic River tributary, on site	N	1	1	1	1	1	1	1
		Value	4.0	79	11.1	8.5	5.3	4.1	< 1
HQ	Peconic River, BNL boundary	N	0 ^(a)						
HA	Peconic River, off site	N	4	4	4	4	4	4	4
		Min.	6.2	53	1.0	3.3	6.4	4.6	< 1
		Max.	6.5	101	20.8	9.6	6.7	25.2	< 1
		Avg.	NA	76	10.5	7.8	6.6	10.3	< 1
HB	Peconic River, off site	N	4	4	4	4	4	4	4
		Min.	5.3	58	0.7	5.5	7.5	< 4	< 1
		Max.	6.3	152	22.8	8.8	9.3	49.0	< 1
		Avg.	NA	86	10.6	7.1	8.3	15.2	< 1
HC	Peconic River, off site	N	4	4	4	4	4	4	4
		Min.	6.3	69	2.8	4.5	10.0	< 4	< 1
		Max.	6.6	80	26.5	12.6	11.2	13.1	< 1
		Avg.	NA	74	14.1	9.0	10.6	7.9	< 1
HR	Peconic River off site, at Riverhead	N	4	4	4	4	4	4	4
		Min.	6.5	119	4.1	7.3	16.1	9.4	< 1
		Max.	7.0	150	26.1	11.2	25.5	13.1	1.4
		Avg.	NA	129	13.9	9.2	18.7	11.2	< 1
HH	Carmans River (control location)	N	4	4	4	4	4	4	4
		Min.	6.5	130	4.6	10.0	18.3	11.0	< 1.0
		Max.	7.0	170	23.4	11.5	26.0	12.3	2.0
		Avg.	NA	153	13.1	10.8	23.4	11.8	1.1
NYS AWQS			6.5 – 8.5	SNS	SNS	> 4.0	250 ^(b)	250 ^(b)	10 ^(b)
Typical MDL			NA	10	NA	NA	4.0	4.0	1.0

Notes:

See Figure 5-8 for sample station locations.

N = No. of samples

NA = Not Applicable

NS = Not Sampled

MDL = Minimum Detection Limit

SNS = Standard Not Specified

SU = Standard Units

* Holding times for nitrate analyses are routinely exceeded.

^(a) There was no flow recorded at Station HQ throughout 2002.^(b) Because there are no Class C Surface Water Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for groundwater is provided, if specified.

upstream Station HY. The sample collected from Station HY in January measured 748 mg/L, most probably due to road salting and surface runoff, due to that station's proximity to William Floyd Parkway. There are no limits imposed for chloride discharges to surface water; however, a

discharge limit of 500 mg/L is imposed for discharges to groundwater.

The pH measured at several locations was very low due to the low pH of precipitation, groundwater, and the formation of humic acids from decaying organic matter. As the spring rains

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

Station	N	Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Na mg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se* µg/L	Tl µg/L	V µg/L	Zn µg/L	
Peconic River																							
HY (total)	3	Min.	<2.0	595.0	<6.0	14.6	<1.3	<2.2	0.8	3.1	17.3	0.4	<0.1	20.2	<10.0	6.5	<2.2	7.1	<1.8	<10.0	<1.3	<11.0	23.4
		Max.	<4.0	2106.0	<12.0	44.8	<2.6	<4.4	1.2	10.8	129.3	1.6	<0.1	70.4	<20.0	485.0	18.2	13.9	<3.5	<20.0	<2.6	<22.0	39.3
		Avg.	<4.0	1500.3	<12.0	29.7	<2.6	<4.4	1.0	6.2	82.2	0.8	<0.1	44.4	<20.0	199.8	7.5	9.7	<3.5	<20.0	<2.6	<22.0	32.7
HY (D)	1	Val.	<1.0	79.6	3.4	24.6	<0.7	<1.1	0.4	2.8	76.7	0.1	<0.1	25.1	<5.0	446.3	2.4	1.4	<0.9	10.1	<0.7	<5.5	20.3
HE (total)	4	Min.	<1.0	116.0	<3.0	18.0	<0.7	<1.1	0.3	<1.0	<2.0	0.5	<0.1	62.7	<5.0	5.3	<2.2	<1.3	<0.9	<5.0	<0.7	<5.5	10.9
		Max.	<2.0	204.0	<6.0	32.2	<1.3	<2.2	1.0	<2.0	<4.0	1.0	<0.1	164.0	<10.0	6.9	<2.2	<2.6	<1.8	<10.0	<1.3	<11.0	44.7
		Avg.	<2.0	164.7	<6.0	23.8	<1.3	<2.2	0.6	<2.0	<4.0	0.8	<0.1	115.6	<10.0	6.1	<2.2	<2.6	<1.8	<10.0	<1.3	<11.0	25.0
HE (D)	2	Min.	<1.0	79.0	<3.0	11.4	<0.7	<1.1	0.6	<1.0	<2.0	0.4	<0.1	114.1	<5.0	5.9	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	4.2
		Max.	<1.0	152.9	<3.0	20.2	<0.7	<1.1	0.7	<1.0	2.5	0.6	<0.1	115.4	<5.0	6.4	1.8	<1.3	<0.9	8.7	<0.7	<5.5	17.0
HM-N (total)	11	Min.	<1.0	45.9	<3.0	9.1	<0.7	<1.1	0.4	<2.0	29.6	0.2	<0.1	<8.0	<5.0	30.6	<4.4	<1.3	<0.9	<5.0	<0.7	<5.5	11.2
		Max.	22.7	2828.0	<12.0	54.8	<2.6	<4.4	2.8	15.2	240.0	2.1	1.5	113.0	127.0	40.9	10.8	14.6	<3.5	23.9	<2.6	<22.0	91.5
		Avg.	3.8	501.2	<12.0	22.7	<2.6	<4.4	0.7	3.3	77.1	0.5	0.17	23.8	28.5	31.8	5.3	5.4	<3.5	<20.0	<2.6	<22.0	41.6
HM-N (D)	6	Min.	<1.0	8.2	<3.0	10.0	<0.7	<1.1	0.3	<1.0	29.6	0.1	<0.1	6.1	<5.0	28.5	3.1	<1.3	<0.9	<5.0	<0.7	<5.5	9.3
		Max.	1.6	69.2	3.6	25.6	<0.7	<1.1	0.6	1.6	53.9	0.2	0.1	19.9	88.9	53.4	6.1	1.8	<0.9	12.1	<0.7	8.8	81.8
		Avg.	<1.0	42.4	<3.0	15.9	<0.7	<1.1	0.5	1.3	39.2	0.1	<0.1	10.2	14.8	36.6	4.0	<1.3	<0.9	<5.0	<0.7	<5.5	36.9
HM-S (total)	1	Val.	<4.0	2327.2	<12.0	27.6	2.6	<4.4	<0.5	<4.0	158.2	0.5	<0.1	34.6	<20.0	5.9	8.8	6.2	<3.5	58.2	<2.6	<22.0	30.6
HQ (total)																							
HA (total)	4	Min.	<1.0	44.9	<3.0	10.4	<0.7	<1.1	0.3	<1.0	<2.0	1.1	<0.1	45.5	<5.0	4.7	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<4.0	786.0	<12.0	18.3	<2.6	<4.4	0.5	6.7	139.1	3.6	<0.1	135.0	<20.0	7.3	<4.4	<5.3	<3.5	<20.0	<2.6	<22.0	19.7
		Avg.	<4.0	332.5	<12.0	14.5	<2.6	<4.4	0.4	1.7	103.8	1.7	<0.1	82.6	<20.0	5.8	<4.4	<5.3	<3.5	<20.0	<2.6	<22.0	<16
HA (D)	2	Min	<1.0	29.8	<3.0	6.4	<0.7	<1.1	0.3	<1.0	<2.0	0.5	<0.1	74.5	<5.0	5.0	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<1.0	56.0	<3.0	8.5	<0.7	<1.1	0.4	<1.0	<2.0	1.9	<0.1	75.9	<5.0	5.0	<1.1	<1.3	<0.9	8.9	<0.7	<5.5	12.0
HB (total)	4	Min.	<1.0	41.9	<3.0	8.4	<0.7	<1.1	0.2	<1.0	<2.0	0.7	<0.1	40.5	<5.0	5.9	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<4.0	613.6	<12.0	40.2	2.7	<4.4	2.8	10.1	89.0	4.0	<0.1	281.0	<20.0	10.1	9.9	16.8	3.5	<20.0	<2.6	<22.0	44.4
		Avg.	<4.0	189.8	<12.0	19.2	0.7	<4.4	1.1	2.5	22.3	1.9	<0.1	120.5	<20.0	7.3	2.9	4.2	0.9	<20.0	<2.6	<22.0	11.1
HB (D)	2	Min.	<1.0	25.5	<3.0	7.3	<0.7	<1.1	0.3	<1.0	<2.0	0.4	<0.1	41.3	<5.0	<0.1	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max	<1.0	39.7	<3.0	9.1	<0.7	<1.1	0.4	<1.0	<2.0	2.0	<0.1	83.1	<5.0	6.1	<1.1	<1.3	<0.9	8.5	<0.7	<5.5	<4.0
HC (total)	4	Min.	<1.0	9.6	<3.0	10.9	<0.7	<1.1	<0.1	<1.0	<2.0	0.4	<0.1	23.2	<5.0	6.7	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<4.0	1543.2	<12.0	28.8	3.0	<4.4	2.9	<4.0	113.8	3.0	<0.1	160.0	<20.0	11.7	6.7	7.5	<3.5	<20	<2.6	<22	<16
		Avg.	<4.0	339.5	<12.0	15.7	<1.3	<4.4	0.8	<4.0	28.8	1.3	<0.1	89.8	<20.0	10.1	<2.2	1.8	<3.5	<20	<2.6	<22	<16
HC (D)	2	Min	<1.0	31.6	<3	9.6	<0.7	<1.1	0.2	<1.0	<2.0	0.3	<0.1	21.6	<5.0	3.2	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<1.0	54.6	<3.0	12.8	<0.7	<1.1	0.4	<1.0	<2.0	2.9	<0.1	154.5	<5.0	7.8	<1.1	1.8	<0.9	8.9	<0.7	<5.5	<4.0
HR (total)	4	Min.	<1.0	26.3	<3.0	20.5	<0.7	<1.1	0.1	<1.0	<2.0	0.5	<0.1	99.2	<5.0	1.7	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<2.0	1095.2	<12.0	33.8	<2.6	<4.4	1.1	8.2	196.8	1.3	<0.1	234.2	<5.0	17.8	13.4	32.4	<3.5	<20.0	<2.6	<22.0	<16
		Avg.	<2.0	302.6	<12.0	28.2	<2.6	<4.4	0.4	2.1	49.2	0.8	<0.1	149.4	<5.0	15.3	3.4	8.1	<3.5	<20.0	<2.6	<22.0	<16
HR (D)	2	Min.	<1.0	10.5	<3.0	18.1	<0.7	<1.1	<0.12	<1.0	<2.0	0.3	<0.1	102.0	<5.0	4.5	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<1.0	81.2	<3.0	24.2	<0.7	<1.1	0.4	<1.0	<2.0	0.4	<0.1	103.0	<5.0	12.2	<1.1	<1.3	<0.9	9.1	<0.7	<5.5	<4.0
Carmans River																							
HH (total)	4	Min.	<1.0	21.1	<3.0	19.5	<0.7	<1.1	<0.1	<1.0	<2.0	0.2	<0.1	27.0	<5.0	12.2	<1.1	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
		Max.	<2.0	743.0	<6.0	49.2	<1.3	<2.2	0.4	3.1	74.5	0.8	<0.1	129.0	<10.0	18.9	<5.9	4.4	<1.8	<20.0	<1.3	<11.0	38.8
		Avg.	<2.0	222.2	<6.0	38.3	<1.3	<2.2	0.2	<2	23.8	0.5	<0.1	78.1	<10.0	15.2	<5.9	<2.6	<1.8	<20.0	<1.3	<11.0	11.2

(continued on next page)

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

Station	N	Ag μg/L	Al μg/L	As μg/L	Ba μg/L	Be μg/L	Cd μg/L	Co μg/L	Cr μg/L	Cu μg/L	Fe mg/L	Hg μg/L	Mn μg/L	Mo μg/L	Na mg/L	Ni μg/L	Pb μg/L	Sb μg/L	Se* μg/L	Ti μg/L	V μg/L	Zn μg/L
HH (D)	2	Min. Max.	<1.0 93.6	<3.0 <3.0	27.4 35.9	<0.7 <0.7	<1.1 <1.1	0.2 0.3	<1.0 <1.0	2.1 2.4	0.2 0.2	<0.1 <0.1	35.1 96.0	<5.0 <5.0	<1.0 19.6	<1.1 2.8	<1.3 <1.3	<0.9 <0.9	<5.0 8.8	<0.7 <0.7	<5.5 <5.5	<4.0 <4.0
NYSDEC AWQS		0.1	100	150	SNS	11	1.1	5	34	4	0.3	0.2	SNS	SNS	SNS	23	0.1	SNS	4.6	8	14	0.1
Solubility State		I*	I*	D	AS	AS	D	AS	D	D	AS	D	AS	D	D	D	D	D	D	AS	AS	I*
Typical MDL		1	2.2	3	1.8	0.66	1.1	0.12	1	2	0.075	0.2	2	5	1	1.1	1.3	0.88	5	0.66	5.5	4

Notes:

See Figure 5-8 for sample station locations.

The concentration of selenium detected in several samples is estimated, due to contamination of the blank. Analysis of the method blank showed detectable levels of selenium very similar to those found in the samples.

AS = Acid Soluble

D = Dissolved

I* = Ionic

MDL = Minimum Detection Limit

N = No. of Samples

NYSDEC AWQS = New York State Department of Environmental Conservation Ambient Water Quality Standard for Class C Surface Water

SNS = Standard Not Specified for these elements for Class C waters

Surface water location HV was not sampled for metals in 2002.

(a) There was no flow recorded at Station HQ in 2002.

* Holding times for nitrate analyses are routinely exceeded.

mix with the decaying matter, these acids decrease the already low pH of precipitation, resulting in a pH as low as 4.1 Standard Units. A discussion of precipitation monitoring is provided in Chapter 6 of this report.

Ambient water quality standards for metallic elements are based on their solubility state. Certain metals are only biologically available to aquatic organisms if they are in a dissolved or ionic state, whereas other metals are toxic in any form (i.e., dissolved and particulate combined). In 2002, the BNL monitoring program continued to assess water samples for both the dissolved and particulate form. Dissolved concentrations were determined by first filtering the samples prior to acid preservation and analysis. Examination of the metals data showed that aluminum, copper, iron, lead, selenium, and zinc were present in concentrations that exceeded ambient water quality standards at locations both upstream and downstream of the STP discharge, and at the control location HH. Additionally, silver and mercury were detected above water quality standards at Station HM-N, immediately downstream of the STP discharge. The concentration of selenium was highest in a water sample collected at Station HM-S, a tributary not impacted by STP operations. Copper was detected at high levels in samples collected at the upstream station (HY), immediately downstream of the STP discharge (HM-N), and at the Riverhead Station HR. Due to its wide range of detection, this element is most likely attributable to native sediment carried over into the water column. Similarly, concentrations of iron, aluminum, lead, and zinc are high throughout the Peconic River and may be indicative of sediment carryover.

The concentration of copper, mercury, and silver are highest at Station HM-N. These elements are the metals of interest under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Operable Unit (OU) V investigation. During 2002, disturbances to the riverbed from pilot studies may explain their high levels. A full description of the OU V activities conducted in 2002 is contained in Chapter 2. While these elements are detected in the STP discharge, the

concentrations detected in the river are much higher than those in the STP effluent. Filtration of samples had a drastic impact on the concentration of metals. In most instances, the concentration was significantly lower in the filtered sample than in the unfiltered (i.e., acid-digested) sample, indicating that sediments contained in the water were the likely contributor to the observed concentrations. The BNL STP effluent is routinely monitored for suspended solids. The concentration of solids in the STP discharge is typically nondetectable (see Table 3-3); consequently, the current BNL STP discharge is not the source of these contaminants. The most likely

source is sediment scoured from the riverbed and entrained in the flowing stream. BNL will continue to collect both filtered and unfiltered samples to assess water quality impacts.

REFERENCES AND BIBLIOGRAPHY

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Natural and Cultural Resources

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

Monitoring to determine whether current or historical activities are affecting natural resources is also part of this program. In 2002, deer and fish sampling results were consistent with previous years. Local farm-grown produce and vegetables grown in the BNL garden plot continue to support historical analyses that there are no Laboratory-generated radionuclides in farm produce.

Completing the second year of operation of the Upton Ecological and Research Reserve (Upton Reserve), its advisory group approved funding for research on the 530-acre area. Multiple research grants to investigate important local ecological issues were awarded.

The BNL Cultural Resource Management program is currently being developed to identify, assess, and document BNL's historic and cultural resources. Additional goals of the program include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of identified resources to on-site personnel and the public for research and interpretation. The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL/DOE historic resources is established and maintained. In 2002, cultural resource surveys of WW I training trenches and foundations were completed.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The purpose of the Natural Resource Management Program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource protection with BNL's mission. To meet this purpose, the Laboratory has a Wildlife Management Plan that describes the program strategy, elements, and planned activities (Naidu

1999). The plan and related information about natural resources at the Laboratory can be found at the Environmental Services Division website, <<http://www.bnl.gov/esd/wildlife/>>.

6.1.1 Identification and Mapping

An understanding of the environmental baseline is the foundation of natural resource management planning. The use of a geographic information systems (GIS) aids the understanding

Figure 6-1. Vegetation Map of BNL.

of interactions between varying parts of an ecosystem. In 2001, through funding managed by the U.S. Fish & Wildlife Service (FWS), the entire BNL property was surveyed using the National Vegetation Standard; a new map was produced that clearly identifies the major vegetation complexes and their extents (Figure 6 -1). An additional tool provided with the vegetation map allows the user to predict distributions of key animal species based on the presence of suitable habitat. In addition to the vegetation map, natural resource monitoring activities were added to BNL's GIS system in order to track changes over time and interactions between components of the ecosystem, and to identify the locations of management activities on the 5,265-acre property.

As noted in Chapter 1, a wide variety of vegetation, birds, reptiles, amphibians, and mammals reside at BNL. The only New York State endangered species known to inhabit BNL property is the tiger salamander (*Ambystoma t. tigrinum*). Three New York State threatened species have been positively identified on site and a fourth species is considered likely. The banded

sunfish (*Enneacanthus obesus*), the swamp darter (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). A fourth species, the frosted elfin butterfly (*Callophrys irus*) has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant (wild lupine). In addition, several species that inhabit the BNL site or visit during migration are listed as "rare," "species of special concern," or "exploitably vulnerable" by New York State (Table 6-1).

6.1.2 Habitat Protection and Enhancement

BNL takes many precautions to protect on-site habitat and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into BNL procedures or into specific program or project plans. Environmental restoration efforts remove pollutant sources that could contaminate habitats. Human access to critical habitats is limited. In some cases, habitats are enhanced to

improve survival or increase populations. Routine activities that are not expected to affect habitat (such as road maintenance) are not undertaken until they have been duly evaluated.

6.1.2.1 Tiger Salamander Efforts

To safeguard tiger salamander breeding areas, a map of those locations is reviewed when new projects are proposed. Distribution of the map is limited, to protect the tiger salamander from exploitation by collectors and the pet trade. Other efforts to protect this state endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near tiger salamander habitat are postponed. BNL environmental protection staff must review any project planned near tiger salamander habitat, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of water basins. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been conducted annually since 1999. Biologists conducting egg mass surveys have confirmed that 15 on-site ponds are used by tiger salamanders. Normally all ponds that had egg masses during the spring surveys are surveyed again in June and July to check for the presence of larval salamanders; unfortunately, drought conditions that existed during most of 2002 prevented the development of eggs to larva and larva to adults. Information acquired from surveys is entered into a database and will eventually be linked to a GIS. These data will be used to visualize distributions, track reproductive success, and identify areas for focused management or study.

6.1.2.2 Other Species

As part of the tiger salamander surveys, incidental information is recorded on other amphibian species located in and around the tiger salamander habitat. Other species recorded include the northern redback salamander (*Plethodon c. cinereus*), marbled salamander

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

Common Name	Scientific Name	State Status
Insects		
Frosted elfin	<i>Callophrys iris</i>	T
Fish		
Banded sunfish	<i>Enniacanthus obesus</i>	T
Swamp darter	<i>Etheostoma fusiforme</i>	T
Amphibians		
Eastern tiger salamander	<i>Ambystoma tigrinum tigrinum</i>	E
Marbled salamander	<i>Ambystoma opacum</i>	SC
Reptiles		
Spotted turtle	<i>Clemmys guttata</i>	SC
Eastern box turtle	<i>Terrapene carolina</i>	SC
Eastern hognose snake	<i>Heterodon platyrhinos</i>	SC
Birds (nesting or common)		
Horned lark	<i>Eremophila alpestris</i>	SC
Whip-poor-will	<i>Caprimulgus vociferus</i>	SC
Vesper sparrow	<i>Pooecetes gramineus</i>	SC
Grasshopper sparrow	<i>Ammodramus savannarum</i>	SC
Plants		
Butterfly weed	<i>Asclepias tuberosa</i>	V
Spotted wintergreen	<i>Chimaphila maculata</i>	V
Flowering dogwood	<i>Cornus florida</i>	V
Pink lady's slipper	<i>Cypripedium acaule</i>	V
Winterberry	<i>Ilex verticillata</i>	V
Sheep laurel	<i>Kalmia angustifolia</i>	V
Narrow-leaved bush clover	<i>Lespedeza angustifolia</i>	R
Ground pine	<i>Lycopodium obscurum</i>	V
Bayberry	<i>Myrica pensylvanica</i>	V
Cinnamon fern	<i>Osmunda cinnamomera</i>	V
Clayton's fern	<i>Osmunda claytoniana</i>	V
Royal fern	<i>Osmunda regalis</i>	V
Swamp azalea	<i>Rhododendron viscosum</i>	V
Stiff goldenrod	<i>Solidago rigida</i>	T
New York fern	<i>Thelypteris novaboracensis</i>	V
Marsh fern	<i>Thelypteris palustris</i>	V
Virginia chain-fern	<i>Woodwardia virginica</i>	V

Notes:

Table information is based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data. No federally listed threatened or endangered species are known to inhabit the BNL site.

E = Endangered

R = Rare

SC = Species of special concern

T = Threatened

V = Exploitably vulnerable

(*Ambystoma opacum*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*), and Fowler's toad (*Bufo fowleri*).

Banded sunfish protection efforts include ensuring that adequate flow of the river is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in the sunfish habitat is not disturbed, and evaluating all river remediation efforts for potential impacts on these habitats. River surveys in 2002 identified a single banded sunfish east of monitoring station HM-N. In an attempt to rescue banded sunfish and swamp darters from severe drought conditions, a large coastal plain pond was seined to remove the remaining fish. Of the fish rescued, only six banded sunfish survived. The rescued fish were kept by fisheries experts at the Cold Spring Harbor Museum and Fish Hatchery in Cold Spring Harbor, New York and were to be released when the pond filled with water.

BNL's Wildlife Management Plan also calls for habitat enhancement. A total of 216 species of birds have been identified at BNL since 1948, of which at least 85 are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along six permanent bird survey routes in various habitats on site. A sixth route was established, in 2002, within the Upton Reserve, in order to gain data on that parcel of land. Monthly surveys were conducted, starting at the end of March and extending to the end of October. The surveys in 2002 resulted in the identification of 73 species during the year. Of those species, seven species were seen that had not been counted on previous surveys, resulting in a total of 100 species having been identified during surveys in the past three years; 48 of these species were present each year. Variations in the number and species make-up identified may simply be an artifact of the time of sampling, variations in weather patterns between years, or actual changes in the environment. The two most diverse transects pass near wetlands by the Biology Fields and the Peconic River. The four transects passing through the various forest

types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database that is linked to BNL's GIS.

The eastern bluebird (*Sialia sialis*) has been identified as one of the declining species of migratory birds in North America. This decline is due to loss of habitat and to nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). In 2002, BNL installed additional bluebird boxes around the RHIC ring, bringing the total to 46 boxes around open grassland areas of the site to enhance the bluebird population. Boxes were monitored approximately every three weeks during the breeding season to determine use and nesting success. Nineteen bluebird nests were observed. Other birds using the houses included house wrens (*Troglodytes aedon*) (12 nests), black-capped chickadees (*Poecile atricapilla*) (two nests), and tree swallows (*Tachycineta bicolor*) (four nests).

6.1.3 Population Management

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

6.1.3.1 Wild Turkeys

The wild turkeys (*Meleagris gallopavo*) on site are doing well. The forested areas of BNL provide good nesting and foraging habitat for this large bird. The on-site population was estimated at 60 to 80 birds in 1999 and had grown to around 250 birds by the end of 2001. Due to drought conditions the population dropped to around 175 birds by the end of 2002. This drop appeared to be more a result of dispersal than to starvation or lack of water. Updated population reports are periodically sent to NYSDEC to assist with their population estimates. At year's end, NYSDEC was planning to transfer some of the turkeys at BNL to other localities on Long Island to better establish the population. BNL will continue to monitor the turkey population and cooperate with NYSDEC to ensure the turkeys' success at BNL and on Long Island.

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 BNL, there are no significant pressures on the population to migrate beyond their typical home range of approximately one square mile. A 1992 study indicated that the population of deer on site exceeded 700, or approximately 85 per square mile (Thomlinson 1993). Normally, a population density of 10 to 30 per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the BNL property under normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966). The current estimate, based on surveys conducted late in 2002, is 1,100 deer, or approximately 135 deer per square mile.

The deer surveys are conducted three times per year: mid-spring before fawns are born, late summer after all fawns are born, and late fall. These surveys track reproductive success and mortality. In 2002, spring surveys indicated a population of 1,169 animals. Late summer surveys estimated 1,606 animals, for a 37 percent increase in the population over the previous year. By early winter, the population estimate was 1,100 animals. This indicated a decline of nearly 32 percent, which could not be supported by evidence of dead animals. The survey methods depend on good weather for accurate counts. Toward the end of 2002, the drought had ended and a pattern of cold wet weather consistently prevented accurate surveys. The actual year-end population was likely somewhat higher than the 1,100 deer recorded, but lower than the 1,606 deer recorded in the summer surveys (Dyer 2002).

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries—both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (auto damage, browsing damage to ornamental plantings). In 2002, there were 20

deer-related collisions on site, compared to the eight accidents documented in 2001. This dramatic increase in the number of on-site collisions is attributed to increasing populations. Deer health appeared to be affected due to drought conditions reducing the summer and fall food sources. Deer damage to vegetation around buildings was much less during the winter of 2001–2002, due to mild temperatures and little snow cover. However, damage from deer browse the previous winter was still evident on much of the ornamental vegetation around the Laboratory. Although damage to shrubbery is not a threat to human health, it is undesirable because it may result in the need to replace shrubs, at substantial cost.

BNL submitted National Environmental Policy Act (NEPA) documentation for deer management to DOE for review and approval in October 2001. The preparation of an environmental assessment was delayed in 2002 because another agency was creating a document to cover the entire state of New York. At year's end this document had not been completed, but once it has been, BNL can adopt the document, prepare site-specific information, and finalize the findings based on local data and input. Since management of a large deer population is controversial, BNL continues to carefully consider options and continues to work with NYSDEC to develop options.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL is one of the keys to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. BNL will continue to use NEPA (or NEPA-like) values under the Comprehensive Environmental Response, Compensation and Liability Act (Environmental Restoration Program) when identifying potential environmental impacts associated with site activities—especially with physical alterations. As appropriate, stakeholders such as the U.S. Environmental Protection Agency (EPA), NYSDEC, Suffolk County Department of Health Services, The Nature Conservancy, the Town of Brookhaven, the Community Advisory Council,

and local environmental advocacy groups are involved in reviewing major projects that have potentially significant environmental impacts.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

On November 9, 2000, then-Secretary of Energy Bill Richardson, and Susan MacMahon, Acting Regional Director of Region 5 U.S. Fish & Wildlife Service, dedicated 530 acres of Laboratory property as an ecological research reserve. The property was designated by the Department of Energy as the Upton Ecological and Research Reserve (Upton Reserve) and is managed by FWS under an Interagency Agreement (DOE–FWS 2000). Additional information on the establishment of the Upton Reserve and accomplishments during 2002 is available on the Internet at <http://www.bnl.gov/esd/reserve/default.htm>. The Upton Reserve, near the eastern boundary of BNL (Figure 6-2), 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 the 1994–1995 biological survey of BNL, 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).

In establishing the Upton Reserve, DOE committed to provide FWS with \$1 million over a five-year period, to manage the reserve. In 2001, the first full year of the reserve's existence, FWS hired two biologists, formally established the boundary, and posted the area. During 2002, the staff conducted baseline biological survey work, initiated basic research, and funded educational programs in conjunction with BNL, Suffolk County Community College, and Longwood High School.

Figure 6-2. BNL Site Map Indicating the Boundary of the Upton Ecological and Research Reserve.

The Interagency Agreement that established the Upton Reserve specified the formation of a Technical Advisory Group (TAG), which includes the reserve's supervisory FWS biologist and representatives from NYSDEC, Suffolk County Parks Department, Central Pine Barrens Joint Policy and Planning Commission, DOE, BNL's Citizens Advisory Council, Brookhaven Executive Roundtable, Brookhaven Science Associates, and The Nature Conservancy. The TAG's primary responsibility is to provide technical input into the development of a comprehensive natural resource management plan for both BNL and the Upton Reserve. This plan will eventually replace the existing Wildlife Management Plan. The TAG also has developed criteria for soliciting and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. The TAG has approved research proposals that include an assessment of the effects of prescribed fire on the survival of orange-striped oakmoth (*Anisota senatoria*) pupae, and a project to investigate why some vines are more invasive than others. Preliminary results of one previously funded research project on the physiological effects of fall defoliation by the orange-striped oakmoth caterpillar were presented at the annual Pine Barrens Research Forum held at BNL in October.

Additionally, education programs funded by the Upton Reserve began investigating the effects of deer browse on forest health. Five deer exclosures (10 ft. x 50 ft. fenced areas) were established to keep deer out of specific areas. Baseline data for vegetation growth and spatial coverage was acquired both inside each fenced area and at a comparable reference site outside each fence. Annual visitation and measurement at these locations will build the needed base of information to document the effects of deer browse as well as the effectiveness of deer management once it is implemented at the Laboratory. Students from Longwood High School took on the task of monitoring gypsy moth (*Lymantria dispar*) egg mass distributions within the Upton Reserve. The gypsy moth has historically caused moderate to severe damage to oak trees, due to spring defoliation. The

information gained from this study will assist the U.S. Forest Service in determining potential management activities that may be conducted in 2003. The information is important to the Upton Reserve and BNL, due to the coupled effects of spring defoliation by the gypsy moth and late season defoliation by the orange-striped oak moth caterpillar. This double defoliation, if it occurs year after year, can result in tree death; large sections of oak forest at BNL might be lost.

Management activities of the Upton Reserve included mapping trails, assisting with bird and deer surveys, educating and involving the public, managing fire prevention and suppression measures, and coordinating researcher access and training requirements. FWS also coordinated two aerial surveys by the U.S. Forest Service to document damage to oak trees by the gypsy moth in the spring and the oak moth in the fall. The surveys, along with monitoring, will document the long-term effects of defoliation on forest health.

6.3 MONITORING FLORA AND FAUNA

BNL conducts routine monitoring of flora and fauna to determine the impact of past and present Laboratory activities. Because soils contaminated with cesium-137, a radioactive isotope of cesium, were used in some BNL landscaping projects at some point in the past, traces of contamination are found in deer and possibly in other animals and plants. Most radionuclide tables in this chapter list both potassium-40 (a naturally occurring isotope of potassium) and cesium-137 data. Potassium-40 occurs naturally in the environment and is not uncommon in flora and fauna. It is presented as a comparison to cesium-137, because cesium-137 competes with potassium at a cellular level. General trends indicate that cesium-137 will out-compete potassium when potassium salts are limited in the environment, which is the typical case on Long Island. In general, potassium-40 values do not receive significant discussion in the scientific literature due to this relationship and the fact that potassium-40 occurs naturally. The paragraphs below describe the results of the annual sampling conducted under the flora and fauna monitoring program.

6.3.1 Deer Sampling

Deer in New York State typically are large, with males weighing, on average, about 150 pounds; females typically weigh one-third less, about 100 pounds. However, deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer. This fact has implications for calculations of radiation dose from the consumption of deer meat containing cesium-137.

In 2002, as in recent years, an off-site deer sampling program was conducted with the NYSDEC Wildlife Branch and FWS. NYSDEC samples provide data on deer moving beyond BNL boundaries, where they can be legally hunted, and also provides control data on deer living far from BNL. Also, FWS informed BNL staff of deer killed in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. BNL sampling technicians then collected the samples and processed them for analysis. Samples were also obtained from road kill on and near BNL, and hunter donations were obtained from Laboratory employees. The total number of samples obtained near the BNL site increased from past years, due to a larger number of deer-vehicle accidents that occurred on and off site; hunter donations remained the same as in past years. In all, 21 deer were obtained on site and 43 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to as far away as East Islip, New York.

6.3.1.1 Cesium-137 in Deer

It has been previously established (BNL 2000) that deer sampled on the BNL site contain higher concentrations of cesium-137 (half-life = 30 years) than deer from off site. This is most likely the result of deer consuming contaminated soil and grazing on vegetation growing in soil where elevated cesium-137 levels are known to exist. Cesium-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals.

Removal of contaminated soil areas at BNL has occurred under the site Environmental Restoration Program. All major areas of contami-

nation in lawn soils were remediated in 2000. Some soil contamination is still present in areas that are part of Operable Units (OU) I/VI and V. The cleanup of areas covered by the *Record of Decision for Operable Units I and Radiologically Contaminated Soils* (BNL 1999) is scheduled and will be completed as funds are available. Cleanup of one of the two remaining contaminated soil areas under the OU I/VI actions was completed in 2002, leaving only the Former Waste Management Facility still to be cleaned up. A Record of Decision for the Sewage Treatment Plant, a part of OU V, was signed in 2001; cleanup there began in 2002 and is scheduled for completion in 2003.

The number of deer taken for sampling has steadily increased since 1996. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from BNL locations were needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer. The number taken each year has varied, due to the sampling method that depends on vehicle/deer accidents and people reporting dead deer on the side of the roads. The number of deer hit by cars varies widely from year to year, depending on the population of deer present near major roadways. Figure 6-3 shows the location of all deer samples taken within a 5-mile radius of BNL since 1992. The majority of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, while the on-site concentration is near the front gate area and the constructed portions of BNL. This distribution is due largely to the fact that people see dead deer on the way to work and report them. Deer are hit on site primarily early or late in the day, when they are more active.

In 2002, cesium-137 concentrations in deer meat samples taken at BNL ranged from 0.01 to 4.95 pCi/g wet weight. (The “wet weight” concentration is before a sample is dried for analysis, and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values.) The maximum 2002 on-site concentration (4.95 pCi/g wet weight) is slightly higher than the highest

Figure 6-3. Distribution of Deer Samples 1992-2002.

level reported in 2001 (4.31 pCi/g wet weight) but much lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). In 2001, the maximum off-site concentration of cesium-137 in deer meat samples was 10.56 pCi/g wet weight from a road-kill deer provided by NYSDEC (see below for a discussion of high off-site values). The arithmetic average concentration in on-site meat samples was 1.05 pCi/g. The average concentration in off-site meat samples was 1.22 pCi/g wet weight.

Cesium-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within one mile of BNL and samples taken farther away (see Table 6-2). Concentrations in meat samples nearby range from 0.06 to 10.56 pCi/g wet weight, with an average of 2.07 pCi/g wet weight; concentrations in meat taken from farther away ranged from 0.02 to 3.48 pCi/g wet weight, with an average of 0.60 pCi/g wet weight.

Figure 6-4 compares the average values of cesium-137 concentrations in meat samples collected in 2002 from four different location groupings. Although the figure does not show this, the majority of all samples taken both on and off site are at or below 1 pCi/g wet weight (see Table 6-2).

Figure 6-5 presents the five-year trend of on-site and near off-site cesium-137 averages in deer meat. Although there is no statistical difference between the values across the five years, there is a statistical difference between values in 2000 (when landscape soils were cleaned up) and values in 2002. There is an overall downward trend in cesium-137 found in deer sampled on and around the Laboratory.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates cesium-137 at a lower rate than muscle tissue (meat). The lower values in liver allow the results to be used somewhat as a validity check for meat values (i.e., if liver values are higher than meat values, results should be confirmed). In liver samples collected on site, the range of cesium-137 concentrations was 0.02 to 1.12 pCi/g wet weight, with an average of 0.30 pCi/g wet weight. The off-site cesium-137 concentration in liver ranged from

nondetectable to 1.81 pCi/g wet weight, with an average for all off-site liver samples being 0.24 pCi/g wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated cesium-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999). Their report may be accessed at http://www.bnl.gov/esd/wildlife/deer_issues.htm.

With respect to the health of the 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 cesium-137 at the highest levels observed to date (11.74 pCi/g wet weight, reported in 1996) would carry a total body burden of about 0.2 μ Ci. Under these conditions, an animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the threshold evaluated by the IAEA. The deer observed and sampled on site appear to have no health effects from the level of cesium-137 found in their tissues, although the general health of the herd is not optimal because of overpopulation.

6.3.1.2 Unusual Cesium-137 Results in Deer Meat

Two deer taken along William Floyd Parkway on the west boundary of BNL had levels of cesium-137 of 8.28 and 10.56 pCi/g wet weight. Both of these values are statistical outliers with levels of cesium-137 likely from limited access to a single location of contaminated soil at BNL. Therefore, these two values are not considered in the dose assessment prepared for discussion in Chapter 8. The deer with the 8.28 pCi/g wet weight value was originally analyzed at BNL with a value of 21 pCi/g wet weight, which was twice as high as any value previously seen in the monitoring

Table 6-2. Radiological Analysis of Deer Tissue.

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
BNL					
Outer RHIC Rd., south of Bldg. 1006	1/9/02	Flesh	3.37 ± 0.77	1.78 ± 0.34	
		Liver	1.79 ± 0.33	0.30 ± 0.05	
		Bone			3.32 ± 0.49
Inside Main Gate	1/14/02	Flesh	3.55 ± 0.88	4.95 ± 0.91	
		Bone			2.27 ± 0.47
Child Development area	2/8/02	Flesh*	2.81 ± 0.44	2.78 ± 0.43	
		Bone			2.68 ± 0.54
Water Treatment Plant	2/8/02	Flesh	2.07 ± 0.36	0.28 ± 0.05	
		Liver	2.19 ± 0.39	0.05 ± 0.01	
		Bone*			0.91 ± 0.39
Old settling pond west of Station EA	2/26/02	Flesh	2.72 ± 0.28	0.51 ± 0.05	
		Liver	2.37 ± 0.37	0.43 ± 0.05	
		Bone			5.88 ± 0.34
North side of RHIC Ring	4/9/02	Flesh	3.13 ± 0.34	0.03 ± 0.01	
		Bone			0.70 ± 0.14
East Fifth Ave., west of Bldg. 930	4/11/02	Flesh	2.67 ± 0.29	0.01 ± 0.01	
		Bone			1.88 ± 0.41
RHIC Ring, Bldg. 1004	5/2/02	Flesh	2.99 ± 0.33	0.26 ± 0.03	
		Liver	2.10 ± 0.51	0.11 ± 0.03	
		Bone			2.12 ± 0.28
Upton Rd. at Bldg. 50	5/31/02	Flesh	2.93 ± 0.41	0.15 ± 0.02	
		Liver	2.32 ± 0.25	0.07 ± 0.01	
		Bone			1.08 ± 0.29
Bldg. 1002 outside RHIC Ring	6/18/02	Flesh	3.36 ± 0.35	1.02 ± 0.08	
		Liver	2.32 ± 0.30	1.12 ± 0.10	
		Bone			9.17 ± 0.75
Main Gate, outbound, 100 ft. east of guard booth	7/10/02	Flesh	3.03 ± 0.49	0.05 ± 0.03	
		Bone			3.54 ± 0.43
By Bldg. T96	7/26/02	Flesh	3.00 ± 0.35	0.08 ± 0.02	
		Liver	1.89 ± 0.27	0.08 ± 0.01	
		Bone			2.31 ± 0.37
50 ft. east of Main Gate	8/1/02	Flesh	3.35 ± 0.37	0.13 ± 0.01	
		Liver	3.21 ± 0.45	0.04 ± 0.01	
		Bone			1.75 ± 0.35
100 ft. south of Bldg. 1004, outer RHIC Rd.	8/2/02	Flesh	3.13 ± 0.30	0.21 ± 0.03	
		Liver	3.02 ± 0.88	ND	
		Bone			3.97 ± 0.46
West of Bldg. 600	8/15/02	Flesh	2.82 ± 0.56	0.09 ± 0.03	
		Liver	2.81 ± 0.37	0.02 ± 0.01	
		Bone			1.71 ± 0.32
South of Bldg. 1004, outside RHIC Ring	9/13/02	Flesh	2.77 ± 0.30	0.15 ± 0.02	
		Bone			2.62 ± 0.43
North Gate access road	10/30/02	Flesh	3.28 ± 0.34	3.93 ± 0.49	
		Liver	2.78 ± 0.40	0.83 ± 0.10	
		Bone			1.62 ± 0.22
BERA ballfield driveway by fields 1 & 2	11/1/02	Flesh	3.79 ± 0.39	1.09 ± 0.09	
		Liver	2.00 ± 0.25	0.33 ± 0.03	
		Bone			1.44 ± 0.24

* Average of multiple analyses of tissue from same deer; errors are propagated from individual sample errors.

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Table 6-2. Radiological Analysis of Deer Tissue *(continued)*.

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
100 ft. west of Main Gate outbound lane	11/20/02	Flesh Liver Bone	3.16 ± 0.34 2.33 ± 0.28	1.55 ± 0.12 0.44 ± 0.04	1.13 ± 0.24
West of Bldg. 1008, inside RHIC Ring Rd.	11/26/02	Flesh Liver Bone	3.07 ± 0.33 2.66 ± 0.37	1.69 ± 0.21 0.37 ± 0.05	2.74 ± 0.49
South Gate access road	12/16/02	Flesh* Liver Bone	3.50 ± 0.36 1.92 ± 0.23	1.40 ± 0.14 0.30 ± 0.04	2.47 ± 0.45
Off Site < 1 mile					
Near Brookhaven—donated by hunter	11/24/01	Flesh Bone	1.58 ± 0.29	1.98 ± 0.34	2.72 ± 0.23
Ridge/Brookhaven—donated by hunter	11/13/01	Liver Heart	2.09 ± 0.37 2.42 ± 0.44	1.81 ± 0.30 5.00 ± 0.87	
Wm. Floyd Prkwy. east of Colonial Pines	12/15/01	Flesh*	2.53 ± 0.04	10.6 ± 1.5	
Wm. Floyd Prkwy. south of Whispering Pines	1/9/02	Flesh* Bone	2.00 ± 0.34	8.28 ± 0.71	3.46 ± 0.52
Rte. 25 just west of Wm. Floyd Prkwy.	1/25/02	Flesh	2.25 ± 0.60	0.60 ± 0.13	
Rte. 25 east of Firefighters' Museum in Ridge	1/29/02	Flesh	2.56 ± 0.44	2.87 ± 0.48	
Wm. Floyd Prkwy. near North Gate	2/22/02	Flesh Liver Bone	2.29 ± 0.41 2.19 ± 0.39	1.24 ± 0.21 0.36 ± 0.07	4.58 ± 0.37
Wm. Floyd Prkwy. just north of Main Gate	2/26/02	Flesh Liver Bone	3.25 ± 0.54 2.51 ± 0.86	2.06 ± 0.23 0.52 ± 0.11	3.56 ± 0.30
Wm. Floyd Prkwy. North Gate exit ramp	2/27/02	Flesh Liver Bone	3.14 ± 0.35 1.95 ± 0.32	0.67 ± 0.05 0.16 ± 0.02	2.44 ± 0.30
Wm. Floyd Prkwy. half-mile north of LIE	3/15/02	Flesh* Liver Bone	3.01 ± 0.46 2.52 ± 0.37	1.26 ± 0.19 0.33 ± 0.04	3.3 ± 0.4
Rte. 25 west of Wm. Floyd Prkwy.	5/22/02	Flesh Bone	2.65 ± 0.37	0.06 ± 0.01	2.11 ± 0.37
Wm. Floyd Prkwy. just north of Colonial Pines	5/29/02	Flesh Bone	2.70 ± 0.47	0.28 ± 0.05	2.15 ± 0.40
Wm. Floyd Prkwy. half-mile north of Main Gate	6/6/02	Flesh* Liver Bone	3.42 ± 0.40 1.89 ± 0.22	0.49 ± 0.06 0.21 ± 0.03	3.94 ± 0.49
LIE westbound service road at BNL South Gate	6/20/02	Flesh Liver Bone	2.96 ± 0.60 2.59 ± 0.36	0.08 ± 0.03 0.05 ± 0.01	2.86 ± 0.53
Longwood Rd. half-mile west of Main Gate	8/26/02	Flesh Liver Bone	3.66 ± 0.43 2.12 ± 0.32	0.11 ± 0.01 0.04 ± 0.01	5.39 ± 0.51
Rte. 25 west of Randall Rd. in Ridge	10/23/02	Flesh Liver Bone	3.13 ± 0.30 2.77 ± 0.92	1.07 ± 0.13 0.24 ± 0.09	5.86 ± 0.73
Wm. Floyd Prkwy. south of Whispering Pines	10/25/02	Flesh Liver Bone	2.99 ± 0.41 2.35 ± 0.25	2.77 ± 0.28 0.69 ± 0.08	1.61 ± 0.23

* Average of multiple analyses of tissue from same deer; errors are propagated from individual sample errors.

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Table 6-2. Radiological Analysis of Deer Tissue *(continued)*.

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
LIE just west of Exit 68	11/1/02	Flesh Bone	3.39 ± 0.54	0.85 ± 0.10	1.81 ± 0.31
Off Site > 1 mile					
Calverton east of Grumman—donation by hunter	1/7/02	Flesh* Liver Heart Bone Bone	1.48 ± 0.28 2.43 ± 0.42 2.07 ± 0.40	0.21 ± 0.04 0.06 ± 0.01 0.12 ± 0.02	1.71 ± 0.32 2.68 ± 0.54
Seatuck Wildlife Preserve Deer Cull Deer 1	1/9/02	Flesh Liver Bone	2.45 ± 0.54 2.12 ± 0.37	0.02 ± 0.01 0.01 ± 0.01	1.26 ± 0.32
Seatuck Wildlife Preserve Deer Cull Deer 2	1/9/02	Flesh Liver Bone	2.23 ± 0.40 2.02 ± 0.37	0.13 ± 0.02 0.04 ± 0.01	1.77 ± 0.41
Seatuck Wildlife Preserve Deer Cull Deer 3	1/9/02	Flesh* Liver Bone	2.72 ± 0.46 5.24 ± 2.65	0.15 ± 0.03 ND	0.9 ± 0.3
Seatuck Wildlife Preserve Deer Cull Deer 4	1/9/02	Flesh Liver Bone	3.15 ± 0.78 2.32 ± 0.41	0.08 ± 0.04 0.01 ± 0.01	1.41 ± 0.43
Seatuck Wildlife Preserve Deer Cull Deer 5	1/9/02	Flesh Liver Bone	2.68 ± 0.45 1.44 ± 0.28	0.07 ± 0.01 0.02 ± 0.01	0.89 ± 0.28
Seatuck Wildlife Preserve Deer Cull Deer 6	1/9/02	Flesh* Liver Bone	2.90 ± 0.49 1.82 ± 0.43	0.06 ± 0.01 0.02 ± 0.01	0.92 ± 0.39
Seatuck Wildlife Preserve Deer Cull Deer 7	1/9/02	Flesh Liver Bone	2.34 ± 0.40 4.2 ± 1.4	0.04 ± 0.01 ND	1.57 ± 0.40
Seatuck Wildlife Preserve Deer Cull Deer 8	1/9/02	Flesh Liver Bone	3.42 ± 0.77 1.92 ± 0.35	0.11 ± 0.03 0.02 ± 0.01	2.03 ± 0.37
Donation J. McGovern DEC Area #27	1/14/02	Flesh*	2.23 ± 0.26	3.02 ± 0.31	
Seatuck Deer Cull	1/23/02	Flesh Liver Bone	2.05 ± 0.38 2.26 ± 0.40	0.02 ± 0.01 ND	1.54 ± 0.36
Smith Rd. and Ranch Dr., Shirley	2/4/02	Flesh Liver Bone	2.41 ± 0.41 1.87 ± 0.46	1.01 ± 0.17 0.18 ± 0.05	0.68 ± 0.52
Smith Rd., Shirley	2/8/02	Flesh Liver Bone	5.1 ± 1.1 3.21 ± 0.75	0.65 ± 0.15 0.19 ± 0.05	1.01 ± 0.29
Seatuck Deer Cull	2/8/02	Flesh Liver Bone	2.50 ± 0.71 ND	0.10 ± 0.04 ND	0.9 ± 0.3
Seatuck Deer Cull Buck	2/12/02	Flesh Liver Bone	2.50 ± 0.42 4.1 ± 1.1	0.03 ± 0.01 ND	1.33 ± 0.32
Seatuck Deer Cull Doe	2/12/02	Flesh Liver Bone	2.80 ± 0.71 2.24 ± 0.40	0.04 ± 0.02 0.02 ± 0.01	1.57 ± 0.40

* Average of multiple analyses of tissue from same deer; errors are propagated from individual sample errors.

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Table 6-2. Radiological Analysis of Deer Tissue *(concluded)*.

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
Rte. 25, Calverton National Cemetery	2/19/02	Flesh Bone	2.30 ± 0.40	0.46 ± 0.08	1.53 ± 0.20
Carmen's View Drive, Shirley	3/14/02	Flesh Liver Bone	2.22 ± 0.81 2.26 ± 0.25	0.22 ± 0.05 0.14 ± 0.02	1.7 ± 0.3
Wading River Rd. at Pine Hills entrance	3/17/02	Flesh Bone	2.65 ± 0.50	0.53 ± 0.08	2.91 ± 0.50
LIE quarter-mile west of Exit 69	3/20/02	Flesh Liver Bone	3.25 ± 0.43 2.27 ± 0.25	0.07 ± 0.01 0.02 ± 0.01	1.7 ± 0.3
Entrance to Wertheim	5/22/02	Bone			<MDL
Barns Rd. half-mile south of Moriches—Middle Is. Rd.	8/20/02	Flesh Liver Bone	3.07 ± 0.41 3.03 ± 0.35	0.37 ± 0.04 0.16 ± 0.02	3.95 ± 0.51
Rte. 25, quarter-mile east of Woodlot Rd.	10/9/02	Flesh* Liver Bone	2.94 ± 0.33 2.06 ± 0.26	2.90 ± 0.25 0.95 ± 0.12	2.71 ± 0.45
West of Yaphank Rd., north of Sunrise Hwy	11/21/02	Flesh Liver Bone	2.83 ± 1.00 2.61 ± 0.31	3.48 ± 0.51 1.11 ± 0.11	3.61 ± 0.47
Averages by Tissue	No. of Samples		K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
Flesh					
Average for all samples	61		2.9 ± 1.1	1.2 ± 3.7	
BNL on-site avg.	21		3.1 ± 0.7	1.0 ± 2.7	
BNL on-site and off-site < 1 mile avg.	38		3.0 ± 0.9	1.5 ± 4.4	
Off-site avg.	40		2.7 ± 1.2	1.2 ± 4.2	
Off-site < 1 mile avg.	17		2.8 ± 1.1	2.1 ± 5.7	
Off-site > 1 mile avg.	23		2.7 ± 1.3	0.6 ± 2.0	
Liver					
Average for all samples	45		2.4 ± 1.5	0.3 ± 0.7	
BNL on-site avg.	15		2.4 ± 0.8	0.3 ± 0.6	
BNL on-site and off-site < 1 mile avg.	25		2.4 ± 0.7	0.4 ± 0.8	
Off-site avg.	30		2.4 ± 1.8	0.2 ± 0.8	
Off-site < 1 mile avg.	10		2.3 ± 0.6	0.4 ± 1.0	
Off-site > 1 mile avg.	20		2.5 ± 2.1	0.2 ± 0.6	
Bone					
Average for all samples	59				2.4 ± 3.0
BNL on-site avg.	21				2.6 ± 3.7
BNL on-site and off-site < 1 mile avg.	36				2.9 ± 3.3
Off-site avg.	38				2.3 ± 2.5
Off-site < 1 mile avg.	14				3.3 ± 2.6
Off-site > 1 mile avg.	24				1.7 ± 1.7

Notes:

All values 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 averages and include nondetections as 0 and <MDL as detection limit.

MDL = Minimum Detection Limit

ND = not detected

* Average of multiple analyses of tissue from same deer; errors are propagated from individual sample errors.

Notes:

Averages are reported for samples collected on site, on site plus off site within 1 mile of BNL, off site but within 1 mile, and off site greater than one mile. Numbers in parentheses indicate the number of samples in that data set.

All values are shown with a 95% confidence interval. A statistical outlier was removed from two of the data sets (see text).

Figure 6-4. Comparison of Cs-137 Average Concentrations in Deer, 2002.

Notes:

Averages are shown for samples collected at BNL and within a 1-mile radius. Numbers in parentheses indicate the number of samples in that data set.

All values are shown with a 95% confidence interval. Two statistical outliers were removed from each year's data set.

There is no significant difference between years, except between 2000 and 2002 averages.

Figure 6-5. Five-Year Cs-137 Concentration Trends in Deer Meat at BNL and within 1 Mile.

program. This increased value was verified and actions subsequent to the verification included notification of the public, submission of the sample to NYSDOH for re-analysis, review of sampling practices, a review of historic docu-

ments concerning contaminated soils at BNL, and an assessment of fenced areas containing cesium-137 contamination.

When NYSDOH reanalyzed the sample, they determined that the cesium-137 content was

around 8.5 pCi/g wet weight, or about one third the value reported by BNL. The sample was then returned to BNL's Analytical Services Laboratory and analyzed on all eight of the detectors used there. In the comparative reanalysis it was discovered that one detector (the one used for the original analysis) produced erroneous readings due to detector configuration, sample geometry, and correction factors used for specific geometries and sample matrixes. The end result of the reanalysis was improved laboratory procedure, the purchase of a matrix-specific calibration sample comparable to the density of deer meat, and the finalization of an Environmental Event Response protocol that is used when unusual data are received.

The review of historic documents concerning cesium-137 contamination within landscape soil and other areas did not reveal any new or overlooked sources. Because of this, the focus for concern was on two facilities, the 650 Sump area and the Former Waste Management Facility, that were either in the process of cleanup or were scheduled for cleanup. The 650 Sump Area was determined to be secure, with no evidence of deer having entered the facility. The Former Waste Management Facility was discovered to have holes in the fence that allowed access to the facility, and evidence of deer having moved in and out of the holes was present. All holes in the fence were repaired. Samples of vegetation growing along the margin of the fence were taken and analyzed and those plants showing cesium-137 at elevated levels were removed. A species-specific vegetation study looking at uptake was completed to determine if plants that deer might eat differentially accumulated cesium-137. The results of that study are discussed in section 6.3.6.3, Special Vegetation Sampling. The assessment of access to the facility resulted in procedures to ensure deer could not get in. Besides sealing access points, periodic inspections of the fence are now made to ensure that no deer enter the facility through new holes. Since the changes were implemented, there has been no evidence of deer entering the facility. The facility is scheduled for cleanup in the FY03–05 time frame.

The second deer mentioned above, with a value of 10.56 pCi/g wet weight, was below the level of the historic high results for cesium-137 in deer meat. This value was verified through repeated analysis of two sub-samples of the animal provided by NYSDEC. As all actions implemented from the review of the first deer samples were taking place, no additional work review was carried out.

6.3.1.3 Strontium-90 in Deer Bone

BNL began testing deer bones (when available) for strontium-90 content in 2000 and continued this analysis in 2002. Strontium-90 content ranged from 0.7 to 9.17 pCi/g dry weight in on-site samples, 1.61 to 5.86 pCi/g dry weight in samples taken within one mile of BNL, and 0.68 to 3.95 pCi/g dry weight in samples taken from locations greater than a mile from BNL. This overlap in values between all samples suggests that strontium-90 is present in the environment at background levels; it is likely a result of worldwide fallout from nuclear weapons testing. Strontium-90 is present at very low levels in the environment, is readily incorporated into bone tissue, and may concentrate over time. BNL will continue to test for strontium-90 in bone to develop baseline information on this radionuclide and its presence in deer.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2002. The original idea for this sampling was to determine the suitability of using small mammals, primarily squirrels, as a surrogate for deer sampling. Squirrels are readily trapped and tend to eat similar food as deer, but have a much more restricted range and therefore can indicate areas where low levels of contamination may be present. Squirrels were sent to an off-site laboratory for dissection and analysis. The meat was separated from the bone and tested for gamma-emitting radionuclides and the bone was tested for strontium-90. Results of the analyses are presented in Table 6-3. Cesium-137 in off-site samples ranged from 0.05 to 0.67 pCi/g wet weight. On-site samples contained cesium-137 ranging from 0.23 to 8.69 pCi/g wet weight. Strontium-90 was found in

the bone samples of eight squirrels, six on site and two off site.

The cesium-137 level in one squirrel was elevated, 8.69 pCi/g wet weight, compared to all other squirrels analyzed in 2002. The area where this squirrel was taken is near old sewer lines that contain cesium-137. Contaminated sewer lines in the area have been isolated from the sewer system. The issue of cleanup of these lines or abandonment in place has been addressed in the Record of Decision for the Sewage Treatment Plant portion of Operable Unit V. Small mammals will continue to be sampled to obtain additional information about their usefulness in environmental surveillance and to better define where they may be acquiring cesium-137.

6.3.3 Other Animals Sampled

Occasionally, other animals of interest are found dead along the roads of BNL and the immediate vicinity. The wild turkey is prevalent at BNL and has a diet similar to deer, eating mostly insects in the spring and summer and

acorns during the fall and winter. In 2002, one of BNL's turkeys was killed by a motor vehicle.

This resulted in the opportunity to see if the wild turkeys on site might contain cesium-137 in the meat. The results of the analysis on the turkey indicated a cesium-137 concentration of 0.04 pCi/g wet weight, which is comparable to the far off-site values found in deer meat.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. The annual sampling at BNL over the past several years has depleted the number of larger fish. As a result, it would be necessary to take more of the smaller fish to obtain a sufficiently large sample to complete all analyses desired. For this reason, BNL suspended most on-site sampling beginning in 2001 and will continue with the suspension for up to three years to allow the on-site fish populations to recover and mature. To determine

Table 6-3. Radiological Analysis of Small Mammals (Squirrels).

Location	Collection Date	K-40 (pCi/g, wet weight)	Cesium-137 (pCi/g, wet weight)	Strontium-90 (pCi/g, dry weight)
BNL				
Trailer 533	1/15/02	15.30 ± 2.48	0.58 ± 0.14	< MDL
Berkner Hall	1/16/02	15.80 ± 3.21	0.27 ± 0.15	< MDL
Railroad St. north of Fifth Ave.	3/14/02	13.80 ± 4.40	8.69 ± 1.28	0.77 ± 0.35
East of Fleming House	3/27/02	12.70 ± 1.60	1.11 ± 0.14	< MDL
Trailer 533	4/19/02	1.89 ± 0.34	0.24 ± 0.03	0.05 ± 0.03
Southwest of STP	4/24/02	2.56 ± 0.42	1.58 ± 0.19	0.10 ± 0.03
Trailer 533	9/30/02	14.10 ± 2.28	1.33 ± 0.22	< MDL
Trailer 533	10/22/02	14.50 ± 2.08	1.55 ± 0.23	0.30 ± 0.13
Rochester and Bell	10/25/02	12.30 ± 2.56	0.23 ± 0.13	0.34 ± 0.15
Ballfield #5	11/4/02	12.50 ± 1.81	0.47 ± 0.09	0.20 ± 0.10
Off Site				
Moriches	2/7/02	13.90 ± 2.26	0.34 ± 0.10	< MDL
Moriches	3/17/02	9.20 ± 1.21	0.26 ± 0.05	< MDL
Moriches	4/21/02	2.50 ± 0.37	0.05 ± 0.02	< MDL
Moriches	11/2/02	14.20 ± 2.22	0.67 ± 0.13	0.36 ± 0.15
Moriches	12/14/02	13.90 ± 2.17	0.46 ± 0.11	0.60 ± 0.21

Notes:

All values are shown with a 95% confidence interval.

MDL = Minimum Detection Limit

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

population recovery, a population assessment was conducted and the results are discussed below.

Off-site sampling continued as in the past. All samples were analyzed for whole-body content of each of the analytes reported; in most instances, the samples were a composite of several fish to ensure adequate sample size for analysis. In 2002, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, and Lower Lake on the Carmans River (see Chapter 5, Figure 5-8 for locations). Swan Pond is a semi-control location on the Peconic River system and Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out in cooperation with NYSDEC and through a contract with Cold Spring Harbor Fish Hatchery and Museum. The number of species and number of samples taken in 2002 dropped compared to previous years. This is due primarily to the drought that occurred across much of the northeast, which made sampling more difficult.

6.3.4.1 Radiological Analysis of Fish

The species collected in 2002 by BNL, NYSDEC, and through contract labor for radiological analysis included Brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*). Gamma spectroscopy analysis was performed on all samples. Table 6-4 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations.

Cesium-137 was identified at low levels in all samples from the Peconic River system, ranging from 0.16 pCi/g wet weight in brown bullheads from Forge Pond, to 0.74 pCi/g wet weight in chain pickerel from Donahue's Pond. In 2002, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) were below the minimum detection limit for the analysis, except for brown bullhead, which had a level of 0.09 pCi/g wet weight.

Strontium-90 is readily deposited in bone. In 2002, BNL continued the testing for strontium-90 that was initiated in 2000. Values ranged from

less than minimum detection limit to 1.42 pCi/g dry weight. Because fish were analyzed for whole-body content, values for strontium-90 may vary somewhat, as seen in the data presented in Table 6-4. These variations result from random pieces of bone included in the aliquot of the sample used for analysis. BNL will continue to test for strontium-90 in off-site samples in order to build baseline values for future comparisons.

Some cesium-137 is detectable in the environment worldwide as a result of global fallout from past aboveground nuclear weapons testing. This is evident when examining the analytical results of fish from the control locations. To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders—in this case, other brown bullhead). Cesium-137 concentrations in bullhead collected at all locations along the Peconic River had values less than 0.26 pCi/g wet weight, whereas values for bullhead at Lower Lake on the Carmans River had 0.09 pCi/g wet weight. Levels of cesium-137 in all fish species appear to be declining compared to historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides—with the exception of tritium—were released between the late 1950s and early 1970s, and concentrations continue to decline over time through natural decay (cesium-137 has a half-life of 30 years).

6.3.4.2 Fish Population Assessment

As was mentioned earlier, in 2001 BNL suspended fish sampling on site because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. To document the number and size of fish in the on-site portions of the Peconic River, BNL conducted an electroshock survey (which does not harm the fish) from the Sewage Treatment Plant outfall to just beyond the east firebreak (HM-N). The results of the 2002 survey

Table 6-4. Radiological Analysis (Whole Body) of Fish from the Peconic River System and Control Locations.

	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)	Sr-90 (pCi/g, dry weight)
Swan Pond			
Large Mouth Bass	10.80 ± 1.67	0.70 ± 0.13	0.48 ± 0.07
Pumpkinseed	7.55 ± 1.11	0.17 ± 0.04	0.46 ± 0.15
Forge Pond			
Chain Pickerel	10.40 ± 1.88	0.53 ± 0.12	< MDL
Brown Bullhead	8.54 ± 1.98	0.16 ± 0.07	0.79 ± 0.40
Pumpkinseed	6.65 ± 1.63	0.24 ± 0.09	1.24 ± 0.43
Donahue's Pond			
Blue Gill	7.48 ± 1.36	0.28 ± 0.07	1.42 ± 0.47
Brown Bullhead	7.78 ± 1.59	0.26 ± 0.10	1.14 ± 0.33
Chain Pickerel	11.00 ± 1.55	0.74 ± 0.11	< MDL
Lower Lake, Carmans River			
Blue Gill	9.58 ± 1.47	< MDL	< MDL
Brown Bullhead	11.80 ± 1.91	0.09 ± 0.08	< MDL
Large Mouth Bass	8.68 ± 1.52	< MDL	< MDL
Pumpkinseed	8.68 ± 1.48	< MDL	< MDL

Notes:

MDL = Minimum Detection Limit

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

All values are presented with a 95% confidence interval.

compared to the 2001 survey are summarized in Table 6-5. In 2002, a total of 119 fish and six species were found in this section of river. The average length of fish ranged from 1.6 inches to 11.3 inches. The largest fish was an 11.3-inch chain pickerel. The total number of fish is indicative of poor population numbers. Unfortunately, the numbers sampled in 2002 were lower than in 2001. This was likely a result of drought conditions that kept water levels reduced. This reduced water level also had an effect on banded sunfish numbers. There was only one banded sunfish captured in 2002, compared to 18 in 2001. BNL will continue to

monitor the fish population to determine when routine sampling may resume.

6.3.4.3 Nonradiological Analysis of Fish and Shellfish

In 1997, under the Operable Unit V remediation project, the BNL Environmental Restoration Program sampled and analyzed fish from the Peconic River for metals, pesticides, and polychlorinated biphenyls (PCBs). The contaminant levels found were not considered to have a health impact on fish or humans, but DOE directed that sampling and analysis should be done annually. This analysis was conducted

Table 6-5. 2001 and 2002 Fish Population Survey Results in the Peconic River (STP to HM-N).

Species	2001		2002	
	No. Caught	Avg. Length (in.)	No. Caught	Avg. Length (in.)
Banded Sunfish	18	2.8	1	2.1
Brown Bullhead	43	5.1	13	6.2
Chain Pickerel	20	7.1	1	11.3
Creek Chubsucker	53	3.6	4	2.6
Golden Shiner	9	4.4	23	1.8
Largemouth Bass	1	5.5	0	0
Pumpkinseed	15	3.9	77	1.6
Total no. caught	159		119	

Table 6-6. Metals Analysis of Fish and Shellfish from the Peconic River System and Control Locations.

	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead mg/kg	Manganese	Mercury	Nickel	Selenium	Silver	Sodium	Zinc
Swan Pond	< MDL	1.07	0.15	0.50	0.54	15.3	0.13	7.76	0.11	< MDL	0.54	0.28	1410	16.5
	< MDL	4.36	< MDL	0.65	1.14	32.2	0.20	59.1	0.01	< MDL	0.50	0.25	1710	29.5
Forge Pond	< MDL	0.32	< MDL	0.15	0.67	56.2	< MDL	1.38	0.05	0.14	0.53	< MDL	871	6.9
	< MDL	0.39	< MDL	0.19	0.83	30.8	< MDL	3.54	0.33	0.08	0.54	< MDL	1260	54.8
	0.62	71.2	0.03	< MDL	3.73	1300	< MDL	1460	0.08	0.17	0.83	0.18	1350	29.6
Donahue's Pond	< MDL	3.09	< MDL	0.50	0.25	75	0.13	21.2	0.07	< MDL	0.67	< MDL	1110	16.5
	< MDL	4.36	< MDL	0.53	0.27	14	0.21	14.6	0.13	0.09	0.45	< MDL	1520	40.5
	< MDL	0.64	< MDL	0.20	0.22	7.74	< MDL	5.79	0.26	< MDL	0.43	< MDL	1200	55.9
Lower Lake, Carmans River	< MDL	5.96	< MDL	0.63	0.20	7.26	< MDL	13.7	0.03	0.12	0.52	< MDL	1080	27.6
	< MDL	0.25	< MDL	0.12	0.50	26.9	< MDL	0.55	0.02	< MDL	0.43	< MDL	910	4.94
	< MDL	1.15	< MDL	0.44	0.21	15.2	< MDL	2.60	0.40	< MDL	0.74	< MDL	1860	17.0
	< MDL	1.42	< MDL	0.33	0.19	5.94	< MDL	10	0.03	0.12	0.66	< MDL	869	27.9
Connecticut Ave. (HC)	0.75	1080	0.37	< MDL	0.89	8420	4.14	3470	0.05	0.23	2.72	5.80	339	81.3
	3.48	0.64	0.04	0.26	3.62	95.8	0.31	2.42	0.11	0.20	0.88	0.95	4150	18.5
Forge Pond Peconic R. RGC	< MDL	245	0.11	< MDL	0.65	941	0.10	876	0.01	< MDL	0.53	0.40	273	32.3
	2.03	0.19	0.08	0.17	10.4	10.6	0.21	2.55	< MDL	0.34	0.33	0.45	5760	8.8
	2.76	0.25	0.11	0.19	3.32	20.4	< MDL	2.46	< MDL	0.26	0.52	1.21	6400	12.9
Flanders Bay	2.29	0.18	0.09	0.19	0.78	12.9	< MDL	0.80	0	0.55	< MDL	0.56	6410	6.0
Indian Point	1.03	0.97	0.13	0.27	1.32	50.5	0.29	11.3	0	0.64	0.29	< MDL	6110	6.7
Moriches Bay	0.94	959	0.39	< MDL	1.11	7600	4.36	2660	0.07	< MDL	1.28	1.89	281	76.7

Notes:

See Figure 5-8 for sampling locations.

MDL = Minimum Detection Limit

on site in 1999 and 2000; analysis in 2002, as in 2001, was limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. Since 2000, sampling has occurred from July through August. Additionally, there has been a wide variation in fish size; samples have had to be composite whole-body to obtain significant mass for analysis. These variables make the comparisons from year to year difficult, as there can be significant seasonal variations in feeding, energy consumption, and incorporation of nutrients in tissues.

Table 6-6 shows the concentration levels of metals in fish and shellfish (clams and mussels) for 2002. None of the metal concentrations were considered capable of affecting the health of the consumers of such fish or clams. Mercury was found in all fish at levels less than 1.0 mg/kg, which is the consumption standard set by the U.S. Food and Drug Administration. The highest levels of mercury detected were in largemouth bass, taken from Lower Lake on the Carmans River.

Metals in shellfish are also presented in Table 6-6. In most samples, metals appear to be consistent with previous years' sampling efforts. However, unusually high levels (up to 1,080 mg/kg) of barium were detected in clams and mussels from Connecticut Avenue and beyond. Values were nearly three times higher than in 2001 (280 mg/kg). It is not certain why barium is present at these levels in shellfish when it is not present within the sediments (see Table 6-9), but fragments of shell within the tissue sample may partially account for the values. Also, manganese was detected at high levels in some shellfish, as it was in 2001.

Table 6-7 shows the concentrations of pesticides in fish and shellfish for 2002. The table reflects only samples with detectable levels of pesticide in the tissues. None of the shellfish showed measurable levels of pesticides. The levels detected in fish do not exceed any standards that may constitute a health impact to the consumers of such fish and thus are not considered harmful. The pesticides DDT, DDD, and DDE were detected at low levels at several off-site locations. DDD and DDE pesticides are breakdown products of DDT, a pesticide commonly used before 1970. Chlordane was also commonly used across Long Island and is found occasionally in fish samples. Heptachlor epoxide and Methoxychlor were detected at Swan Pond in Pumpkinseed and Largemouth Bass. Heptachlor epoxide was part of the formulation and is a breakdown product of

Chlordane. Before 1988, it was used as a pesticide outdoors (on lawns and fields) and indoors. Methoxychlor is still in use, primarily as an agricultural pesticide.

No detectable levels of PCBs (Aroclor-1242 and Aroclor-1260) were found in fish taken from the Peconic River or control site locations. Historically, Aroclor-1260 was used in electrical equipment and this PCB has been found historically in fish taken on site at BNL.

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of clams, mussels, sediment, vegetation, freshwater and seawater in the Peconic River, Lower Lake Carmans River (control location), Peconic Bay, Flanders Bay, Indian Point, and Moriches Bay (control loca-

Table 6-7. Pesticide Analysis of Fish and Shellfish from the Peconic River System and Control Locations.

		4,4'-DDD	4,4'-DDE	4,4'-DDT	alpha-Chlordane µg/kg	Heptachlor epoxide	Methoxychlor
Swan Pond	Large Mouth Bass	31.7	75.7	< MDL	< MDL	2.8	214
	Pumpkinseed	5.4	14.4	< MDL	< MDL	2.4	7.3
Forge Pond	Brown Bullhead	33.3	84.7	< MDL	4.3	< MDL	< MDL
	Chain Pickerel	71.8	103	20.1	< MDL	< MDL	< MDL
	Pumpkinseed	6.4	22.4	61.4	< MDL	< MDL	< MDL
Donahue's Pond	Blue Gill	15.1	45	11.6	< MDL	< MDL	< MDL
	Brown Bullhead	3.4	7.1	1.3	< MDL	< MDL	< MDL
	Chain Pickerel	10.6	31.1	7.3	< MDL	< MDL	< MDL
Lower Lake, Carmans River	Blue Gill	13.3	60.4	41	< MDL	< MDL	< MDL
	Brown Bullhead	2.1	7.3	3.8	< MDL	< MDL	< MDL
	Large Mouth Bass	27.7	201	384	< MDL	< MDL	< MDL
	Pumpkinseed	10.9	150	91.5	< MDL	< MDL	< MDL
Connecticut Ave. (HC)	Freshwater mussels	0.42	6.6	7.4	< MDL	< MDL	< MDL
	Freshwater mussels	< MDL	0.3	2	< MDL	< MDL	< MDL
Forge Pond	Freshwater mussels	< MDL	< MDL	1.1	< MDL	< MDL	< MDL
Peconic River-RGC	Clams	2.1	7.3	5.5	< MDL	< MDL	< MDL
	Clams	< MDL	2.6	2.8	< MDL	< MDL	< MDL
Flanders Bay	Clams	< MDL	13.2	6.9	< MDL	< MDL	< MDL
Indian Point	Blue Mussels	< MDL	2.8	9.3	< MDL	< MDL	< MDL
Moriches Bay	Clams	< MDL	0.55	0.67	< MDL	< MDL	< MDL

Notes:

MDL = Minimum Detection Limit

tion) was conducted in 2002. (See Chapter 5, Figure 5-8, for locations.) Stakeholder concern that BNL's discharges and ongoing work with Operable Unit V may affect the clamming industry has been the basis for this sampling program. As in past years, the NYSDEC Marine Fisheries Branch assisted BNL in coordinating the sampling with local baymen. Table 6-8 summarizes the radiological data. Low levels of cesium-137 were documented in vegetation taken on site at BNL, and levels below 0.25 pCi/g wet weight were detected in vegetation in the Peconic River and Moriches Bay (control location). Cesium-137 was detected in Peconic River sediments below 0.2 pCi/g dry weight, and also at a concentration of 0.80 pCi/g dry weight at the Lower Lake control location. Since sampling began in 1992, no BNL-generated nuclides have been detected in marine shellfish samples. Because there is a solid baseline of data indicating that cesium-137 is not present above background in shellfish, BNL will not sample marine/estuarine/freshwater locations on an annual basis beginning in 2003. BNL may periodically conduct confirmatory sampling to update its baseline in the future.

6.3.5.2 Metals in Aquatic Samples

Metals analysis (Table 6-9) was conducted on aquatic vegetation, water, and sediments from the Peconic River, bays, and estuaries. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the soil cleanup objectives for heavy metals supported by Suffolk County Department of Health Services. Water sample results are compared to New York State Drinking Water Standards (see Chapter 3). Vegetation results are compared to both standards, because metals in vegetation may accumulate via uptake from sediment or water. Various metals are seen in vegetation at levels above drinking water standards but below sediment standards; this is likely due to some vegetation having the ability to concentrate metals.

Levels of chromium, copper, mercury, nickel, and silver were lower in vegetation taken on the BNL site from the Peconic River near the east firebreak. This area was included in a pilot study of cleanup options being considered for use in the Operable Unit V remediation activities. Off site,

Table 6-8. Radiological Analysis of Shellfish, Aquatic Vegetation, Water, and Sediment.

Location/ Sample Type	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL (EA – HM-N)		
Algae	13.2 ± 1.7	2.71 ± 0.31
Burr reed	29.9 ± 4.1	0.11 ± 0.08
Burr reed	34.9 ± 4.6	0.16 ± 0.09
Duckweed	31.1 ± 3.6	1.35 ± 0.17
Duckweed	23.4 ± 3.2	0.88 ± 0.13
Connecticut Ave. (HC)		
Clams	2.5 ± 1.9	< MDL
Clams	1.78 ± 0.99	< MDL
Sediment	2.63 ± 0.46	0.05 ± 0.02
Vegetation	19.2 ± 3.5	< MDL
Water (pCi/L)	NV	< MDL
Forge Pond		
Freshwater mussels	1.66 ± 0.52	0.08 ± 0.03
Sediment	2.99 ± 1.14	0.2 ± 0.1
Vegetation (Lily Pad)	15.6 ± 2.4	0.25 ± 0.09
Water (pCi/L)	< MDL	< MDL
Swan Pond		
Sediment	1.39 ± 0.37	< MDL
Vegetation (Lily Pad)	19.4 ± 2.8	0.19 ± 0.07
Water (pCi/L)	< MDL	< MDL
Lower Lake, Carmans R.		
Sediment	9.13 ± 4.11	0.80 ± 0.36
Vegetation (Milfoil)	11 ± 11.8	< MDL
Water (pCi/L)	33.8 ± 16.4	< MDL
Peconic River - RGC		
Clams	10.5 ± 3.3	< MDL
Clams	10.6 ± 1.9	< MDL
Sediment	14.5 ± 1.6	0.09 ± 0.04
Vegetation	10 ± 3.2	< MDL
Water (pCi/L)	235 ± 41.9	< MDL
Indian Point		
Blue Mussel	12.9 ± 3.1	< MDL
Sediment	1.69 ± 0.35	< MDL
Vegetation	49.2 ± 6.3	< MDL
Water (pCi/L)	290 ± 48	< MDL
Flanders Bay		
Clams	12.1 ± 2.3	< MDL
Sediment	11.1 ± 1.3	0.09 ± 0.03
Water (pCi/L)	317 ± 50.1	< MDL
Moriches Bay		
Clams	12.4 ± 1.7	< MDL
Sediment	2.17 ± 0.49	< MDL
Vegetation	6.47 ± 2.95	0.06 ± 0.12
Water (pCi/L)	254 ± 65.3	< MDL

Notes:

All values shown with 95% confidence interval.

MDL = Minimum Detection Limit

NV = No value given

Sediment values are for dry weights.

Water values are given in pCi/L.

Table 6-9. Metals Analysis of Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.

Location/ Sample Type	Arsenic mg/kg	Barium mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Iron mg/kg	Lead mg/kg	Manganese mg/kg	Mercury mg/kg	Nickel mg/kg	Selenium mg/kg	Silver mg/kg	Sodium mg/kg	Zinc mg/kg
BNL (EA - HM-N)														
Algae	< MDL	4.17	0.16	0.75	14	165	1.02	23.5	0.09	0.5	0.27	1.31	115	32.6
Burr reed	< MDL	2.6	< MDL	0.27	1.88	21.1	0.18	8.17	0.02	0.3	< MDL	0.29	428	6.15
Burr reed	< MDL	4.67	< MDL	0.22	1.62	45.6	0.12	48.8	0.01	0.3	< MDL	0.3	363	5.05
Duckweed	< MDL	2.95	0.32	0.58	19.7	53	0.56	13	0.04	1.05	< MDL	1.21	557	30.9
Duckweed	< MDL	3.48	0.19	1.09	15.7	156	1.07	12.2	0.04	0.91	< MDL	2.25	285	19.8
Connecticut Ave. (HC)														
Sediment	1.37	2.87	0.06	14.9	3.09	1910	25.6	9.27	< MDL	1	< MDL	< MDL	10.9	10.7
Vegetation	< MDL	23	0.02	0.12	0.4	149	< MDL	284	0	< MDL	< MDL	< MDL	592	3.14
Water (mg/L)	< MDL	0.01	< MDL	< MDL	< MDL	2.38	< MDL	0.14	< MDL	< MDL	< MDL	< MDL	7.17	0
Forge Pond														
Sediment	0.84	12.9	< MDL	2.31	4.19	1730	7.61	23.9	0.01	1.07	< MDL	0.27	15	11.1
Veg. (Lily Pad)	< MDL	20.2	< MDL	0.19	< MDL	33.7	< MDL	44.8	< MDL	< MDL	< MDL	0.23	466	1.73
Water (mg/L)	< MDL	0.02	< MDL	0	< MDL	0.71	< MDL	0.04	< MDL	< MDL	< MDL	0	10.8	< MDL
Swan Pond														
Sediment	< MDL	2.42	< MDL	0.48	0.17	51.7	1.85	38	< MDL	0.11	< MDL	0.2	7.04	1.32
Veg. (Lily Pad)	< MDL	63.2	< MDL	< MDL	0.21	46.1	< MDL	806	< MDL	0.22	< MDL	0.24	344	5.22
Water (mg/L)	< MDL	0.01	< MDL	0	< MDL	0.08	0	0.44	< MDL	< MDL	< MDL	0	8.8	0
Lower Lake, Carmans R.														
Sediment	7.06	123	0.87	34.4	17.8	11860	104	566	0.18	10.4	3.23	< MDL	288	128
Vegetation	< MDL	22.5	< MDL	0.1	0.15	184	< MDL	265	0	< MDL	0.36	< MDL	1250	2.5
Water (mg/L)	< MDL	0.03	< MDL	0	0	1.58	0	0.07	< MDL	0	< MDL	< MDL	11.3	0.01
Indian Point														
Sediment	0.95	1.89	< MDL	1.73	1.06	1010	1.97	66.5	< MDL	0.53	< MDL	< MDL	4750	7.05
Vegetation	0.42	0.14	< MDL	0.2	< MDL	44.5	0.16	18.3	< MDL	< MDL	< MDL	< MDL	9450	0.34
Water (mg/L)	< MDL	0.02	< MDL	< MDL	< MDL	0.94	< MDL	0.15	< MDL	< MDL	< MDL	< MDL	9600	< MDL
Peconic River - RGC														
Sediment	17.8	48.6	1.08	42.7	61.9	55610	43.1	777	0.08	22.7	1.51	0.69	44830	155
Vegetation	3.63	6.31	0.08	0.87	3.57	2570	1.5	2260	0.01	2.21	0.27	< MDL	2530	13.4
Water (mg/L)	< MDL	0.02	< MDL	< MDL	< MDL	0.3	< MDL	0.13	0	< MDL	< MDL	< MDL	7420	< MDL
Flanders Bay														
Sediment	14	31.4	0.85	27.5	28.5	32190	26.1	481	0.07	15.1	< MDL	< MDL	19140	93.8
Water (mg/L)	< MDL	0.02	< MDL	< MDL	< MDL	< MDL	< MDL	0.07	0	< MDL	< MDL	< MDL	10150	< MDL
Moriches Bay														
Sediment	0.5	1.39	< MDL	2.02	0.49	828	1.67	10.1	< MDL	0.37	< MDL	< MDL	3430	2.32
Vegetation	0.83	1.41	0.02	0.24	0.23	126	0.3	37	0	0.13	< MDL	< MDL	10700	0.74
Water (mg/L)	< MDL	0.01	< MDL	< MDL	0	0.32	0	0.02	< MDL	< MDL	< MDL	< MDL	11130	0.08

Notes:

Water values are in mg/L.

MDL = Minimum Detection Limit

chromium, copper, and nickel were detected at levels just above Suffolk County cleanup objectives in sediments from Connecticut Avenue (HC), Lower Lake - Carmans River, Peconic River near the Riverhead golf course, and in Flanders Bay.

6.3.5.3 Pesticides in Aquatic Samples

Pesticides and PCBs are reported in Table 6-10 for only those samples with detectable limits. No PCBs were detected in any vegetation, sediment, or water samples. DDT or its breakdown products, DDD and DDE, were detected in various samples of vegetation, sediment, and water at nearly all locations.

Chlordane or its breakdown products were only detected in sediments at Connecticut Avenue (HC) on the Peconic River. Aldrin and beta-BHC were only detected in one sample of duckweed on site at BNL. All of these pesticides were used historically across Long Island, including at BNL.

6.3.6 Vegetation Sampling

6.3.6.1 Farm and Garden Plants

A variety of farm and garden vegetables were sampled in 2002. Samples were collected from farms near BNL as well as from an on-site garden (Figure 6-6). Samples were submitted for

Table 6-10. Pesticide and PCB Analysis of Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.

Location/ Sample Type	4,4'-DDD	4,4'-DDE	4,4'-DDT	Aldrin mg/kg	alpha- Chlordane	gamma- Chlordane	beta- BHC
BNL (EA - HM-N)							
Algae	< MDL	< MDL	2.4	< MDL	< MDL	< MDL	< MDL
Duckweed	1.5	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Duckweed	< MDL	< MDL	3.1	3.5	< MDL	< MDL	1.3
Connecticut Ave. (HC)							
Sediment	0.97	3.3	5.3	< MDL	0.51	0.4	< MDL
Vegetation	< MDL	< MDL	1.4	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	0.01	0.16	0.1	< MDL	< MDL	< MDL	< MDL
Forge Pond							
Sediment	0.67	0.74	< MDL	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.05	< MDL	< MDL	< MDL	< MDL
Swan Pond							
Lily Pad	1.7	< MDL	2.3	< MDL	< MDL	< MDL	< MDL
Sediment	0.5	0.3	< MDL	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.05	< MDL	< MDL	< MDL	< MDL
Lower Lake, Carmans R.							
Sediment	7.7	16.4	4	< MDL	< MDL	< MDL	< MDL
Vegetation	< MDL	1.5	2	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	0.01	< MDL	0.01	< MDL	< MDL	< MDL	< MDL
Indian Point							
Sediment	< MDL	0.37	2	< MDL	< MDL	< MDL	< MDL
Vegetation	< MDL	< MDL	2.8	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	0.01	< MDL	0.08	< MDL	< MDL	< MDL	< MDL
Peconic River - RGC							
Sediment	< MDL	< MDL	2.7	< MDL	< MDL	< MDL	< MDL
Flanders Bay							
Sediment	1.2	2.6	6.6	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.03	< MDL	< MDL	< MDL	< MDL
Moriches Bay							
Vegetation	< MDL	< MDL	1.2	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.1	< MDL	< MDL	< MDL	< MDL

Notes:

Water values are in mg/L.

beta-BHC = benzene hexachloride

MDL = Minimum Detection Limit

radiological analysis and the results are presented in Table 6-11. As in the past, no radionuclides attributable to BNL operations were observed in farm produce off site. Cesium-137 was detected in acorn squash from the on-site garden and in crab apples taken near the on-site gas station at levels just above detection. Potassium-40, which occurs naturally, was the only radionuclide detected in all of the produce sampled. BNL plans to discontinue farm vegetation sampling off site because there is no longer a source for potential release from the BNL site (all reactor operations ceased when the Brookhaven Medical Research Reactor stopped operating in December of 2000) and because historic data indicate the absence of any BNL-related radionuclides in off-site farm vegetation. BNL may conduct confirmatory sampling periodically to update its database on farm vegetation. On-site garden

vegetables will continue to be sampled annually because cesium-137 is occasionally detected in various vegetables grown on site.

6.3.6.2 Grassy Plants

BNL sampled grassy vegetation (Table 6-12) near the air monitoring stations to support surveillance monitoring associated with these locations. Vegetation sampling is carried out to determine if depositional material is accumulating on plant surfaces and soils and whether there is uptake by the vegetation. In 2002, the only anthropogenic radionuclide found in grassy vegetation was cesium-137. A single sample from air station P-4 near the apartment complex and the on-site vegetable garden indicated a very low cesium-137 level (0.01 pCi/g wet weight). This corroborates the presence of cesium-137 that was detected in acorn squash from the garden.

Table 6-11. Radiological Analysis of Farm and Garden Produce.

Location/ Sample Type	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL Fruit Trees		
Apple (Bldg. 555)	1.15 ± 0.14	ND
Apple (Bldg. 630)	1.39 ± 0.17	0.01 ± 0.00
Apple (Bldg. 630)	2.99 ± 0.29	ND
BNL Garden		
Acorn squash	2.45 ± 0.23	0.01 ± 0.00
Cucumber	1.21 ± 0.12	ND
Eggplant	2.14 ± 0.22	ND
Green pepper	1.72 ± 0.30	ND
Tomato	1.45 ± 0.22	ND
Bruno Farm		
Corn	2.15 ± 0.46	ND
Cucumber	1.86 ± 0.17	ND
Eggplant	2.43 ± 0.21	ND
Zucchini	1.91 ± 0.17	ND
Cheryl's Farm		
Pumpkin	2.15 ± 0.18	ND
Cornell Farm		
Corn	1.99 ± 0.49	ND
Fox Hollow Farms		
Strawberry	1.16 ± 0.14	ND
Kennedy Farm		
Pumpkin	ND	ND
Lewins Farm		
Brussel sprout	3.58 ± 0.37	ND
Cauliflower	ND	ND
Corn	2.39 ± 0.28	ND
Peach	1.67 ± 0.21	ND
Potato	4.09 ± 0.36	ND
Pumpkin	1.53 ± 0.36	ND
Red cabbage	1.78 ± 0.16	ND
String bean	2.77 ± 0.26	ND
Zucchini	1.88 ± 0.15	ND
Mays Farm		
Corn	1.98 ± 0.38	ND
Eggplant	2.85 ± 0.24	ND
Pumpkin	2.70 ± 0.25	ND
String bean	3.23 ± 0.34	ND
Tomato	2.08 ± 0.20	ND
Zucchini	2.06 ± 0.31	ND
River Road Farms		
Snap pea	1.13 ± 0.50	ND
Strawberry	1.14 ± 0.11	ND

Notes:

See Figure 6-6 for sampling locations.

All values shown with a 95% error.

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

ND = Not Detected

Table 6-12. Radiological Analysis of Grass and Other Vegetation.

Location	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL		
P-7	3.05 ± 0.60	ND
P-9	5.5 ± 2.2	ND
S-5	5.1 ± 1.2	ND
P-2	2.48 ± 0.53	ND
HT-E	2.48 ± 0.53	ND
P-4	2.87 ± 0.41	0.01 ± 0.01
Off Site		
NYSDEC Game Farm	5.39 ± 0.61	ND

Notes:

All values shown with 95% confidence interval.

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

ND = Not Detected

6.3.6.3 Special Plant Sampling

BNL conducted special vegetation sampling in and around the Former Waste Management Facility (FWMF) in support of the assessment resulting from the suspected high cesium-137 content found in an off-site deer (see Section 6.3.1.2). The FWMF was identified as one of two areas that was a potential source for deer acquiring cesium-137. It was also discovered that the fence of this facility had vegetation growing through it and several holes existed that would allow deer to readily access the facility. The holes were patched and no deer have been documented in the facility since then.

Vegetation growing through the fence is available to deer for browse. This material, if contaminated with cesium-137, could consequently be absorbed by deer when consumed. A sampling of the vegetation growing through the fence showed that fungus, moss, high bush blueberry, and leaves of an ornamental tree (see Table 6-13) were the only species that accumulated significant amounts of cesium-137. The high bush blueberry and ornamental tree were cut away from the fence line to prevent deer from browsing on their leaves. Although moss and fungi were identified as containing significant amounts of cesium-137, there was no evidence that deer were eating that material, and there was not enough to significantly contribute to their diet.

Historically, deer had entered this facility; therefore a study was conducted to determine if individual plant species that may be browsed by deer were accumulating cesium-137. This study was significant because deer are highly selective in their feeding and will select foods containing needed nutrients over less nutritious species. Sampling occurred only in areas known to contain high levels of cesium-137 (see Table 6-14 and Section 6.4 for soil sample values), where plant and soil samples were obtained. Plants that had significant amounts of cesium-137 present in their above ground tissues included fern, mustard, white flowering aster, smartweed, and steplebush. Of these plants, steplebush had the highest concentrations of cesium-137, at 95.80 pCi/g wet weight. This plant was growing in soil containing cesium-137 between 46 and 79 pCi/g dry weight, indicating that it can concentrate this radionuclide (Tatum-Byers 2003). Other plants contained lesser amounts of cesium-137 yet, if made available to deer, they could result in elevated levels in deer tissues. Eliminating deer access to the facility greatly reduces the likelihood that deer will acquire cesium-137.

6.4 SOIL SAMPLING

Soil sampling was conducted to correspond with vegetation sampling near air stations, the on-site garden, local farms, and in association with the special vegetation sampling discussed above. Soil sampling is conducted as part of the surveillance program and is used to determine uptake in plants as well as to determine long-term deposition or lack thereof. Soil samples were analyzed for gamma-emitting radionuclides. Table 6-14 shows the sampling results of the radiological analysis of soils. All radionuclides, with the exception of cesium-137, that are detected in soils (other than from the Former Waste Management Facility) are found naturally in Long Island soils. Higher levels of some of the radionuclides, such as lead-212, lead-214, bismuth-214, and potassium-40 in some of the farm locations, are likely due to the addition of fertilizers to soils for growing crops. The maximum cesium-137 concentration in soils not associated with the Former Waste Management Facility was 0.62 pCi/g dry weight, seen in a

Table 6-13. Radiological Analysis of Special Vegetation Sampling at the Former Waste Management Facility (FWMF).

Location/ Sample Type	K-40		Cs-137	
	(pCi/g, wet weight)			
Outside FWMF Fence				
Fungus	3.6	± 1.5	69	± 11
Moss	1.7	± 1.2	50	± 11
Blackberry fruit	1.61	± 0.57	ND	
Blackberry bush	3.1	± 1.1	0.08	± 0.07
Grape vegetation	2.14	± 0.40	0.62	± 0.07
Wild rose vegetation	3.51	± 0.45	0.28	± 0.04
Common Elderberry	4.17	± 0.47	0.97	± 0.09
Highbush Blueberry	0.94	± 0.22	3.15	± 0.35
Ornamental tree	2.16	± 0.35	3.94	± 0.35
Bittersweet vegetation	6.1	± 1.6	ND	
Swamp Red Maple	2.04	± 0.37	0.12	± 0.03
Choke Cherry	0.41	± 0.05	0.12	± 0.02
Inside FWMF Fence				
Fern	2.55	± 0.53	66.5	± 5.5
Mustard	2.07	± 0.63	48.6	± 4.2
Goldenrod -				
Yellow Flowering	4.7	± 1.1	6.73	± 0.74
Goldenrod-				
Yellow Flowering B	4.57	± 0.57	6.27	± 0.48
Common Mullein	6.9	± 2.1	2.00	± 0.36
Common Mullien B	6.52	± 0.99	0.46	± 0.06
Sweet Everlasting	7.0	± 1.1	0.73	± 0.10
Sweet Everlasting B	7.6	± 1.2	0.58	± 0.10
Sassafras	2.46	± 0.36	2.92	± 0.25
Sassafras B	2.18	± 0.41	1.53	± 0.18
Goldenrod (Euthamia)	4.28	± 0.66	5.10	± 0.64
Goldenrod (Euthamia) B	4.05	± 0.56	4.29	± 0.51
Small Flowered White Aster	4.1	± 1.1	9.8	± 1.2
Small White Flowering Aster B	4.1	± 1.0	12.1	± 1.3
Evening Primrose	2.89	± 0.54	0.60	± 0.08
Evening Primrose B	3.8	± 1.3	0.87	± 0.19
Wild Lettuce	4.39	± 0.48	6.77	± 0.51
Rumex	2.62	± 0.27	9.77	± 0.81
Dogwood	1.63	± 0.36	6.08	± 0.46
Dogwood B	1.76	± 0.42	7.92	± 0.78
Smartweed	2.53	± 0.45	30.2	± 3.0
Smartweed B	2.93	± 0.39	30.6	± 2.3
Steeplebush	3.07	± 0.58	93	± 1.1
Steeplebush B	1.97	± 0.48	95.8	± 6.9
Goldenrod	4.38	± 1.18	0.40	± 0.13
Goldenrod B	5.16	± 0.82	0.87	± 0.10
Off-Site Controls				
Dogwood	1.78	± 0.27	ND	
Sassafras	1.08	± 0.22	ND	

Notes:

All values shown with 95% confidence interval.

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

ND = Not Detected

Table 6-14. Radiological Analysis of Soil Samples.

Sampling Location	Potassium-40 pCi/g	Cobalt-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Actinium-228 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Thorium-232 pCi/g
BNL								
S6	1.1 ± 0.9	ND	0.11 ± 0.05	ND	0.37 ± 0.20	0.16 ± 0.14	ND	ND
P7	6.6 ± 1.1	ND	0.41 ± 0.08	0.25 ± 0.05	0.69 ± 0.10	0.70 ± 0.11	0.51 ± 0.08	0.60 ± 0.25
P9	5.2 ± 1.8	ND	ND	0.43 ± 0.16	ND	1.11 ± 0.34	0.51 ± 0.40	ND
S5	4.2 ± 1.3	ND	0.22 ± 0.09	0.18 ± 0.11	ND	0.60 ± 0.16	ND	ND
P2	3.4 ± 0.7	ND	ND	0.13 ± 0.04	ND	0.27 ± 0.07	0.27 ± 0.09	ND
P4 Garden	1.5 ± 0.9	ND	0.24 ± 0.06	ND	ND	0.29 ± 0.15	ND	ND
P4	4.6 ± 0.8	ND	0.13 ± 0.04	0.25 ± 0.05	0.69 ± 0.10	0.70 ± 0.10	0.55 ± 0.09	0.62 ± 0.27
Bldg 555	5.6 ± 1.0	ND	0.17 ± 0.04	0.26 ± 0.06	0.73 ± 0.10	0.87 ± 0.13	0.58 ± 0.15	0.93 ± 0.21
Bldg 630	2.6 ± 1.0	ND	0.08 ± 0.05	0.20 ± 0.08	0.51 ± 0.23	0.61 ± 0.17	ND	ND
Former Waste Management Facility Soils*								
FWMF -								
goldenrod/everlasting	2.9 ± 1.0	ND	455 ± 77	ND	ND	ND	ND	ND
FWMF - mullein	5.6 ± 1.0	2.37 ± 0.28	1050 ± 173	0.23 ± 0.16	ND	0.71 ± 0.36	0.47 ± 0.13	ND
FWMF - mullein B	6.8 ± 1.8	ND	2.87 ± 0.54	0.31 ± 0.14	ND	0.92 ± 0.21	ND	ND
FWMF - sassafras	8.2 ± 2.2	0.16 ± 0.11	588 ± 114	0.43 ± 0.37	ND	0.96 ± 0.82	ND	ND
FWMF - sassafras B	5.7 ± 1.0	0.09 ± 0.02	339 ± 56	0.35 ± 0.14	ND	0.84 ± 0.28	ND	ND
FWMF - aster/primrose	5.0 ± 1.3	ND	68 ± 12	ND	ND	0.57 ± 0.36	ND	ND
FWMF - aster/primrose B	3.6 ± 0.7	0.05 ± 0.01	69 ± 11	0.14 ± 0.06	ND	0.36 ± 0.11	0.36 ± 0.25	ND
FWMF - rumex/wild lettuce	3.7 ± 0.7	0.25 ± 0.04	149 ± 25	0.19 ± 0.08	ND	0.36 ± 0.18	0.43 ± 0.24	ND
FWMF - rumex/wild lettuce B	8.8 ± 2.2	0.37 ± 0.12	269 ± 52	ND	ND	ND	ND	ND
FWMF - fern	4.3 ± 0.8	1.36 ± 0.16	908 ± 150	ND	ND	ND	ND	ND
FWMF - fern B	4.2 ± 1.3	1.30 ± 0.20	1010 ± 174	ND	ND	ND	ND	ND
FWMF - smartweed	3.6 ± 0.7	0.11 ± 0.02	161 ± 27	0.15 ± 0.07	ND	0.41 ± 0.17	0.22 ± 0.16	0.63 ± 0.39
FWMF - smartweed B	3.8 ± 0.7	ND	68 ± 11	0.20 ± 0.07	ND	ND	ND	ND
FWMF - steeplebush	1.0 ± 0.9	ND	79 ± 13	ND	ND	0.32 ± 0.25	ND	ND
FWMF - steeplebush B	3.5 ± 0.7	0.03 ± 0.02	46 ± 8	0.17 ± 0.07	ND	0.44 ± 0.12	0.37 ± 0.23	0.57 ± 0.30
FWMF - mustard	4.4 ± 0.8	0.35 ± 0.05	157 ± 26	0.13 ± 0.07	ND	0.42 ± 0.15	0.25 ± 0.18	ND
FWMF - mustard B	4.5 ± 0.8	0.43 ± 0.06	158 ± 26	0.23 ± 0.08	ND	0.50 ± 0.16	0.37 ± 0.17	ND
FWMF - ornamental tree	4.0 ± 1.3	ND	5.30 ± 0.96	0.23 ± 0.14	ND	0.43 ± 0.17	0.53 ± 0.20	ND
FWMF - ornamental tree B	3.3 ± 0.6	ND	13.9 ± 2.3	0.14 ± 0.05	0.48 ± 0.08	0.42 ± 0.09	0.37 ± 0.09	0.75 ± 0.26
FWMF - highbush blueberry	3.7 ± 0.7	ND	1.87 ± 0.32	0.16 ± 0.05	0.41 ± 0.09	0.52 ± 0.09	0.37 ± 0.13	0.63 ± 0.23
FWMF - highbush blueberry B	5.6 ± 1.6	ND	4.88 ± 0.99	0.42 ± 0.15	ND	0.68 ± 0.26	0.94 ± 0.26	ND
FWMF - goldenrod	9.4 ± 2.3	0.21 ± 0.11	338 ± 65	0.60 ± 0.39	ND	1.42 ± 0.74	ND	ND
FWMF - goldenrod B	1.4 ± 0.9	ND	3.91 ± 0.67	ND	ND	ND	ND	ND
FWMF - dogwood	3.7 ± 0.7	0.09 ± 0.02	230 ± 38	0.20 ± 0.12	ND	0.41 ± 0.22	ND	ND

(continued on next page)

Table 6-14. Radiological Analysis of Soil Samples (concluded).

Sampling Location	Potassium-40 pCi/g	Cobalt-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Actinium-228 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Thorium-232 pCi/g
Off-Site Control Location*								
Long Beach soil	3.51 ± 0.70	ND	0.62 ± 0.11	0.11 ± 0.03	0.37 ± 0.09	0.30 ± 0.06	0.26 ± 0.05	ND
Middle Island soil	2.30 ± 0.96	ND	0.13 ± 0.05	0.16 ± 0.08	0.61 ± 0.22	0.47 ± 0.15	ND	ND
Farm Soils								
Lewin's Farm	9.6 ± 2.4	ND	ND	0.53 ± 0.22	1.85 ± 0.47	1.84 ± 0.41	1.41 ± 0.34	1.82 ± 1.10
Bruno's Farm	6.7 ± 1.2	ND	0.10 ± 0.03	0.25 ± 0.05	0.82 ± 0.12	0.79 ± 0.12	0.68 ± 0.10	0.89 ± 0.28
May's Farm	3.7 ± 1.1	ND	0.09 ± 0.06	0.23 ± 0.09	0.75 ± 0.22	0.76 ± 0.18	ND	ND
Cornell Coop	7.0 ± 1.2	ND	0.15 ± 0.04	0.37 ± 0.07	0.98 ± 0.14	0.93 ± 0.14	0.71 ± 0.16	1.17 ± 0.39
NYSDEC Game Farm	4.33 ± 0.80	ND	0.34 ± 0.07	0.22 ± 0.04	0.66 ± 0.09	0.61 ± 0.09	0.45 ± 0.07	0.61 ± 0.26

Notes:

All values shown with 95% confidence interval.

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

ND = Not Detected

* = Soil samples are from special uptake program and are associated with vegetation sample results shown in Table 6-13.

control sample taken in Long Beach. The lower values are considered to be consistent with background levels resulting from worldwide fallout from historic aboveground nuclear weapons testing.

The soils taken from the FWMF show the levels of cesium-137 and cobalt-60 contamination still present at this facility. As mentioned above, the soil sampling in the FWMF was conducted in association with vegetation sampling in order to calculate uptake of cesium-137 by specific species of plants that may be consumed by deer. The highest level of cesium-137 (1,050 pCi/g dry weight) was found near the eastern portion of the facility. The highest level of Co-60 (2.37 pCi/g dry weight) was found in the same sample that contained the highest level of cesium-137. The higher levels of radionuclide contamination in these soils is a potential source for deer to acquire cesium-137. However, restrictive measures and repairs to the fence surrounding the FWMF are preventing deer from entering the facility to feed.

6.5 BASIN SEDIMENTS

BNL tests basin sediment samples on a two-year cycle. There are 14 basins associated with outfalls that receive discharges permitted under the State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-6 for basin locations). One basin, HZ, was added to the list in 2002; data presented in this report form the baseline for this new basin. Names for the basins have suffixes indicating their locations: E = east, N = north, M = middle, R = canal north of the railroad tracks, S = South.

6.5.1 Chemical Analysis

Table 6-15 presents the results of analysis for semivolatile organic compounds in basin sediments. Only those basins and chemicals that were detected are presented. The majority of all chemicals present in the table are estimated values, meaning that the chemical was detected but the value was below the required detection limit. All of the chemicals listed were detected above the detection limit in

at least one basin. The phthalates listed are likely a result of cross contamination from the sample bottles used for shipping samples to the analytical laboratory. Phthalates are commonly used as plasticizers. The other listed chemicals represent petroleum breakdown products typically found in road run-off. All of the basins represented in Table 6-15 receive stormwater discharges from the road system at BNL.

6.5.2 PCBs and Pesticides

Basin sediments were analyzed for PCBs and pesticides. The results of these analyses are presented in Tables 6-16 and 6-17, respectively.

The PCBs Aroclor 1254 and Aroclor 1260 were detected in basin sediments from the HS outfall, HS canal, HS basin, HW basin, HT-E basin, HT-W basin, HN outfall, HN south basin, and the HN middle basin. PCBs have been detected in the HS and HW basins in the past. Present results are similar to past results in these basins. In 2002, sampling of the outfall and canal associated with the HS basin was completed to document the level of PCBs that were suspected of being present. Both HS and HW basins were covered under one or more Records of Decision associated with the environmental cleanup of the Laboratory. The presence of PCBs in the other basins and canals, while not unexpected, had never been documented by past sampling. BNL will continue to periodically sample all basins to maintain the baseline for PCBs.

The pesticides shown in Table 6-17 were commonly used throughout Long Island, including at BNL. The levels indicated in the table are fairly low, with most below or just above detection limits. All of the pesticides detected are long-lived and tend to persist in the environment at low concentrations. Continued periodic monitoring of basin sediments will enable BNL to track the continued degradation of these chemicals.

6.5.3 Metals

Table 6-18 presents the results of metals analysis on basin sediments. Samples from all basins were analyzed for metals, except for basins associated with the outfall at HN. With a few exceptions, all metals in all basins were

within regulatory standards established for environmental cleanup. The exceptions to this include copper, lead, mercury, and nickel. Copper was found in excess of the Suffolk County action levels for cleanup in basin HT-E. Lead was also found in HT-E above the cleanup standard but below action levels. Mercury and nickel were found in both HW and HT-E basins above cleanup standards but below action levels. Cleanup actions for both basins have been covered under one or more Records of Decision for the environmental cleanup of the Laboratory and have been determined not to need remedial actions.

6.5.4 Radiological Analysis

All basins were sampled and analyzed for gamma-emitting radionuclides. The results of this sampling and analysis are presented in Table 6-19. All of the radionuclides presented, with the exception of cobalt-60 and cesium-137, are naturally occurring and are seen at similar levels in soil samples from elsewhere on site and from local farms. Cesium-137 levels are considered to be at background, are similar to values seen elsewhere, and result from worldwide fallout from historical aboveground nuclear weapons testing. The cobalt-60 seen in sediments in the HN area basins is likely from past Laboratory practices and is at levels consistent with those reported in 2000.

6.6 TOXICITY TESTS, SEWAGE TREATMENT PLANT

Under the SPDES discharge permit, BNL conducted toxicity testing for the Sewage Treatment Plant effluent. Two species were evaluated—the fathead minnow (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*). Results from this testing program are presented in Chapter 3.

6.7 PRECIPITATION MONITORING

As part of the Environmental Monitoring Program, precipitation samples were collected approximately quarterly at air monitoring Stations P4 and S5 (see Chapter 4, Figure 4-4 for station locations) and analyzed for radiological content. Four samples were taken from each of these two stations in 2002. Gross alpha activity

Table 6-15. Semivolatile Organic Compound Analysis of Basin Sediments.

Basin Depth Analyte	HS 0"-2" µg/kg	HS 2"-4" µg/kg	HS 4"-6" µg/kg	HS-R 0"-2" µg/kg	HS-R 2"-4" µg/kg	HS-R 4"-6" µg/kg	HS BASIN 0"-2" µg/kg	HS BASIN 2"-4" µg/kg	HW BASIN 0"-2" µg/kg	HW BASIN 2"-4" µg/kg	HW BASIN 4"-6" µg/kg
2-Methylnaphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Acenaphthene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Anthracene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Benzo(a)anthracene	100*	100*	200*	300*	300*	200*	200*	< MDL	400*	300*	200*
Benzo(a)pyrene	100*	100*	200*	300*	200*	200*	200*	80*	400*	200*	200*
Benzo(b)fluoranthene	< MDL	< MDL	200*	200*	300*	200*	300*	< MDL	560	200*	200*
Benzo(ghi)perylene	< MDL	< MDL	< MDL	100*	100*	< MDL	90*	< MDL	100*	100*	< MDL
Benzo(k)fluoranthene	< MDL	< MDL	< MDL	300*	200*	< MDL	< MDL	< MDL	400*	200*	< MDL
Bis(2-ethylhexyl)phthalate	100*	< MDL	< MDL	100*	< MDL	< MDL	100*	< MDL	1200	660	400*
Butyl benzyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Carbazole	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Chrysene	100*	100*	200*	300*	300*	200*	200*	90*	510	300*	300*
Di-n-butyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Di-n-octyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Dibenzofuran	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Fluoranthene	200*	200*	400*	560	470	300*	300*	100*	830	550	400*
Fluorene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Indeno(1,2,3-cd)pyrene	< MDL	< MDL	< MDL	100*	100*	< MDL	90	< MDL	100*	100*	< MDL
Naphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Phenanthrene	90*	100*	200*	200*	100*	100*	100*	< MDL	400*	300*	200*
Pyrene	200*	200*	300*	480	410	300*	300*	100*	670	490	400*

Basin Depth Analyte	HT-E 0"-2" µg/kg	HT-E 2"-4" µg/kg	HT-E 4"-6" µg/kg	HN 0"-2" µg/kg	HN 2"-4" µg/kg	HN 4"-6" µg/kg	HN-N 0"-2" µg/kg	HN-N 2"-4" µg/kg	HN-N 4"-6" µg/kg	HN-M 0"-2" µg/kg	HN-M 2"-4" µg/kg
2-Methylnaphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	70	< MDL	< MDL	< MDL	< MDL	< MDL
Acenaphthene	< MDL	300*	< MDL	< MDL	50*	430	< MDL	< MDL	< MDL	< MDL	< MDL
Anthracene	< MDL	300*	< MDL	< MDL	100*	540	< MDL	< MDL	< MDL	50*	< MDL
Benzo(a)anthracene	200*	1300	500*	70*	400*	1200	60*	< MDL	< MDL	300*	< MDL
Benzo(a)pyrene	200*	960	500*	70*	440	1100	90*	< MDL	< MDL	300*	< MDL
Benzo(b)fluoranthene	200*	1400	400*	60*	400*	1100	100*	< MDL	< MDL	300*	< MDL
Benzo(ghi)perylene	< MDL	300*	200*	60*	300*	640	70*	< MDL	< MDL	200*	< MDL
Benzo(k)fluoranthene	< MDL	850	500*	80*	570	1200	100*	< MDL	< MDL	400*	< MDL
Bis(2-ethylhexyl)phthalat	100*	200*	400	100*	1600	400*	100*	< MDL	< MDL	590	< MDL
Butyl benzyl phthalate	< MDL	< MDL	< MDL	< MDL	200*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Carbazole	< MDL	510	< MDL	< MDL	80*	430	< MDL	< MDL	< MDL	50*	< MDL
Chrysene	300*	1500	590*	80*	540	1300	100*	< MDL	< MDL	400*	< MDL

(continued on next page)

Table 6-15. Semivolatile Organic Compound Analysis of Basin Sediments (concluded).

Basin Depth Analyte	HT-E 0'-2" µg/kg	HT-E 2'-4" µg/kg	HT-E 4'-6" µg/kg	HN 0'-2" µg/kg	HN 2'-4" µg/kg	HN 4'-6" µg/kg	HN-N 0'-2" µg/kg	HN-N 2'-4" µg/kg	HN-N 4'-6" µg/kg	HN-M 0'-2" µg/kg	HN-M 2'-4" µg/kg
Di-n-butyl phthalate	< MDL	< MDL	< MDL	50*	60*	50*	60*	< MDL	60*	70*	< MDL
Di-n-octyl phthalate	< MDL	< MDL	< MDL	< MDL	90*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Dibenzofuran	< MDL	400*	< MDL	< MDL	< MDL	200*	< MDL	< MDL	< MDL	< MDL	< MDL
Fluoranthene	510	3000	1000	200*	960	3000	200*	50*	< MDL	660	50*
Fluorene	< MDL	300*	< MDL	< MDL	50*	300*	< MDL	< MDL	< MDL	< MDL	< MDL
Indeno(1,2,3-cd)pyrene	< MDL	300*	200*	50*	300*	660	60*	< MDL	< MDL	200*	< MDL
Naphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	100*	< MDL	< MDL	< MDL	< MDL	< MDL
Phenanthrene	400*	3200	500*	90*	490	2600	60*	< MDL	< MDL	300*	< MDL
Pyrene	400*	2200	860	100*	800	2100	100*	40*	< MDL	550	40*

Basin Depth Analyte	HN-M 4'-6" µg/kg	HN-S 0'-2" µg/kg	HN-S 4'-6" µg/kg	HT-W 0'-2" µg/kg	HT-W 2'-4" µg/kg	HT-W 4'-6" µg/kg	HX-W 0'-2" µg/kg	HX-W 2'-4" µg/kg	HX-E 2'-4" µg/kg
2-Methylnaphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Acenaphthene	< MDL	< MDL	< MDL	100*	200*	< MDL	< MDL	< MDL	< MDL
Anthracene	< MDL	60*	< MDL	300*	300*	90*	< MDL	< MDL	< MDL
Benzo(a)anthracene	< MDL	300*	< MDL	840	630	300*	< MDL	< MDL	< MDL
Benzo(a)pyrene	< MDL	400	< MDL	770	600	300*	< MDL	40*	< MDL
Benzo(b)fluoranthene	< MDL	440	< MDL	640	480	300*	< MDL	< MDL	< MDL
Benzo(ghi)perylene	< MDL	200*	< MDL	570	470	200*	< MDL	< MDL	< MDL
Benzo(k)fluoranthene	< MDL	410	< MDL	870	680	300*	< MDL	< MDL	< MDL
Bis(2-ethylhexyl)phthalat	40*	200*	< MDL	200*	100*	60*	< MDL	70*	< MDL
Butyl benzyl phthalate	< MDL	70*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Carbazole	< MDL	60*	< MDL	200*	200*	70*	< MDL	< MDL	< MDL
Chrysene	< MDL	440	< MDL	940	730	300*	< MDL	40*	< MDL
Di-n-butyl phthalate	40*	50*	40	60*	< MDL	60*	50*	40*	40*
Di-n-octyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Dibenzofuran	< MDL	< MDL	< MDL	60*	80*	< MDL	< MDL	< MDL	< MDL
Fluoranthene	< MDL	730	< MDL	2000	1700	720	< MDL	70*	< MDL
Fluorene	< MDL	< MDL	< MDL	100*	100*	< MDL	< MDL	< MDL	< MDL
Indeno(1,2,3-cd)pyrene	< MDL	200*	< MDL	560	440	200*	< MDL	< MDL	< MDL
Naphthalene	< MDL	< MDL	< MDL	50*	60*	< MDL	< MDL	< MDL	< MDL
Phenanthrene	< MDL	300*	< MDL	1100	1300	430	< MDL	< MDL	< MDL
Pyrene	< MDL	590	< MDL	1500	1200	520	< MDL	60*	< MDL

Notes:

MDL = minimum detection limit

* = Values that are below the detection limit, but above the instrument detection limit.

Only basins and depths with detections above the minimum detection limit are provided in table format

Table 6-16. PCB Analysis of Basin Sediments.

Basin	Depth	Aroclor 1254	Aroclor 1260
		µg/kg	µg/kg
HS	0"-2"	96	68
HS	2'-4"	93	66
HS	4"-6"	130	78
HS-R	0"-2"	70	61
HS-R	2'-4"	65	56
HS-R	4"-6"	62	54
HS Basin	0"-2"	50	45
HW Basin	0"-2"	180	360
HW Basin	2'-4"	180	1000
HW Basin	4"-6"	160	1700
HT-E	0"-2"	220	36*
HT-E	2'-4"	870	120
HT-E	4"-6"	930	110
HT-W	0"-2"	30*	160
HT-W	2'-4"	< MDL	55
HT-W	4"-6"	42	40
HN	0"-2"	30*	< MDL
HN	2'-4"	58	48
HN	4"-6"	180	50
HN-M	0"-2"	30*	< MDL
HN-S	0"-2"	69	43

Notes:

Only basins with detectable levels of PCBs are included in this table.

* = Values are estimated based on laboratory qualifiers.

MDL = Minimum Detection Limit

measurements above the minimum detection limit were found in samples taken in January, July, and October at Station S5 and in January, April, and October at Station P4. The samples from the P4 location showed a maximum of 16.7 pCi/L activity, whereas the samples from the S5 location had a maximum activity level of 89.7 pCi/L. Both of these values are within the range of historic values reported for gross alpha activity. Gross beta activity was measured in all samples at each of the sampling locations, except for the July sample taken at P4. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation. Location P4 had a maximum gross beta activity level of 14.0 pCi/L, with an average of 6.64 pCi/L. Location S5 had a maximum of 77.7 pCi/L, with the average activity of 24.0 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Tritium was not detected in any of the samples from either location. Gamma analysis of samples showed the presence of beryllium-7 at a maximum of 41.7 pCi/L at Station P4 in April

and 55.1 pCi/L in January at Station S5.

Beryllium-7 is a naturally occurring radionuclide resulting from solar flare activity.

6.8 WILDLIFE PROGRAMS

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

In 2002, the Environmental Services Division (ESD) hosted two student interns during the summer. One intern was from the University of Georgia and continued research on the tiger salamander and other amphibians that was started in 2001. The research focus was on the use of coverboards and the variability of relative humidity on the distribution of amphibians. Unfortunately, the drought of 2002 resulted in less than optimal conditions for this research.

The second intern, from the University of Rhode Island, looked at population estimating techniques using BNL's deer population. Estimating deer populations is difficult and may result in a wide range of variability. One of the more difficult methodologies utilizes a method called Distance Sampling. This method requires the observer to identify each deer or cluster of deer, measure the vertical distance from the observer's path, and estimate the deer's angle from the observer's path. The data are then entered into a program that estimates population levels. This method was used by the student and compared to the standard method used by BNL, as well as two modifications of this method. The resulting population estimates ranged from 567 animals using the Distance Sampling approach, to 1,866 animals by modifying the standard method used by BNL and dropping the area of open fields from the calculation. The results of the research highlighted the variability in population estimating and the importance of using standardized methodology.

Table 6-17. Pesticide Analysis of Basin Sediments.

Basin Depth	HS 0'-2" µg/kg	HS 2'-4" µg/kg	HS 4'-6" µg/kg	HS-R 0'-2" µg/kg	HS-R 2'-4" µg/kg	HS-R 4'-6" µg/kg	HS BASIN 0'-2" µg/kg	HS BASIN 2'-4" µg/kg	HS BASIN 4'-6" µg/kg	HW BASIN 0'-2" µg/kg
Analyte										
4,4'-DDD	2.7*	3.5*	5.9	< MDL	< MDL	< MDL	3.3*	< MDL	< MDL	4.9
4,4'-DDE	3.8*	4.5*	6.6	3.1*	2.5*	< MDL	4.3*	< MDL	< MDL	11
4,4'-DDT	9.6	10	11	3.2*	2.9*	2.5*	11	4.8	2.6	< MDL
alpha-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
alpha-Chlordane	1.4*	1.2*	2.0*	< MDL	< MDL	< MDL	1.9*	1.1*	< MDL	3.1
delta-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.8*	< MDL	< MDL	< MDL
Endosulfan I	2.6	1.5*	2.2	2.4	2.0	1.9*	1.8*	< MDL	< MDL	6.7
Endosulfan sulfate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endrin	< MDL	3.0*	2.9*	2.5*	2.8*	< MDL	< MDL	< MDL	< MDL	6.0
Endrin aldehyde	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endrin ketone	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
gamma-Chlordane	1.7*	1.8*	2.5	< MDL	1.1*	< MDL	1.1*	< MDL	< MDL	2.2*
Heptachlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Heptachlor epoxide	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Methoxychlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL

Basin Depth	HW BASIN 2'-4" µg/kg	HW BASIN 4'-6" µg/kg	HT-E 0'-2" µg/kg	HT-E 2'-4" µg/kg	HT-E 4'-6" µg/kg	HT-W 0'-2" µg/kg	HT-W 2'-4" µg/kg	HT-W 4'-6" µg/kg	HN 0'-2" µg/kg	HN 2'-4" µg/kg
Analyte										
4,4'-DDD	8.2	7.2	< MDL	4.0*	17	2.0	< MDL	4.5	< MDL	2.0*
4,4'-DDE	7.3	5.3	2.8*	10	9.4	3.0*	4.1	5.9	< MDL	< MDL
4,4'-DDT	< MDL	< MDL	< MDL	6.6	8.0	3.0*	3.0*	3.0*	< MDL	< MDL
alpha-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.0*
alpha-Chlordane	3.1	2.4	< MDL	3.4	2.9*	2.0*	2.0*	< MDL	1.0*	1.0*
delta-BHC	< MDL	MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endosulfan I	7.8	3.9	4.7	3.3	7.0	< MDL	1.0*	2.0	< MDL	2.0*
Endosulfan sulfate	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	4.4	< MDL	< MDL	< MDL
Endrin	8.6	8.7	3.2*	8.0	14	7.9	6.9	5.1	< MDL	< MDL
Endrin aldehyde	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	6.5	< MDL	< MDL	< MDL
Endrin ketone	2.2*	3.3*	< MDL	< MDL	< MDL	4.4	17	< MDL	< MDL	< MDL
gamma-Chlordane	2.9	3.3	2.6	10	10	2.0*	2.0*	2.7	< MDL	1.0*
Heptachlor	< MDL	< MDL	< MDL	< MDL	2.6*	< MDL	< MDL	< MDL	< MDL	< MDL
Heptachlor epoxide	< MDL	< MDL	< MDL	2.8	< MDL	2.0*	< MDL	< MDL	< MDL	3.3
Methoxychlor	< MDL	16*	< MDL	< MDL	< MDL	< MDL	23	< MDL	< MDL	< MDL

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Table 6-17. Pesticide Analysis of Basin Sediments (concluded).

Basin Depth Analyte	HN 4"-6" µg/kg	HN-W 0"-2" µg/kg	HN-W 2"-4" µg/kg	HN-W 4"-6" µg/kg	HN-M 0"-2" µg/kg	HN-M 2"-4" µg/kg	HN-M 4"-6" µg/kg	HN-S 0"-2" µg/kg	HN-S 2"-4" µg/kg
4,4'-DDD	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2.0*	< MDL
4,4'-DDE	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3*	< MDL
4,4'-DDT	2.0*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2.0*	< MDL
alpha-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
alpha-Chlordane	< MDL	< MDL	2.5	2.0	2.0*	< MDL	2.0	2.0	< MDL
delta-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endosulfan I	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.0*	< MDL
Endosulfan sulfate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	< MDL
Endrin	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endrin aldehyde	3.0*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	< MDL
Endrin ketone	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	< MDL
gamma-Chlordane	2.0*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.0*	< MDL
Heptachlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Heptachlor epoxide	< MDL	1.0*	6.1	4.7	2.3	1.0*	6.9	14	2.2
Methoxychlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL

Notes:

MDL = Minimum Detection Limit

* = Values that are below the detection limit, but above the instrument detection limit.

Only basins and depths with detections above the minimum detection limit are provided in table format

The results of both research projects can be used to modify management strategies for the tiger salamander as well as altering deer population estimating protocols.

Additionally, Suffolk County Community College, in association with FWS and BNL, conducted summer field research opportunities for local high school students. These opportunities also allowed two undergraduate students from the University of Puerto Rico to gain teaching skills through the Pre-Service Teacher program. The high school students worked on several projects collecting useful data on deer browse, forest health, oak seedling recruitment, and fuel loading. The students also had the opportunity to visit nearly all of the ecosystems present on Long Island.

In addition to hosting interns, members of ESD and other departments volunteer as speakers to schools and civic groups and provide on-site ecology tours. ESD also hosted activities in association with Earth Day 2002 and provided activities to educate Laboratory employees and the general public on the environment and conservation during a Summer Sunday event. BNL hosted the Seventh Annual Pine Barrens Research Forum in October, providing a venue for researchers who are conducting work on pine barrens ecosystems to share and discuss their results. BNL also hosted the annual Wildland Fire Academy offered by NYSDEC and the Central Pine Barrens Commission. This academy trains fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis, all using the Incident Command System of wildfire management.

Table 6-18. Metals Analysis of Basin Sediments.

Basin Depth Analyte	HO-W 0"-2" mg/kg	HO-W 2"-4" mg/kg	HO-W 4"-6" mg/kg	HO-E 0"-2" mg/kg	HO-E 2"-4" mg/kg	HO-E 4"-6" mg/kg	HS 0"-2" mg/kg	HS 2"-4" mg/kg	HS 4"-6" mg/kg	HS-R 4"-6" mg/kg	0"-2" mg/kg
Aluminum	784	612	581	859	589	576	1490	2250	1540		1820
Antimony	< MDL	0.36	< MDL	0.40	0.48	< MDL	0.66	0.66	0.46		0.39
Arsenic	0.30	0.35	< MDL	0.94	0.23	0.61	0.71	0.67	0.34		0.42
Barium	14	9.7	8.7	26.4	14.9	11.4	8.3	12.6	7.5		10.2
Beryllium	0.05	0.05	0.03	0.05	0.04	0.03	0.04	0.06	0.04		0.05
Cadmium	0.05	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.06	0.04		0.06
Calcium	214	129	127	241	259	121	295	419	282		454
Chromium	2.1	3.4	1.2	2.1	1.5	1.5	8.0	4.4	3.0		2.6
Cobalt	1.3	0.93	0.75	1.7	0.93	0.83	1.1	1.9	0.84		1.1
Copper	7.5	5.4	3.7	9.5	5.4	4.6	11.4	13.2	8.4		11.8
Iron	2280	2270	1500	4300	2490	2190	5270	4200	2100		2370
Lead	2.2	1.5	1.3	2.8	1.6	1.4	12.4	18	11.8		8.4
Magnesium	254	169	183	227	155	159	241	422	266		329
Manganese	192	127	108	304	170	134	42.1	62.5	31.2		52.7
Mercury	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.02	0.02		< MDL
Nickel	2.8	4.1	1.7	2.3	1.3	1.2	3.8	4.4	2.6		3.6
Potassium	54.6	48.6	50.4	54.9	37.7	35.4	70.1	89.8	72.5		79.3
Selenium	0.21	0.32	0.34	0.21	< MDL	< MDL	0.58	0.44	< MDL		0.44
Silver	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL		< MDL
Sodium	18.6	14	14.6	14.9	13.4	13.2	37.3	53.6	38.0		56.5
Thallium	0.38	0.33	< MDL	< MDL	0.4	0.43	0.48	< MDL	< MDL		< MDL
Vanadium	3.4	3.8	1.9	3.9	2.3	2.1	5.5	7.1	4.7		5.0
Zinc	18.7	25.8	10.2	20.9	11.2	11.2	43.4	62	39.5		59.6

Basin Depth Analyte	HS-R 2"-4" mg/kg	HS-R 4"-6" mg/kg	HS BASIN 0"-2" mg/kg	HS BASIN 2"-4" mg/kg	HS BASIN 4"-6" mg/kg	HW BASIN 0"-2" mg/kg	HW BASIN 2"-4" mg/kg	HW BASIN 4"-6" mg/kg	HTE 0"-2" mg/kg
Aluminum	1530	1600	3630	2970	1800	8400	7850	8390	2520
Antimony	0.44	0.58	0.48	0.46	< MDL	1.1	0.78	0.9	0.61
Arsenic	0.34	0.45	1.1	0.96	0.81	1.7	1.8	2.8	0.58
Barium	8.7	8.8	14.1	11.4	6.4	29.3	24.4	25.6	16.0
Beryllium	0.05	0.05	0.09	0.08	0.06	0.22	0.20	0.21	0.09
Cadmium	0.06	0.05	0.13	0.08	0.05	2.9	0.80	1.3	0.30
Calcium	342	269	479	313	224	1320	815	785	2750
Chromium	2.3	2.9	5.6	4.6	3.0	20.2	13.4	17.1	6.8
Cobalt	0.92	1.1	1.8	1.3	0.86	4.4	3.1	3.0	3.1
Copper	9.6	8.6	12.9	10.8	6.1	54.3	22.8	27.1	74.7
Iron	1920	2260	4950	3810	2610	9200	8090	7950	7520
Lead	7.3	9.8	18.2	13.8	6.0	99.6	46.2	70.7	25.5
Magnesium	241	268	602	438	285	1340	1140	966	1680
Manganese	43.7	65.4	66.2	53.3	29.0	68.0	52.6	50.8	48.1
Mercury	< MDL	< MDL	< MDL	< MDL	< MDL	0.48*	0.19*	0.3*	0.15*

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Table 6-18. Metals Analysis of Basin Sediments (concluded).

Basin Depth Analyte	HS-R 2"-4" mg/kg	HS-R 4"-6" mg/kg	HS BASIN 0"-2" mg/kg	HS BASIN 2"-4" mg/kg	HS BASIN 4"-6" mg/kg	HW BASIN 0"-2" mg/kg	HW BASIN 2"-4" mg/kg	HW BASIN 4"-6" mg/kg	HT-E 0"-2" mg/kg
Nickel	3.0	3.1	4.7	3.9	2.4	17.5*	9.6	12.1	6.2
Potassium	66.0	75.6	155	125	96.3	371	283	279	123
Selenium	< MDL	< MDL	0.47	0.48	< MDL	0.83	0.96	0.9	0.35
Silver	< MDL	< MDL	< MDL	< MDL	< MDL	0.25	0.23	0.12	0.14
Sodium	42.2	40.2	47.9	35.9	29.1	109	87.2	65.7	59.3
Thallium	0.44	< MDL	0.76	0.44	0.55	< MDL	0.62	0.65	0.64
Vanadium	4.2	4.5	9.9	7.8	4.9	32.1	23	24.5	7.9
Zinc	46.7	54.7	69.6	59.1	35.4	256	132	128	65.6

Basin Depth Analyte	HT-E 2"-4" mg/kg	HT-E 4"-6" mg/kg	HP-E 0"-2" mg/kg	HP-E 2"-4" mg/kg	HP-E 4"-6" mg/kg	HP-W 0"-2" mg/kg	HP-W 2"-4" mg/kg	HP-W 4"-6" mg/kg	HZ ¹ 2"-4" mg/kg
Aluminum	5450	7350	767	450	516	853	685	857	1514
Antimony	0.93	0.87	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Arsenic	1.3	4.2	1.6	0.6	1.2	1.6	1.4	0.67	0.85
Barium	29.9	52	27.2	15.9	16.7	71.8	41.4	21.7	4.3
Beryllium	0.19	0.26	0.06	0.02	0.03	0.05	0.04	0.04	0.06
Cadmium	0.58	1.4	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Calcium	1660	2400	136	98	99.1	235	220	135	122
Chromium	15.8	20.8	2.2	0.97	1.2	3.0	2.5	1.8	2.5
Cobalt	5.2	6.6	1.4	0.85	0.91	3.0	1.7	1.2	0.99
Copper	207*	535**	22.4	10.5	14.6	32.9	22.6	11	2.07
Iron	7090	9110	3600	1620	1880	6130	4030	2460	2560
Lead	70.9	130*	1.7	0.92	1.4	2.1	1.6	1.4	1.92
Magnesium	1380	1200	161	104	127	254	209	284	306
Manganese	48.3	43	333	204	223	765	415	202	43.0
Mercury	0.15*	0.22*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Nickel	9.9	15.6*	1.6	1.2	1.4	2.4	1.7	1.5	1.50
Potassium	235	223	49.8	31	45.7	69.4	59.1	66.3	116
Selenium	0.83	2.3	0.66	0.58	0.45	0.69	0.56	0.42	< MDL
Silver	0.77	2.3	0.2	0.09	0.22	0.2	0.22	0.21	< MDL
Sodium	84.4	105	14.0	10.9	11.8	13.5	14.2	17.1	22.5
Thallium	0.67	0.62	0.32	< MDL	< MDL	< MDL	0.35	< MDL	0.45
Vanadium	15.7	25.5	2.7	1.5	1.7	3.5	2.6	2.5	4.1
Zinc	109	195	7.3	4.8	4.5	6.3	4.7	5.9	5.3

Notes:

MDL = Minimum Detection Limit

¹ = HZ is a new basin installed in 2002. Values are averaged from ten samples taken as baseline information.

* = Values above Suffolk County cleanup objectives but below action levels.

** = Values above Suffolk County action levels.

Table 6-19. Radiological Analysis of Basin Sediments.

Location	Depth	Potassium-40 pCi/g	Co-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Actinium-228 pCi/g	Thorium-232 pCi/g
HO-W	0"-2"	3.2 ± 0.6	ND	ND	0.08 ± 0.03	0.32 ± 0.06	0.14 ± 0.08	0.27 ± 0.07	ND
HO-W	2"-4"	3.4 ± 1.5	ND	ND	0.23 ± 0.13	0.54 ± 0.21	ND	ND	ND
HO-W	4"-6"	3.0 ± 1.1	ND	0.09 ± 0.07	0.11 ± 0.06	0.24 ± 0.10	ND	ND	ND
HO-E	0"-2"	3.4 ± 0.7	ND	0.04 ± 0.03	0.15 ± 0.04	0.35 ± 0.07	0.27 ± 0.10	0.43 ± 0.09	0.46 ± 0.20
HO-E	2"-4"	3.1 ± 0.6	ND	ND	0.09 ± 0.03	0.29 ± 0.06	0.20 ± 0.06	0.35 ± 0.08	ND
HO-E	4"-6"	3.8 ± 0.7	ND	ND	0.09 ± 0.03	0.26 ± 0.05	0.18 ± 0.05	ND	ND
HS	0"-2"	ND	ND	0.08 ± 0.04	0.08 ± 0.08	ND	ND	ND	ND
HS	2"-4"	2.7 ± 0.5	ND	0.06 ± 0.02	0.08 ± 0.03	0.25 ± 0.05	0.22 ± 0.05	0.28 ± 0.06	0.24 ± 0.12
HS	4"-6"	2.5 ± 1.3	ND	ND	ND	0.25 ± 0.20	ND	ND	ND
HS-R	0"-2"	2.8 ± 1.1	ND	ND	ND	0.18 ± 0.10	ND	ND	ND
HS-R	2"-4"	3.4 ± 0.7	ND	0.05 ± 0.03	0.12 ± 0.03	0.25 ± 0.06	0.21 ± 0.09	0.33 ± 0.08	ND
HS-R	4"-6"	2.3 ± 0.5	ND	0.05 ± 0.02	0.09 ± 0.03	0.22 ± 0.05	0.21 ± 0.05	0.27 ± 0.08	ND
HS BASIN	0"-2"	3.3 ± 0.6	ND	0.09 ± 0.03	0.15 ± 0.04	0.39 ± 0.07	0.29 ± 0.05	0.41 ± 0.08	0.49 ± 0.19
HS BASIN	2"-4"	6.6 ± 1.1	ND	0.08 ± 0.03	0.12 ± 0.03	0.36 ± 0.06	0.29 ± 0.06	0.29 ± 0.07	0.50 ± 0.17
HS BASIN	4"-6"	ND	ND	0.05 ± 0.03	ND	ND	ND	ND	ND
HW BASIN	0"-2"	4.7 ± 0.8	ND	0.30 ± 0.06	0.19 ± 0.04	0.57 ± 0.09	0.36 ± 0.06	0.56 ± 0.09	0.60 ± 0.23
HW BASIN	2"-4"	9.4 ± 2.3	ND	ND	0.54 ± 0.21	1.52 ± 0.38	0.80 ± 0.27	ND	1.20 ± 0.96
HW BASIN	4"-6"	5.7 ± 1.6	ND	0.37 ± 0.12	0.27 ± 0.11	0.80 ± 0.17	0.51 ± 0.17	ND	ND
HT-E	0"-2"	4.3 ± 0.8	ND	0.08 ± 0.04	0.14 ± 0.04	0.52 ± 0.09	0.35 ± 0.12	0.52 ± 0.10	ND
HT-E	2"-4"	4.3 ± 0.8	ND	0.17 ± 0.04	0.17 ± 0.04	0.48 ± 0.08	0.43 ± 0.07	0.50 ± 0.09	0.55 ± 0.24
HT-E	4"-6"	5.2 ± 1.6	ND	0.87 ± 0.29	0.34 ± 0.17	0.88 ± 0.32	0.50 ± 0.25	ND	ND
HT-W	0"-2"	3.7 ± 0.7	ND	0.37 ± 0.07	0.10 ± 0.04	0.40 ± 0.07	0.21 ± 0.09	0.38 ± 0.07	0.39 ± 0.20
HT-W	2"-4"	3.4 ± 0.7	ND	0.29 ± 0.06	0.15 ± 0.04	0.49 ± 0.08	0.28 ± 0.10	0.51 ± 0.08	0.51 ± 0.24
HT-W	4"-6"	1.9 ± 1.0	ND	0.31 ± 0.07	ND	0.36 ± 0.15	0.34 ± 0.21	ND	ND
HP-E	0"-2"	1.4 ± 0.9	ND	ND	0.13 ± 0.10	0.38 ± 0.14	ND	ND	ND
HP-E	2"-4"	2.0 ± 0.5	ND	ND	0.09 ± 0.03	0.23 ± 0.05	0.19 ± 0.09	ND	ND
HP-E	4"-6"	1.9 ± 0.4	ND	ND	0.08 ± 0.03	0.17 ± 0.05	0.15 ± 0.05	ND	ND
HP-W	0"-2"	3.1 ± 0.6	ND	ND	0.17 ± 0.04	0.51 ± 0.08	0.31 ± 0.06	0.56 ± 0.09	0.49 ± 0.19
HP-W	2"-4"	5.0 ± 0.9	ND	ND	0.12 ± 0.04	0.39 ± 0.07	0.19 ± 0.05	0.37 ± 0.08	0.44 ± 0.19
HP-W	4"-6"	ND	ND	ND	ND	ND	ND	ND	ND
HN	0"-2"	2.1 ± 0.4	0.06 ± 0.01	0.04 ± 0.02	0.12 ± 0.03	0.39 ± 0.07	0.23 ± 0.05	ND	0.44 ± 0.18
HN	2"-4"	2.3 ± 0.5	0.07 ± 0.02	0.06 ± 0.03	0.13 ± 0.03	0.36 ± 0.07	0.23 ± 0.05	0.39 ± 0.08	0.49 ± 0.20
HN	4"-6"	ND	ND	0.05 ± 0.03	ND	ND	ND	0.27 ± 0.23	ND
HN-N	0"-2"	2.8 ± 0.5	0.03 ± 0.01	0.07 ± 0.02	0.12 ± 0.03	0.33 ± 0.06	0.24 ± 0.05	0.35 ± 0.07	0.28 ± 0.14
HN-N	2"-4"	4.1 ± 1.5	ND	ND	0.32 ± 0.14	0.53 ± 0.21	ND	ND	ND

(continued on next page)

Table 6-19. Radiological Analysis of Basin Sediments (concluded).

Location	Depth	Potassium-40 pCi/g	Co-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Actinium-228 pCi/g	Thorium-232 pCi/g
HN-N	4"-6"	3.2 ± 1.1	ND	ND	0.22 ± 0.08	0.38 ± 0.13	0.32 ± 0.14	ND	1.10 ± 0.57
HN-M	0"-2"	3.4 ± 0.7	0.05 ± 0.02	0.12 ± 0.03	0.13 ± 0.04	0.40 ± 0.07	0.26 ± 0.07	0.47 ± 0.10	0.52 ± 0.23
HN-M	2"-4"	4.1 ± 0.8	ND	0.04 ± 0.02	0.14 ± 0.04	ND	ND	0.38 ± 0.09	ND
HN-M	4"-6"	1.4 ± 0.9	ND	ND	ND	ND	ND	ND	ND
HN-S	0"-2"	4.4 ± 0.8	0.07 ± 0.02	0.13 ± 0.03	0.15 ± 0.04	0.41 ± 0.07	0.30 ± 0.09	0.37 ± 0.08	0.38 ± 0.18
HN-S	2"-4"	3.0 ± 0.6	ND	ND	0.12 ± 0.04	0.34 ± 0.07	0.18 ± 0.11	ND	ND
HN-S	4"-6"	2.8 ± 0.6	ND	ND	0.14 ± 0.04	ND	ND	ND	ND
HX-E	0"-2"	2.2 ± 0.5	ND	ND	0.12 ± 0.04	0.29 ± 0.05	0.22 ± 0.05	ND	ND
HX-E	2"-4"	2.0 ± 0.4	ND	ND	0.08 ± 0.03	0.27 ± 0.05	0.20 ± 0.05	0.26 ± 0.06	0.46 ± 0.16
HX-E	4"-6"	ND	ND	ND	ND	ND	ND	ND	ND
HX-W	0"-2"	2.6 ± 0.5	ND	0.02 ± 0.02	0.15 ± 0.04	0.43 ± 0.07	0.27 ± 0.10	0.51 ± 0.08	0.58 ± 0.15
HX-W	2"-4"	3.3 ± 0.6	ND	ND	0.15 ± 0.05	0.40 ± 0.08	0.31 ± 0.07	0.56 ± 0.10	0.70 ± 0.26
HX-W	4"-6"	3.3 ± 0.6	ND	ND	0.19 ± 0.04	ND	ND	0.42 ± 0.10	ND
HZ*	2"-4"	3.0 ± 3.0	ND	ND	0.11 ± 0.15	0.4 ± 0.4	0.25 ± 0.26	0.33 ± 0.16	0.45 ± 0.27

Notes:

ND = Not Detected

* HZ is a new basin installed in 2002. Results are baseline information averaged from 10 samples across the bottom of the basin.

All values are shown with a 95% confidence interval.

6.9 CULTURAL RESOURCE ACTIVITIES

The Cultural Resource Management Program is being developed to ensure that the Laboratory fully complies with the numerous cultural resource requirements. BNL is working toward meeting an accelerated schedule for development of the BNL Cultural Resources Management Plan (CRMP), including having a draft plan submitted to DOE by December 2003. Development of a formal CRMP will guide the management of all of BNL's cultural resources. Along with achieving compliance with applicable regulations, one of the major goals of the Cultural Resource Management Program is to fully assess both known and potential cultural resources. The range of BNL cultural resources potentially includes buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship will be developed and implemented. Achieving these goals will ensure that the contributions BNL and the BNL site have made to the national history and culture are documented and available for interpretation.

BNL has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I training trenches associated with Camp Upton.

As part of developing the management plan, several projects were initiated in 2002. In one project, BNL contracted with an outside firm to evaluate the on-site WWI features for National Register eligibility and preservation or restoration concepts. This project included mapping the training trenches and many of the remaining Camp Upton footprint foundations. Ten separate trench and three foundation complexes were surveyed as part of this effort. Figure

Figure 6-7. Typical World War I Trench Configurations.

Figure 6-8. WWI Training Trench at Camp Upton, Circa 1918.

Figure 6-9. WWI Training Trench As It Appears on the BNL Site Today.

6-7 illustrates an example of how this project provides insight into one of BNL's most unique cultural resources, the World War I training trenches.

Exhibit A of Figure 6-7 shows the result of mapping Trench 6. An overhead view was produced that provides a complete perspective of how this particular trench network was arranged. Exhibits B and C present two diagrams of trench construction methods, from British, and American army field manuals. When the Trench 6 layout is compared to the two field manual methods, similarities become quite apparent.

Figure 6-8 is a photograph from WWI Camp Upton showing a trench warfare training exercise, circa 1918. Figure 6-9 is a recent photograph depicting how the trenches appear today, approximately 85 years later. The BNL trenches may be the only existing examples of World War I earthworks in the United States.

Another contracted project that produced valuable results was the inventory and cataloging of the Camp Upton Museum Collection according to museum standards. This completed project includes more than 2,040 items cataloged and labeled; items organized and stored using standard museum methods and materials; a database established with accession, collection, and photo tables; forms and a procedure created for an

accession and collection records system; and each item digitally photographed.

BNL continued to develop documentation concerning the BGRR associated with the "Memorandum of Agreement Between BHG and New York State Historic Preservation Office Concerning Decommissioning Project" (Desmarais 2000). An initial draft of the BGRR History Video was completed and a draft version was distributed in December 2002 to DOE for submittal to the New York State Historic Preservation Officer for review and comment. Copies were also distributed internally to other interested BNL parties.

In 2002, BNL also identified the potential remains of two 19th-century home sites located on BNL property. See Chapter 3, Section 3.4, Historic Preservation and Archeology, for additional cultural resource compliance accomplishments performed in 2002. The overall goal of the cultural resource program is to establish processes that assure proper stewardship of the historic resources on the BNL site.

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CHAPTER 6: NATURAL AND CULTURAL RESOURCES

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Groundwater Protection

The Brookhaven National Laboratory Groundwater Protection Management Program is made up of four elements: prevention, monitoring, restoration, and communication. BNL is implementing aggressive pollution prevention measures to protect groundwater resources. BNL's extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. In 2002, BNL collected groundwater samples from 745 monitoring wells during 2,345 individual sampling events. During 2002, seven groundwater remediation systems removed 720 pounds of volatile organic compounds and returned approximately 1.3 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, BNL has removed 3,662 pounds of volatile organic compounds by treating nearly 5.5 billion gallons of groundwater.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

U.S. Department of Energy Order 5400.1, *General Environmental Protection Program*, requires development and implementation of a groundwater protection program. The primary goal of Brookhaven National Laboratory's (BNL) Groundwater Protection Management Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a cost-effective manner that is consistent with federal, state, and local regulations. This program is described in the *BNL Groundwater Protection Management Program Description* document (Paquette et al. 2002). The BNL Groundwater Protection Program consists of four interconnecting elements: 1) preventing pollution of the groundwater, 2) monitoring the effectiveness of engineered and administrative controls at operating facilities and groundwater treatment systems, 3) restoring the environment by cleaning up contaminated soil and groundwater, and 4) communicating with interested parties on groundwater protection issues. BNL is committed to protecting groundwater resources from further chemical and

radionuclide releases, and to remediating existing contaminated groundwater.

7.1.1 Prevention

BNL has conducted a three-phased project to prevent further groundwater contamination from ongoing operations. The first phase was to identify past or current activities with the potential to affect groundwater quality. This effort resulted in the implementation of operational and engineered controls at potential source areas and the installation of 85 new monitoring wells to confirm that these controls are working. The second phase resulted in a Laboratory-wide review of all experiments and industrial-type operations to determine the potential impacts of those activities on the environment and to integrate pollution prevention and waste minimization, resource conservation, and compliance into planning, decision making, and implementation. Finally, phase three was to develop and implement an Environmental Management System (EMS), which was finalized when BNL received ISO 14001 certification in 2001. The continuous improvement aspects of the EMS and ongoing reviews are designed to prevent further pollution of the sole source aquifer underlying the

BNL site and are described in Chapter 2. In addition, as described in Chapter 3, efforts are being made to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater. 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).

7.1.2 Monitoring

BNL's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from historical and current operations and to track cleanup progress. Groundwater monitoring is a means of verifying that protection and restoration efforts are working. Groundwater monitoring is focused in two general areas: 1) Environmental Surveillance (ES), designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) Environmental Restoration (ER) monitoring related to BNL's obligations under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). This monitoring is coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and abandonment of wells. The monitoring program elements have been integrated and include data quality objectives, plans and procedures, sampling and analysis, quality assurance, data management, and the installation, maintenance, and abandonment of wells. These elements were 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 (see Chapter 2 for a discussion of BNL's ER Program). To help manage the restoration effort, 30 separate Areas of Concern (AOC) were grouped into six Operable Units

(OU). Remedial Investigation/Feasibility Studies have been conducted for each OU, and the focus is now on designing and implementing cleanup systems. Contaminant sources (e.g., contaminated soil, underground tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the Interagency Agreement involving the U.S. Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), and DOE.

7.1.4 Communication

BNL's Community Education, Government and Public Affairs Program ensures that BNL communicates with the community in a consistent, timely, and accurate manner. A number of communication mechanisms are in place, such as web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include the Community Advisory Council and the Brookhaven Executive Roundtable. Technical reports summarizing data, evaluations, and program indices are prepared annually. In addition, BNL has developed a *Groundwater Protection Contingency Plan* (BNL 2000) that provides a formal process to communicate off-normal or unusual monitoring results to BNL's management, DOE, regulatory agencies, and other stakeholders in a timely manner.

7.2 GROUNDWATER PROTECTION PERFORMANCE

Since 1998, the BNL Groundwater Protection Management Program has been tracking progress toward eliminating new contamination of the aquifer system. The Laboratory has made significant investments in environmental and groundwater protection since 1998 and is making real progress in achieving its goal of preventing any new groundwater impacts. A "new" groundwater impact is defined as the detection of unusual or off-normal groundwater monitoring results. The *Groundwater Protection Contingency Plan* (BNL 2000) is designed to ensure that appropriate and timely actions are taken if unusual or off-normal results are

Figure 7-1. Groundwater Protection Performance 1998 through 2002.

observed. The contingency plan provides guidelines for evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions.

Since 1998, BNL installed several hundred permanent and temporary monitoring wells as a result of a comprehensive evaluation of known or potential contaminant source areas. Using this enhanced monitoring system, BNL identified 10 new groundwater impacts during 1998 through 2001 (Figure 7-1). No impacts were identified during 2002. It is important to note that five of the 10 identified impacts were determined to be from historical (or “legacy”) contaminant releases. These newly discovered legacy issues include low-level petroleum hydrocarbon contamination in groundwater near the BNL Service Station, tritium near the former U-Line target/beam stop area at the Alternating Gradient Synchrotron (AGS), 1,1,1-trichloroethane (TCA) near Building 830 and the BNL Motor Pool, and higher than expected strontium-90 contamination at the Brookhaven Graphite Research Reactor (BGRR) beneath the belowground ducts.

The five remaining cases were related to active science operations and environmental protection activities. Three small tritium plumes that originated from active experimental areas at the AGS (the g-2 and E-20 Catcher areas) and the Brookhaven Linac Isotope Producer (BLIP) facility were discovered in 1998 and 1999. Activities associated with the Laboratory’s environmental protection programs resulted in two new groundwater impacts. One was the inadvertent release of carbon tetrachloride

during the removal of an underground storage tank, and the second was caused by an unexpected displacement of tritium during an innovative grout injection process designed to protect groundwater quality by stabilizing activated soils at the BLIP facility. In all ten cases, BNL thoroughly investigated the cause of the contamination and took corrective actions as necessary to eliminate or limit the scale of these impacts. BNL will continue efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

7.3 GROUNDWATER MONITORING

Groundwater monitoring program elements include installing monitoring wells; planning and scheduling; developing and following quality assurance measures; collecting and analyzing samples; verifying, validating, and interpreting data; and reporting. Monitoring wells (which are not used for the drinking water supply) are used to evaluate BNL’s progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater entering and leaving the BNL site.

BNL monitors research and support facilities where there is a potential for environmental impact and areas where past waste handling practices or accidental spills have already degraded groundwater quality. The groundwater beneath the BNL site is classified by New York State as Class GA groundwater, defined as a source of potable water supply and suitable for drinking. Federal drinking water standards, New York State Drinking Water

Standards (DWS), and New York State Ambient Water Quality Standards (AWQS) for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and nonradiological contamination by comparing analytical results to New York State and DOE reference levels and background water quality levels. Nonradiological analytical results from groundwater samples collected from surveillance wells are usually compared to AWQS. Radiological data are compared to DWS (for tritium, gross beta, and strontium-90), AWQS (for gross alpha and radium-226/228), and Safe Drinking Water Act (SDWA)/DOE Derived Concentration Guides (for determining the 4-mrem dose for other beta/gamma-emitting radionuclides). Contaminant concentrations that are below these standards are also compared to background values to evaluate the potential effects from facility operations. The detection of low concentrations of facility-specific volatile organic compounds (VOCs) or radionuclides may provide important early indications of a contaminant release and allow for timely identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 780 on-site and off-site surveillance wells (see Figure 7-2). In addition to water quality assessments, water levels are routinely measured in more than 875 on-site and off-site wells to assess variations in directions and velocities of groundwater flow. Groundwater flow directions in the vicinity of BNL are shown in Figure 7-3.

Among the active and inactive facilities that have groundwater monitoring programs are the Sewage Treatment Plant (STP)/Peconic River area, Biology Agricultural Fields, Former Waste Management Facility (FWMF), new Waste Management Facility (WMF), two former landfill areas, Central Steam Facility/Major Petroleum Facility (CSF/MPF), AGS, Waste Concentration Facility (WCF), Supply and Material, and several other smaller facilities. As the result of detailed groundwater investigations conducted over the past 15 years, six significant VOC plumes and eight radionuclide plumes have been identified (Figures 7-4 and 7-5).

7.4 SUPPLEMENTAL MONITORING OF POTABLE AND PROCESS SUPPLY WELLS

As discussed in Chapter 3, BNL is a public water purveyor and maintains water supply wells and associated treatment facilities for the distribution of potable water on the site. The BNL potable and cooling water supply well network consists of six wells (wells 4, 6, 7, 10, 11, and 12). A seventh well, number 9, is a small capacity well that supplies process water to a facility where biological research on fish is conducted. This well is not routinely monitored. The locations of the supply wells are shown in Figure 7-3.

The quality of the BNL potable water supply is monitored as required by the SDWA, and the analytical results are reported to the Suffolk County Department of Health Services. As required by the SDWA, BNL also prepares an annual *Water Quality Consumer Confidence Report* (BNL 2003b) that is distributed to all employees and guests. Results of the SDWA-required monitoring are described in Chapter 3.

All of BNL's supply wells are screened within the Upper Glacial aquifer. Because of the proximity of the potable supply wells to known or suspected groundwater contamination plumes and source areas, BNL conducts a supplemental potable supply well monitoring program. Supplemental monitoring of the potable and process supply wells in 2002 included testing for VOCs, anions, metals, and radiological parameters. During 2002, the BNL potable water system fully complied with all primary drinking water requirements. To better understand the geographical source of BNL's drinking water and to identify potential sources of contamination within these geographical areas, BNL prepared the report titled *Source Water Assessment for Drinking Water Supply Wells* (Bennett et al. 2000). The source water assessment is designed to serve as a management tool in further protecting the sole source aquifer system underlying the BNL site.

7.4.1 Radiological Results

Samples collected from supply wells 4, 6, 7, 11, and 12 were analyzed for gross alpha and gross beta activity, tritium, and strontium-90; the results are listed in Table 7-1. (Note: Well 10 was

Figure 7-2. Locations of BNL Groundwater Monitoring Wells.

Table 7-1. Potable Well Radiological Analytical Results.

Potable Well ID ^(a)		Gross Alpha	Gross Beta	Tritium	Sr-90
4 (FD)	N	2	2	3	2
	Max.	< 0.58	< 1.69	< 286	< 1.00
	Avg.	0.24 ± 0.12	1.09 ± 0.54	-20 ± 151	0.06 ± 0.08
6 (FF)	N	4	4	8	4
	Max.	1.03±	0.49 < 1.69	< 353	< 1.00
	Avg.	0.69 ± 0.26	0.59 ± 0.48	13 ± 30	0.27 ± 0.14
7 (FG)	N	7	7	11	7
	Max.	2.86 ± 0.64	1.86 ± 0.96	< 353	< 1.00
	Avg.	0.86 ± 0.66	0.74 ± 0.55	16 ± 67	0.21 ± 0.10
11 (FP)	N	4	4	8	4
	Max.	0.87 ± 0.43	< 2.15	< 287	< 1.00
	Avg.	0.58 ± 0.25	1.27 ± 0.76	25 ± 74	0.12 ± 0.23
12 (FQ)	N	3	3	6	3
	Max.	0.94 ± 0.48	< 2.15	< 345	< 1.00
	Avg.	0.62 ± 0.27	1.39 ± 0.15	-1 ± 88	0.22 ± 0.23
Tap Water ^(b)	N	249	249	249	NS
Bldg 490	Max.	8.10 ± 3.07	11.56 ± 4.30	< 355	
FN)	Avg.	3.33 ± 0.18	4.27 ± 0.34	3 ± 15	
SDWA Limit		15 ^(c)	50 ^(d)	20,000	8

Notes:

All values shown with 95% confidence interval.

No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 2002.

Potable Well #10 was shut down most of the year due to its possible effect on groundwater flow directions in the vicinity of the g-2 Tritium Plume.

N = Number of samples

NS = Not sampled for this analyte

^(a)Historic ID Shown in parentheses.^(b)The gross activity values for FN are elevated compared with the other potable wells due to differences in the analytical procedure (smaller sample volumes and shorter counting times) used to obtain the activity values.^(c)Excluding radon and uranium.^(d)Screening level above which analysis for individual radionuclides is required.

used infrequently during 2002, and was only sampled under the compliance monitoring program described in Chapter 3.) In addition, tap water samples were collected daily from Building 490, the BNL Analytical Services Laboratory (ASL), and analyzed for gross alpha and beta activity and tritium. Nuclide-specific gamma spectroscopy was also performed for potable well samples, supplementing the requirements of the SDWA, which does not require this analysis unless gross beta activity exceeds 50 pCi/L. Average gross activity and tritium levels in the potable water wells were consistent with those of typical background water samples. Neither strontium-90 nor any other man-made gamma-emitting radionuclides were observed above the minimum detection limit (MDL) in any of the potable water samples.

7.4.2 Nonradiological Results

Samples collected in May and August from supply wells 6, 7, 11 and, 12 were analyzed for

VOCs (following EPA Standard Method 624). Method 624 tests for 38 organic compounds, including halogenated and aromatic hydrocarbons. The only parameter detected above the MDL was chloroform, found once during the year in wells 7 and 12 at trace levels (< 2 µg/L). The chloroform concentrations were below the ambient water quality standard of 7 µg/L and well below the drinking water standard of 80 µg/L. Samples were also collected one time during the year from wells 6, 7, and 11, and analyzed for metals and anions (Tables 7-2 and 7-3). Iron was the only parameter detected at concentrations greater than the drinking water standards, which is 0.3 mg/L for iron. Iron levels in wells 6 and 7 were 3.3 and 1.2 mg/L, respectively. Because naturally high levels of iron are present in some portions of the Upper Glacial aquifer, water obtained from wells 4, 6, and 7 is treated at the BNL Water Treatment Plant to reduce the iron levels prior to distribution.

Table 7-2. Potable Water Supply Wells Water Quality Data.

Potable Well ID ^(a)		Chlorides	Sulfates	Nitrate as N
4 (FD) ^(b)	N			
	Value	NS	NS	NS
6 (FF)	N	1	1	1
	Value	23.1	10.1	1
7 (FG)	N	1	1	1
	Value	22.1	12.1	1
10 (FO) ^(b)	N	NS	NS	NS
	Value			
11 (FP)	N	1	1	1
	Value	20.9	13	1
12 (FQ) ^(b)	N	NS	NS	NS
	Value			
NYS DWS		250	250	10
Typical MDL		4	4	1

Notes:

See Figure 7-3 for location of wells.

N = Number of Samples

NYS DWS = New York State Drinking Water Standard

MDL = Minimum Detection Limit

NS = Not sampled for this analyte

^(a)Historic ID shown in parentheses.^(b)Well was shut down at time of annual sampling for anions.

7.5 ENVIRONMENTAL SURVEILLANCE PROGRAM

BNL's Environmental Surveillance Program includes groundwater monitoring at active research facilities (e.g., research reactor areas, accelerator beam stop and target areas) and support facilities (e.g., fuel storage facilities). During 2002, 130 groundwater surveillance wells were monitored during 280 individual sampling events. Results for these programs are summarized below. Detailed descriptions and maps related to groundwater monitoring in the Environmental Surveillance Monitoring Program can be found in the *2002 BNL Groundwater Status Report* (BNL 2003c).

7.5.1 Research Facilities

7.5.1.1 Alternating Gradient Synchrotron Complex

Activated soils have been created near a number of AGS experimental areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. Radionuclides, such as tritium and sodium-22, have been produced by the interaction of these

secondary particles with the soils that surround the experimental areas. Furthermore, historical surface spills and discharges of solvents to cesspools and recharge basins near the AGS have contaminated soil and groundwater with VOCs. VOC contamination is monitored under the ER Program's OU III Central Areas Project (see Section 7.6.3).

During 2002, 49 groundwater wells were monitored to evaluate groundwater quality near potential soil activation areas within the AGS Complex (e.g., Building 912, AGS Booster Beam Stop, 914 Transfer Tunnel, g-2 experimental area, E-20 Catcher, former U-Line Target, and the new J-10 Beam Stop). Following the installation of 39 new wells in the AGS area during 1999–2000, BNL detected three tritium plumes (i.e., groundwater with tritium concentrations greater than the drinking water standard of 20,000 pCi/L). These plumes originated from activated soil shielding at the g-2 experimental area, the former U-Line area, and the Former E-20 Catcher region of the AGS Complex. Following these discoveries, BNL installed impermeable caps over the soil activation areas to prevent rainwater from infiltrating the soil and leaching tritium into the groundwater. Monitoring conducted during 2001 and 2002 showed that these caps have effectively reduced tritium concentrations to below the drinking water standards at the former U-Line and former E-20 Catcher areas. However, tritium continues to be detected at concentrations above the drinking water standard downgradient of the g-2 facility (Figure 7-6).

g-2 Experimental Area. A groundwater investigation conducted during November and December 1999 revealed a narrow tritium plume approximately 250 to 300 feet long, with a maximum tritium concentration of 1,800,000 pCi/L and sodium-22 concentration of 60 pCi/L. (Note: The drinking water standard for sodium-22 is 400 pCi/L.) The source of the contamination was determined to be activated soil shielding adjacent to the g-2 experiment's VQ-12 Magnet. In December 1999, an impermeable coated concrete cap was installed over the soil activation area to prevent rainwater infiltration and the continued leaching of radionuclides out of the soil

and into the groundwater. In September 2000, the activated soil shielding and the associated tritium plume were designated as “Sub-Area of Concern 16T.” Following this designation, DOE agreed to prepare an Engineering Evaluation/Cost Analysis (EE/CA) to evaluate the adequacy of the corrective actions taken to date, and the need for further actions. During 2002, BNL conducted additional characterization work designed to obtain the necessary plume concentration and position data required to prepare the EE/CA.

Since its initial detection in 1999, the leading edge of the tritium plume has migrated to an area just south of the Waste Concentration Facility (Figure 7-6). Samples collected during 2002 from wells located approximately 150 feet downgradient of the VQ12 area indicate that tritium continues to be released to the groundwater. The highest tritium concentrations were measured in July 2002, when 3,440,000 pCi/L was detected in a sample from monitoring well 054-07 (located immediately west of Building 912A). In the area to the east of Building 912, the maximum tritium concentration observed during 2002 was 58,900 pCi/L in well 065-122. The two segments of the plume shown in Figure 7-6 are representative of two distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 prior to the installation of the cap over the VQ12 area, and the second slug is related to tritium released in 2001–2002.

Inspections of the cap and review of its design indicate that the cap over the VQ12 area has not failed and is properly positioned. The cap appears to be effective in preventing the infiltration of rainwater into the activated soil-shielding zone. The leading hypothesis at this time is that a natural rise in the water table may have released residual tritium from the unsaturated soil into the groundwater. It is believed that this tritium had migrated close to the water table (in the “vadose zone”) before the cap was put in place in December 1999.

Water levels in the central BNL area in mid-2000 and mid-2001 were near the highest observed in 49 years of record by the US Geological Survey. Once the cap was in place,

Table 7-3. Total Metals Concentration Data for Potable Water Supply Well Samples.

Well ID ^(a)	Ag µg/L	Al µg/L	As µg/L	Ba µg/L	Be µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe mg/L	Hg µg/L	Mn µg/L	Mo µg/L	Ni µg/L	Na mg/L	Pb µg/L	Sb µg/L	Se µg/L	Tl µg/L	V µg/L	Zn µg/L
4 (FD) ^(b)	N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Value																					
6 (FF)	N	<1.0	16.2	<3.0	27.5	<0.7	<1.1	0.8	1.4	12.3	<0.1	86.3	<5.0	3.4	11.6	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
Value																					
7 (FG)	N	<1.0	15.5	<3.0	19.3	<0.7	<1.1	0.5	<1.0	4.6	<0.1	52.3	<5.0	<1.1	12.7	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
Value																					
10 (FO) ^(b)	N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Value																					
11 (FP)	N	<1.0	5.5	<3.0	31.1	<0.7	<1.1	<0.1	<1.0	8.4	<0.1	<2.0	<5.0	<1.1	5.0	<1.3	<0.9	<5.0	<0.7	<5.5	<4.0
Value																					
12 (FQ) ^(b)	N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Value																					
NYSDWS	100	SNS	50	2000	4	5	SNS	100	1300	0.3	2	300	SNS	SNS	SNS	15	6	50	2	SNS	5000
Typical MDL	1.0	2.2	3.0	1.8	0.7	1.1	0.1	1.0	2.0	0.08	0.1	5.0	2.0	1.1	1.0	1.3	0.9	5.0	0.7	5.5	4.0

Notes:

See Figure 7-3 for well locations.

MDL = Minimum Detection Limit

NS = Not sampled for this analyte

NYSDWS = New York State Drinking Water Standard

SNS = Drinking Water Standard not specified

^(a)Historic ID shown in parentheses.

^(b)Well was shut down at time of annual sampling for metals.

the lack of additional rainwater infiltration kept the tritium in the vadose zone from migrating into the groundwater until the significant rise in the water table mobilized it. There appears to be good correlation between high tritium concentrations detected in monitoring wells immediately downgradient of VQ12, and the groundwater table elevation about one year prior to the sampling. The groundwater travel time from beneath the source to the monitoring wells is about one year.

Former E-20 Catcher. During 1999–2000, tritium and sodium-22 were detected at concentrations above their applicable drinking water standards in wells approximately 100 feet downgradient of the former E-20 Catcher. The location of the E-20 Catcher is shown in Figure 7-6. The highest levels of tritium (40,400 pCi/L) and sodium-22 (704 pCi/L) were found in temporary well 064-65. In April 2000, a temporary impermeable cap was installed over the E-20 Catcher soil activation area to prevent rainwater infiltration and the continued leaching of radionuclides out of the soil and into groundwater. A permanent cap was constructed by October 2000.

During 2001, all tritium and sodium-22 concentrations were found to be well below drinking water standards, with a maximum tritium concentration of 2,070 pCi/L and a maximum sodium-22 concentration of 163 pCi/L. Measurements for tritium during 2002 indicated continued reduction in tritium concentrations, with a maximum concentration of 774 pCi/L detected in well 064-80. The reduction in tritium and sodium-22 concentrations since the impermeable cap was constructed indicates that the cap has been effective in preventing additional rainwater infiltration into the activated soil that surrounds that portion of the AGS tunnel.

Former U-Line Target and Stop Areas. In 1999, BNL installed new monitoring wells downgradient of the former U-Line target area (Figure 7-6) to evaluate whether rainwater infiltration through residual activated soil shielding was affecting groundwater quality. Subsequent monitoring found low levels of tritium and sodium-22, but at concentrations well below the applicable drinking water standards. In

early 2000, BNL installed four Geoprobe™ wells downgradient of the former U-Line beam stop, which is approximately 200 feet north of the target area. Tritium was detected at concentrations up to 71,600 pCi/L. Sodium-22 was not detected in any of the samples. In May 2000, a temporary impermeable cap was installed over the U-Line stop soil activation area. By October 2000, a permanent cap was constructed and two additional permanent wells were installed to provide improved long-term monitoring of this source area.

During 2002, low levels of tritium continued to be detected in wells downgradient of the former U-Line target and stop areas, but at concentrations below drinking water standards. The highest tritium concentration during 2002 was 7,450 pCi/L, detected approximately 200 feet downgradient of the target area, in well 054-129. The highest concentration downgradient of the beam stop area was 5,650 pCi/L, detected in well 054-168. Low-level contamination from the former U-Line area reaches to well 055-14, approximately 800 feet downgradient of the target area, where a maximum tritium concentration of 772 pCi/L was observed in late 2002.

Although low levels of tritium continue to be detected in groundwater downgradient of the former U-Line target, these concentrations are well below drinking water standards. Furthermore, the significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soils surrounding the beam stop.

7.5.1.2 Brookhaven Linac Isotope Producer

The BLIP facility is at the southern end of the Linear Accelerator (Figure 7-6). When the BLIP is operating, the Linear Accelerator (Linac) delivers a beam of protons onto a series of targets within the BLIP target vessel. During irradiation, activation of the soil immediately outside of the vessel occurs, due to the creation of secondary particles produced at the target.

In February 1998, elevated levels of tritium (52,000 pCi/L) and sodium-22 (151 pCi/L) were detected in wells downgradient of the BLIP. To prevent rainwater from infiltrating the activated

soil below the building, the BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive coated concrete cap was installed on three sides of the building. Groundwater monitoring data collected from January 1999 to July 2000 indicated that these corrective actions were highly effective in preventing the release of tritium and sodium-22 from the activated soil surrounding the BLIP target vessel.

In June 2000, BNL took an additional protective measure by using an innovative silica grouting technique to reduce the permeability of the activated soil. Soon after the activated soil was treated with the silica grout injection process, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples. In early July 2000, samples collected from wells located approximately 40 feet downgradient of the BLIP contained tritium up to 5,700 pCi/L. By October 2000, tritium concentrations increased to 56,500 pCi/L. In accordance with the *BNL Groundwater Protection Contingency Plan* (BNL 2000), BNL and DOE notified the regulatory agencies of this situation and increased the sampling frequency for the wells. An evaluation of the grouting process suggested that it displaced residual activated pore water that was located in the soil near the target vessel. The maximum sodium-22 concentration was 299 pCi/L in well 064-67, which is below the 400 pCi/L drinking water standard. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard in the wells immediately downgradient of the BLIP. Concurrently, as the slug of tritium migrated downgradient of the BLIP, concentrations in well 064-50 increased to 20,000 pCi/L by December 2000. This well is approximately 150 feet downgradient of the BLIP.

During 2001-2002, tritium concentrations in wells located 40 feet downgradient of the BLIP did not exceed the 20,000 pCi/L drinking water standard. During 2002, the maximum tritium concentration was 15,100 pCi/L, detected in well 064-67. Tritium concentrations in well 064-50 reached a maximum of 44,100 pCi/L in April 2002, then declined to less than 5,000 pCi/L by

July 2002. Although the grouting process had a short-term impact on groundwater quality, it is believed that the process will provide long-term benefits in reducing the permeability of the contaminated soil shielding. Information on the potential for displacing residual pore water will be used to improve this innovative grouting technology.

7.5.1.3 Relativistic Heavy Ion Collider

Within the RHIC facility, there are three areas where low levels of radionuclides could be produced in the soil outside of the collider tunnel. The first area contains two beam stops that are located at the 10 o'clock position of the ring, the second contains two collimators that are located at the 8 o'clock region, and the third is a beam stop located at the 6 o'clock position. Secondary particles created at the internal beam stop and collimator areas have the potential to activate the soil immediately surrounding those areas. Even though the predicted soil activation is expected to be very small, BNL installed impermeable caps over these areas as a precautionary measure. Thirteen monitoring wells are used to provide a means of verifying that the impermeable caps, and the operational controls designed into the RHIC beam stops and collimators, are effective in protecting groundwater quality.

Groundwater samples were collected from the 13 RHIC monitoring wells on a semi-annual schedule during 2002. Surface water samples were also collected from the Peconic River both upstream and downstream of the beam stop area to verify that potential tritium in groundwater is not discharged to the river during high water table conditions. As in previous years, no tritium was detected in any of the groundwater or surface water samples.

7.5.1.4 Brookhaven Medical Research Reactor

During a 1997 evaluation of groundwater quality near the BMRR, low levels of tritium (up to 11,800 pCi/L) were detected in the groundwater downgradient of the reactor building. No other reactor-related radionuclides were detected in the groundwater. After inspecting the facility and reviewing historical records, BNL concluded that the tritium might have originated

from past discharges of small amounts of BMRR primary cooling water to a basement floor drain and sump system that leaked. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (nonradioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any future accidental releases to underlying soils.

During 2002, tritium concentrations continued to be well below the drinking water standard of 20,000 pCi/L. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 4,680 pCi/L in well 084-27. Compared to the initial monitoring results from 1997, tritium concentrations in groundwater have shown a steady decline.

7.5.1.5 Building 801

In December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the water indicated that it contained cesium-137, strontium-90, and tritium at levels that exceeded drinking water standards. It is believed that the water became contaminated when it came into contact with the basement floor, which contains residual contamination from historical spills. On March 8, 2002, approximately 4,950 gallons of contaminated water were pumped from the basement. Taking into account possible losses due to evaporation, an estimated 1,350 to 2,750 gallons of contaminated water might have leaked into the soils below Building 801. To evaluate the potential impact this release may have on future groundwater quality, BNL initiated monthly monitoring of three existing downgradient monitoring wells and installed a new shallow well closer to the building. Two of the existing wells are screened approximately 10 feet below the water table (wells 065-169 and 065-170), and one well is screened immediately below the water table.

During May through October 2002, these three monitoring wells were monitored monthly for strontium-90, gamma emitting radionuclides (e.g., cesium-137), tritium, gross alpha and gross

beta. Strontium-90 was consistently detected in all three wells. Strontium-90 levels in wells 065-169 and 065-170 were generally less than 2.5 pCi/L. Higher levels of strontium-90 (and associated gross beta levels) were detected in shallower well 065-37. Strontium-90 concentrations in all samples from well 065-37 exceeded the 8 pCi/L drinking water standard, with a maximum concentration of 18.2 pCi/L observed in July 2002. Strontium-90 has been routinely detected in well 065-37 since 1999.

Cesium-137 was not detected in any of the groundwater samples from the Building 801 monitoring wells.

Tritium was not detected in shallow well 065-37. However, a trace level of tritium (389 pCi/L; with an analysis detection limit of 386 pCi/L) was detected in well 065-170, and low levels (<10 pCi/L) of sodium-22 were detected in wells 065-169 and 065-170. The trace levels of tritium and sodium-22 in these deeper wells are probably from source areas in the AGS facility, which is located upgradient of Building 801.

In early October 2002, BNL installed well 065-325 approximately 10 feet south of Building 801. This well is screened within the upper 10 feet of the aquifer to provide improved surveillance of potential releases from the Building 801 basement. The October, November, and December samples from this well had strontium-90 concentrations of 44 pCi/L, 37 pCi/L, and 47.9 pCi/L, respectively. No cesium-137 or tritium was detected in any of the samples from this new well.

Future Monitoring Plans. The strontium-90 concentrations in samples collected during 2002 from shallow groundwater wells downgradient of Building 801 were consistent with values before the Building 801 floodwater release, and cesium-137 has not been detected in any of the groundwater samples. It is estimated that it could take three to eight years for strontium-90, and approximately 100 years for cesium-137, from the Building 801 floodwater release to migrate to the closest downgradient well (065-325). Furthermore, any new groundwater impacts from the 2001 release will be difficult to identify, because the local groundwater was already contaminated with radioactivity from legacy

releases. The Environmental Restoration program is planning additional groundwater characterization efforts to define the extent of legacy strontium-90 contamination sources in the BGRR/Building 801/Pile Fan Sump (PFS) area in the fall of 2003 (see Section 7.6.3.2).

7.5.2 Surveillance Monitoring of Support Facilities

7.5.2.1 Sewage Treatment Plant Area

As described in Chapters 1 and 3, the Sewage Treatment Plant (STP) processes sanitary sewage from BNL facilities. Approximately 15 percent of the treated effluent released to the STP's sand filter beds either evaporates or directly recharges to groundwater; the remaining water is discharged to the Peconic River.

Discharges from the STP are monitored as part of the State Pollutant Discharge Elimination System (SPDES) program. The STP groundwater surveillance program provides an additional means of verifying that current treatment plant operations are not affecting groundwater quality. During 2002, six wells were used to monitor groundwater quality in the filter bed area and three wells were monitored in the holding pond area. Groundwater quality impacts resulting from historical STP discharges are monitored as part of the OU V program, using wells that are at the site boundary and off-site areas (see Section 7.6.5).

Groundwater monitoring results for 2002 indicate that STP operations are not significantly affecting groundwater quality, and that BNL's administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system have been highly effective.

Radionuclides. Radioactivity levels in samples collected from the STP wells were consistent with ambient (background) levels from naturally occurring radionuclides, with the exception of a trace level of tritium (626 pCi/L) detected in one sample from well 039-89. During 2001, tritium was detected in this same well at a concentration of 1,420 pCi/L. This well is downgradient of the holding ponds. Because the ponds have not been used recently to hold tritiated wastewater and the wells are also

downgradient of the filter bed area, it is likely that the tritium originated from past water releases to the filter beds. (See Section 5.2.1 for information related to historical tritium concentrations in STP effluent.)

Volatile Organic Compounds, Metals, and Anions. During 2002, all water quality readings and most metal concentrations were below the applicable AWQS. Sodium was detected at concentrations slightly above the AWQS of 20 mg/L in three filter bed area wells. Wells 039-07, 039-08, and 039-86 had maximum sodium concentrations of 28 mg/L, 32.2 mg/L, and 32.8 mg/L, respectively. Although low levels of nitrates were detected in most filter bed area wells, with a maximum concentration of 8.3 mg/L detected in monitoring well 039-08, these concentrations were below the AWQS of 10 mg/L. No VOCs were detected in any of the monitoring wells.

7.5.2.2 Motor Pool Facility

Building 423 serves as the site Motor Pool, where BNL's fleet vehicles are repaired and refueled. Gasoline is stored in two 8,000-gallon capacity underground storage tanks (USTs), waste oil is stored in one 260-gallon capacity aboveground storage tank, and heating oil is stored in one 3,000-gallon capacity UST. Although the USTs and associated distribution lines conform with Suffolk County Article 12 requirements for secondary containment, leak detection, and high-level alarms, BNL initiated a groundwater monitoring program in 1996 as a means of verifying that groundwater quality is not being affected by current Motor Pool operations.

Groundwater surveillance at the Motor Pool facility during 2002 indicated that releases from historical operations continue to have an impact on groundwater quality in the area. Several activities were conducted to determine that the groundwater contamination came from historical, not current, operations. Monitoring of the leak detection systems, groundwater wells downgradient of the gasoline USTs, and product reconciliation records indicate that the tanks and their associated distribution lines are not leaking. Furthermore, evaluation of vehicle maintenance operations indicates that all waste oils and used

solvents are being properly stored and recycled. Therefore, it is believed that the solvents detected in groundwater originate from historical vehicle maintenance activities at the Motor Pool and are not related to current operations.

Underground Storage Tank Area. During 2002, methyl tertiary butyl ether (MTBE) was the only chemical related to gasoline detected in groundwater downgradient of the UST area. MTBE was detected in the July sample from well 102-06 at a concentration of 3.5 µg/L. The AWQS guidance value for MTBE is 10 µg/L. The solvent 1,1,1-trichloroethane (TCA) was detected in both downgradient wells, but at concentrations below the AWQS of 5 µg/L. The presence of MTBE and TCA could be related to historical parts degreasing operations at the Motor Pool facility. As discussed below, these contaminants are also detected in wells located downgradient of the Motor Pool Building. Wells 102-05 and 102-06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating product (oil floating on top of the groundwater) was observed.

Motor Pool Building. As in previous years, VOCs continue to be detected in all four downgradient wells at concentrations exceeding AWQS. During 2002, TCA was detected in all four wells at concentrations ranging from 4.5 µg/L to 34.5 µg/L, and 1,1-dichloroethane (DCA) was detected in well 102-12 at concentrations up to 6.2 µg/L. The AWQS for TCA and DCA is 5 µg/L. The gasoline additive MTBE was detected in all four wells, with a maximum observed concentration of 40.8 µg/L. The AWQS guidance value for MTBE is 10 µg/L. It is believed that these chemicals originate from historical vehicle maintenance/part degreasing operations.

7.5.2.3 Upton Service Station

Building 630 is a commercial automobile repair and gasoline station for the BNL site. Gasoline is stored in two 8,000-gallon capacity and one 6,000-gallon capacity USTs, and waste oil is stored in one 500-gallon capacity UST. Although the storage tanks and associated distribution lines conform with Suffolk County Article 12 requirements for secondary containment, leak detection, and high-level

alarms, BNL initiated a groundwater monitoring program in 1996 as a means of verifying that groundwater quality is not being affected by current operations.

Groundwater quality in the Service Station area has been impacted by carbon tetrachloride contamination associated with a nearby underground storage tank that was used as part of an experiment conducted in the 1950s. The carbon tetrachloride contamination is being remediated as part of the Laboratory's Environmental Restoration program (see Section 7.6.3.1). During 2002, the maximum carbon tetrachloride concentration observed in this area was 1,940 µg/L, in well 085-16. These concentrations are less than those observed in 2000, when carbon tetrachloride concentrations in these wells approached 4,400 µg/L. The AWQS for carbon tetrachloride is 5 µg/L.

In addition to the carbon tetrachloride contamination described above, groundwater quality has been impacted by a variety of petroleum and solvent-related VOCs that are primarily the result of historical Service Station operations. During the first half of 2000, high levels (>100 µg/L) of petroleum related compounds such as xylene and ethylbenzene were detected in wells 085-17, 085-236, and 085-237. From mid-2000 through mid-2002, individual VOC concentrations generally decreased to less than 10 µg/L. A slight increase in perchloroethylene (PCE) and xylene concentrations was observed in samples collected from well 085-236 in September and December 2002. During this time, PCE reached a maximum of 24.7 µg/L and total xylene concentrations reached a maximum of 46.1 µg/L. The gasoline additive MTBE continues to be detected in wells 085-236 and 085-237. However, MTBE levels decreased from a maximum concentration of 64 µg/L in 2001, to a maximum concentration of 32 µg/L in 2002. The AWQS guidance value for MTBE is 10 µg/L. Monitoring wells 085-17, 085-236, and 085-237 are located downgradient of the southern end of the Service Station building, and it is likely that the PCE and petroleum related chemicals detected in groundwater are due to historical discharges to the former service bay floor drains. Following the 2002 discovery of a hydraulic fluid leak in a vehicle

lift, approximately seven cubic yards of contaminated soil were removed from below the southernmost service bay. End-point samples following cleanup indicated the presence of PCE at 47 µg/Kg. No floating petroleum or semivolatile organic compounds (SVOCs) were detected in the monitoring wells during 2002.

7.5.2.4 Major Petroleum Facility

The Central Steam Facility (CSF, Building 610) supplies steam for heating to all major facilities of the Laboratory through an underground distribution system. The Major Petroleum Facility (MPF) is the storage area for most fuels used at the CSF. Eight shallow Upper Glacial aquifer wells monitor the MPF as part of the licensing requirements for this facility, and are screened across the water table so that potential free product can be detected. Additional surveillance wells are in the nearby CSF area, and are used to monitor groundwater contamination resulting from a 1977 leak of approximately 25,000 gallons of Alternative Liquid Fuel (a mixture of fuel oil and spent solvent). Contaminated soils and groundwater near the 1977 spill underwent active remediation from 1997-2001 (see Section 7.6.4.1).

In accordance with updated license conditions for the MPF, during 2002, groundwater samples were analyzed semi-annually for SVOCs and VOCs, and the wells were tested monthly for the presence of floating petroleum hydrocarbons. During 2002, none of the target compounds associated with fuel oil were detected, and no floating petroleum product was observed. In the April 2002 samples, VOCs were detected in two wells (076-19 and 076-380) at concentrations exceeding the AWQS of 5 µg/L. The compounds detected in well 076-380 were: 1,2-dichloroethene (*total*) at 300 µg/L, tetrachloroethylene (PCE) at 36 µg/L, and trichloroethylene (TCE) at 8.3 µg/L. The compound 1,2-DCE was also detected in well 076-19 at a concentration of 16 µg/L. (Note that 1,2-dichloroethene is a breakdown product of the common degreasing agent PCE.) After these results were received, BNL increased the sampling frequency for well 076-380, as well as several nearby monitoring wells. In May 2002,

1,2-DCE was detected in well 076-185 at a concentration of 26.6 µg/L. This is a shallow well located approximately 350 feet south of well 076-380. During the remainder of the year, 1,2-DCE concentrations in well 076-380 increased to a high of 566 µg/L in June, then steadily decreased to nondetectable levels by October. PCE concentrations also dropped to nondetectable levels by October; however, TCE concentrations increased slightly to 20 µg/L.

Based on an evaluation of groundwater flow directions and modeling, it is likely that the VOC contamination originates from an historical spill near the CSF area. The historical nature of this spill is supported by: 1) degreasing agents such as PCE have not been used at the CSF in many years, 2) PCE has been detected in well 076-19 since the early 1990s, and 3) the presence of 1,2-dichloroethene, which is a breakdown product of PCE. A number of historical spill sites near Building 610 were identified in the late 1990s, and the most contaminated soils were subsequently excavated in accordance with regulatory requirements. In an effort to identify the source of the contamination, BNL will install several temporary wells in early 2003 downgradient of these soil cleanup areas.

7.5.2.5 Waste Management Facility

In 1997, BNL began operating its new Waste Management Facility (WMF), designed and operated in a manner that meets all applicable federal, state, and local environmental protection requirements. Nevertheless, BNL established a voluntary groundwater monitoring program as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls. The WMF is monitored by eight shallow Upper Glacial aquifer wells. Groundwater monitoring results for 2002 were consistent with previous monitoring, and continue to show that WMF operations were not impacting groundwater quality.

Volatile Organic Compounds, Metals, and Anions. In 2002, all water quality and most metals concentrations were below the applicable AWQS. As in past years, sodium was detected at concentrations above the AWQS of 20 mg/L in upgradient well 055-03, at a maximum concen-

tration of 29.5 mg/L. Compared to previous years when low levels of VOCs (1,1,1-trichloroethane and chloroform) were periodically detected in several of the upgradient wells, no VOCs were detected during 2002. Furthermore, the gasoline additive MTBE, which was detected in the February 2001 sample from well 056-22, was not detected in any of the WMF wells during 2002.

Radionuclides. Radioactivity levels in samples collected from the WMF wells were typical of ambient (background) levels. No Laboratory-related radionuclides were detected in the WMF wells during 2002.

7.5.2.6 *Biology Department Greenhouse Area*

The Biology Department facility includes 11 greenhouses where various types of plants are grown for biological research. Eight of the greenhouses have dirt floors and three have concrete floors. Pesticides and fertilizers have been routinely used in the greenhouses. Records indicate that copper sulfate was applied to the dirt floors on an annual basis until the mid-1980s. The pesticide Endosulphan II was detected in soil samples collected from a dry well within Greenhouse 10. Analysis of groundwater samples collected to date does not indicate that greenhouse operations have affected groundwater quality.

In September 2002, the greenhouse area wells were sampled and tested for pesticides, metals, and anions. Pesticides were not detected, and all water quality concentrations were below the applicable AWQS. Sodium was the only metal detected at a concentration above the AWQS of 20 mg/L, with a maximum concentration of 26.8 mg/L in well 084-36. The detection of low levels of sodium is not uncommon in wells within the developed area of the site and could be related to road salting operations.

7.5.2.7 *Shotgun Range*

The BNL Shotgun Range was established in 1974, and is used for trap and skeet target shooting by the Brookhaven Employees Recreation Association. The range is in an isolated, wooded area north of the new Waste Management Facility and consists of an open field that is approximately 200 feet east–west by 400 feet north–south.

From 1974 until 2000, the shotgun shells used at the facility typically contained lead pellets. It is estimated that as many as 30,000 shotgun rounds per year have been used at the range. At an average of 1.125 oz. per round, as much as 2,100 pounds of lead may have been deposited on the surface of the range annually. To prevent additional deposition of lead, in early 2000, BNL implemented a rule that allows only steel shot to be used at the range.

Groundwater monitoring conducted to date does not indicate that Shotgun Range operations are affecting groundwater quality. The groundwater monitoring wells at the Shotgun Range were sampled one time during 2002. All metal concentrations (including lead) were below the applicable AWQS and were consistent with established background levels.

7.5.2.8 *Live Fire Range*

The BNL Live-Fire Range consists of a six-position, 100-yard, bermed, outdoor small arms range located immediately north of the BNL Sewage Treatment Plant's filter bed area. Range operations have been conducted at this site since 1963. The eastern half of the range extends to within 200 feet of the Peconic River. The bullet stop at the range is an earthen berm, and bullets are known to have a typical penetration depth of approximately two to three inches into the berm. The soil of the berm is periodically screened to a depth of approximately one foot. The lead shot recovered during the screening process and the spent brass cartridges are disposed of, off site, by a commercial scrap metal waste handler.

Groundwater monitoring conducted to date does not indicate that range operations are affecting groundwater quality. During 2002, the Live Fire Range wells were sampled one time. All metal concentrations (including lead) were below the applicable AWQS and were consistent with established background levels.

7.6 ENVIRONMENTAL RESTORATION GROUND-WATER MONITORING PROGRAM

The mission of the Environmental Restoration Groundwater Monitoring Program is

to monitor the various contaminant plumes on site and off site, as well as to monitor the progress that the groundwater treatment systems are making toward plume remediation. The information below provides an overview of ER groundwater monitoring and remediation activities for 2002. In this period, a total of 615 groundwater surveillance wells were monitored during 2,065 individual sampling events.

Maps showing the main VOC and radionuclide plumes are provided as Figures 7-4 and 7-5. For each significant contaminant source area and plume described below, specific groundwater contaminant distribution maps are provided. These maps depict the areal extent of contamination and were created by selecting the highest contaminant concentration observed for a given set of wells during a selected sampling period. Detailed monitoring program descriptions, maps, and cross-sections showing the extent of contamination, concentration trend data, as well as the hydrogeology for the BNL site and surrounding areas, are presented in the *2002 BNL Groundwater Status Report* (BNL 2003c).

7.6.1 Background Monitoring

Background groundwater quality for the BNL site was monitored with a network of 10 wells in the northern portion of the site and in off-site areas to the north. The background wells provide information on the composition of groundwater that has not been affected by activities at BNL. These background data are a valuable reference for comparison with groundwater quality data from areas that have been affected. This well network can also provide warning of any contaminants originating from potential sources located upgradient of the BNL site.

Historically, low concentrations of VOCs have been detected in some background wells. During 2002, m/p xylene was detected at a trace level (1.7 µg/L) in well 034-02. Although background samples were not tested for radionuclides during 2002, historical monitoring has demonstrated that radionuclide concentrations are consistent with natural levels.

7.6.2 Operable Unit I

7.6.2.1 Former Landfill, Animal/Chemical Pits, and Glass Holes

The Former Landfill area was initially used by the U.S. Army as a landfill area during World Wars I and II. BNL used the southeast corner of the landfill from 1947 through 1966 for disposal of construction and demolition debris, sewage sludge, chemical and low-level radioactive waste, used equipment, and animal carcasses. From 1960 through 1966, BNL waste, glassware containing chemical and radioactive waste, and animal carcasses containing radioactive tracers were disposed of in shallow pits in an area directly east of the Former Landfill. From 1966 through 1981, BNL disposed of used glassware in shallow pits directly north of these chemical/animal pits. The Former Landfill was capped in 1996 and the Animal/Chemical Pits and Glass Holes were excavated in 1997.

A network of eight monitoring wells monitors the Former Landfill area. This monitoring program is designed in accordance with post-closure operation and maintenance requirements specified in 6 NYCRR Part 360, "Solid Waste Management Facilities." The objective of this program is to verify that the cap effectively prevents the continued leaching of contaminants from the landfill, and to document anticipated long-term improvements to groundwater quality. In addition to these wells, BNL established a separate network of 24 wells to monitor the Animal/Chemical Pits and Glass Holes areas and the downgradient portions of the Former Landfill plume. The downgradient portions of these plumes are currently being monitored as part of the OU III North Street Monitoring Program.

Former Landfill Monitoring Results. The areal extent of VOC contamination from the Former Landfill – Animal/Chemical Pits and Glass Holes area is shown in Figure 7-7. The primary VOCs that are consistently detected in the Former Landfill Monitoring Program wells are TCA, 1,1-DCA, trichloroethylene (TCE), and chloroform. The contaminants of concern for the Former Landfill wells are VOCs and strontium-90. Continued monitoring has shown declining VOC and strontium-90 concentration

trends in downgradient wells, indicating that the landfill cap is performing as planned. A detailed evaluation of VOCs, radionuclides, leachate parameters, metals, and pesticides/PCBs is provided in the *2002 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2003a).

During 2002, VOC concentrations did not exceed the AWQS in any of the Former Landfill area monitoring wells. VOC concentrations have been low in all of the wells over the past five years, with infrequent detections that exceeded the AWQS. TCE and 1,1-DCA were consistently detected at concentrations below the 5 µg/L standard in downgradient wells 097-17, 097-64, 106-02, and 106-30. Trace levels of VOCs have also been occasionally detected in upgradient wells 087-22, 087-72, and 086-42. The trailing edge of the VOC plume emanating from the Former Landfill has migrated south of the monitoring well network (Figure 7-7).

Historically, strontium-90 has been detected in shallow well 097-64, less than 100 feet downgradient of the landfill footprint. Strontium-90 concentrations in this well have been steadily declining since 1998, when it was last detected above the 8 pCi/L drinking water standard, at a concentration of 12 pCi/L. The highest strontium-90 concentration in this well during 2002 was 2.9 pCi/L, in January. The strontium-90 plume has shifted south of wells 097-64 and 106-64, as shown in Figure 7-8.

During 2002, all conventional landfill leachate parameters (e.g., alkalinity, sulfates, chlorides, total nitrogen, nitrates, nitrites, TKN, total dissolved solids, and total suspended solids) were below applicable AWQS. Iron, manganese, aluminum, and thallium were occasionally detected at concentrations above AWQS in three downgradient wells. Sporadic, single detections of iron (0.394 mg/L), aluminum (0.338 mg/L), and thallium (0.0066 mg/L) exceeded water quality standards in several samples from well 106-30. Manganese (up to 1.79 mg/L) was detected in two samples from well 097-277, and thallium (0.005 mg/L) was detected in one sample from well 097-64. The AWQS for iron, manganese, aluminum, and thallium are 0.3 mg/L, 0.3 mg/L, 0.2 mg/L, and 0.0005 mg/L, respectively.

Animal/Chemical Pits and Glass Holes

Monitoring Results. Groundwater samples were obtained from 24 monitoring wells during 2002. Twelve of these wells were installed in 2002 as part of the Chemical/Animal Holes Strontium-90 Pilot System that is designed to determine the feasibility of treating the contaminated groundwater.

Figure 7-8 shows the strontium-90 plume distribution. The highest strontium-90 concentration observed during 2002 was 1,130 pCi/L in well 106-16, which is immediately south of the Animal Pits. This well has historically shown the highest strontium-90 concentrations in this area (see trend plot on Figure 7-8). The sharp increase in strontium-90 in this well appears to be correlated with the excavation of the Animal Pits area in 1997, which may have released additional strontium-90 to the groundwater.

The high concentration segment of the strontium-90 plume, with concentrations greater than 100 pCi/L, extends from approximately 75 feet northwest of well 106-16 to approximately 75 feet south of the Princeton Avenue firebreak road (Figure 7-8). The leading edge of the plume, as defined by the 8 pCi/L drinking water standard, is approximately 240 feet south of this firebreak road. A second, smaller plume occurs south of the Former Landfill. The trailing edge of the plume is estimated to be approximately 80 feet south of the Princeton Avenue firebreak road.

7.6.2.2 Current Landfill

The Current Landfill operated from 1967 through 1990. (Note: This landfill is called the Current Landfill to distinguish it from the older [Former] landfill that closed in 1966.) It was used for disposal of putrescible waste, sludge containing precipitated iron from the Water Treatment Plant, and anaerobic digester sludge from the Sewage Treatment Plant. The latter contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill. As a result, the Current Landfill is a source of groundwater contamination. Permanent closure (capping) of this landfill was completed in November 1995 as part of the ER Program.

Figure 7-8. Former Landfill, Animal/Chemical Pits, and Glass Holes Sr-90 Plumes.

The Current Landfill post-closure groundwater monitoring program consists of a network of 11 monitoring wells adjacent to the landfill in both upgradient and downgradient locations. These wells are monitored quarterly to determine the cap's effectiveness in preventing the continued leaching of contaminants from the landfill, and to document the anticipated long-term improvements to groundwater quality. The monitoring well network was designed in accordance with New York State-specified landfill post-closure operation and maintenance requirements. Data collected to date show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. A detailed evaluation of VOCs, radionuclides, leachate parameters, metals, and pesticides/PCBs is provided in the *2002 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2003a).

Volatile Organic Compounds. The primary VOC that has been consistently detected in wells at the Current Landfill is chloroethane. The highest chloroethane value was 43 µg/L in well 88-109, which is adjacent to the southeast side of the landfill. The peak historical chloroethane concentration in well 088-109 was 560 µg/L in 1998. The extent of the Current Landfill VOC plume is shown in Figure 7-7.

Radionuclides. As in previous years, low levels of tritium and strontium-90 were detected in Current Landfill monitoring wells during 2002, but at concentrations well below their applicable drinking water standards of 20,000 pCi/L and 8 pCi/L, respectively.

Leachate Parameters and Metals. Most conventional landfill leachate parameters (e.g., alkalinity, sulfates, chlorides, total nitrogen, nitrates, nitrites, TKN, total dissolved solids, and total suspended solids) were below applicable AWQS, except for ammonia. Ammonia concentrations exceeded the AWQS of 2 mg/L, with the highest concentrations detected in well 088-109, at 8 mg/L. Ammonia is a common landfill contaminant and is generated by the degradation of organic material. As in past years, the metals iron and magnesium were also detected above AWQS in many of the Current Landfill wells in 2002. Their concentrations are expected to fall

relatively slowly due to their sorption to aquifer materials, thereby reducing mobility.

7.6.2.3 Current Landfill and FWMF Plumes

Groundwater contamination originating from the downgradient section of the Current Landfill plume and the Former Waste Management Facility (FWMF) is being monitored under the OU I South Boundary program. This monitoring program uses a network of 57 wells located downgradient of the Current Landfill and FWMF. Until 1997, the FWMF was BNL's central facility for processing, neutralizing, and storing hazardous and radioactive wastes before off-site disposal. As the result of past waste handling and storage practices, groundwater at the FWMF is contaminated with both chemicals and radionuclides at concentrations that exceed AWQS or DWS.

The Current Landfill and FWMF plumes become commingled south of the FWMF (Figure 7-7). The Current Landfill/FWMF plume is being remediated using a groundwater extraction and treatment system consisting of two wells screened in the deep portion of the Upper Glacial aquifer at the site boundary. This system provides hydraulic containment of those on-site portions of the plume that have total volatile organic compound (TVOC) concentrations greater than 50 µg/L. (Note: TVOC is a summation of all individual VOC concentrations for a particular well sample.)

Volatile Organic Compounds. Total volatile organic compound concentration distributions for the Current Landfill/FWMF plume are shown in Figure 7-7. The primary VOCs found on site include chloroethane and DCA (the signature contaminants for the Current Landfill), whereas TCA, 1,1-dichloroethene (DCE), trichloroethylene (TCE), and chloroethane are prevalent in the off-site (North Street East) segment of the plume. DCA and chloroethane are primarily detected in the Shallow Glacial aquifer near the source areas, and in the deep Upper Glacial aquifer at the site's boundary and off site. TCA, DCE, TCE, chloroethane, and chloroform are found in the mid to deep Upper Glacial aquifer off-site south of North Street.

The Current Landfill/FWMF plume (defined by TVOC concentrations greater than 5 µg/L) extends south from the Current Landfill to an area approximately 2,250 feet south of North Street (approximately 7,300 feet long as measured from the Current Landfill). Its maximum width is about 1,300 feet at the southern site boundary. The areas of the plume displaying the highest VOC concentrations (greater than 100 µg/L) are approximately 500 feet downgradient of the FWMF (at well 098-59), and off site, south of well 000-124. TVOC concentrations in wells positioned in the core of the plume are decreasing. For example, TVOC concentrations in plume core well 098-59 declined after peaking at 239 µg/L in 2001, to 125 µg/L in the fourth quarter of 2002.

The distribution of the plume has changed since the south boundary pump-and-treat system began operation in 1997 (Figure 7-7). The system appears to have created a break in the plume, characterized by a region of low-level TVOC concentrations from south of the extraction wells to just south of the Long Island Expressway (LIE). A new groundwater treatment system (North Street East) is scheduled to be constructed in 2003. This treatment system is designed to remediate the high concentration portion of the VOC plume located off site (see Figure 7-16).

Radionuclides. Tritium levels in wells located inside the FWMF have been declining since 1997 when concentrations approached 44,000 pCi/L in well 088-26. Concentrations were less than 858 pCi/L in this same well during 2002. As previously released tritium continues to migrate away from the FWMF, tritium concentrations have been steadily increasing in downgradient well 098-30 located approximately 900 feet to the south, to a maximum of 24,600 pCi/L in 2002. Low levels of tritium continued to be detected off site during 2002, with a maximum concentration of 2,960 pCi/L, in well 000-138.

Strontium-90 has historically been detected on site at concentrations above the drinking water standard of 8 pCi/L in some wells within and downgradient of the FWMF. In 2001, additional groundwater characterization work

was performed using thirteen temporary wells downgradient of the FWMF. During this investigation, the highest strontium-90 detection was observed in temporary well 108-30, at 65.4 pCi/L. For improved monitoring, sentinel wells were installed in 2002 downgradient of the leading edge of the plume. Strontium-90 was not detected in these new wells during 2002. The peak strontium-90 concentration during 2002 was 7.8 pCi/L, in well 098-30. The extent of strontium-90 concentrations that are greater than the 8 pCi/L drinking water standard is shown in Figure 7-9.

7.6.3 Operable Unit III

The monitoring well network established to monitor the OU III VOC and radionuclide source areas and associated contaminant plumes is comprised of approximately 180 monitoring wells positioned from the north-central portion of the site to the southern site boundary and off site. The OU III groundwater monitoring program is specifically designed to address the following groundwater contamination and plume remediation issues:

- Monitor VOC plumes with identified or suspected sources in the AGS Complex, Paint Shop, former carbon tetrachloride underground storage tank area, former Building 96 area, and the Supply and Material area.
- Monitor the tritium plume associated with the High Flux Beam Reactor (HFBR) and strontium-90 plumes associated with the Waste Concentration Facility and the formerly operated Brookhaven Graphite Research Reactor.
- Evaluate the effectiveness of the OU III South Boundary, Western South Boundary, Middle Road, Carbon Tetrachloride, Industrial Park, and Building 96 groundwater treatment systems. These monitoring programs characterize the effects of the pumping on the contaminant plumes and provide the data necessary for making decisions on the future operations of the remediation systems.
- Monitor the off-site segment of the OU III plume and sentinel wells south (downgradient)

of the defined extent of the off-site VOC plume, to provide data on future downgradient migration of the plume. Sentinel wells are also situated in the southwestern portion of BNL, directly upgradient of the Suffolk County Water Authority's Parr Village Well Field near the William Floyd Parkway. These sentinel wells would provide an early warning if contaminants from BNL were to migrate toward the Suffolk County Water Authority wells.

7.6.3.1 OU III Volatile Organic Compound Plumes

Figure 7-10 shows the areal extent of the OU III VOC plume, which extends from the AGS Complex area in the central part of the site south to the vicinity of Flower Hill Drive in North Shirley, a distance of approximately 18,000 feet.

The OU III VOC plume consists of multiple commingled plumes originating from a number of source areas in the central areas of the BNL site. The primary VOCs detected in on-site monitoring wells include TCA, PCE, and carbon tetrachloride. Carbon tetrachloride and PCE are the primary VOCs detected in off-site groundwater monitoring wells.

In general, PCE, TCA, and carbon tetrachloride occur in the shallow Upper Glacial aquifer in the central portion of OU III, and in the deep Upper Glacial aquifer at the southern site boundary and off site. On-site portions of the plume displaying the highest VOC concentrations during 2002 were the former carbon tetrachloride UST area (with carbon tetrachloride values up to 1,940 µg/L) and the former Building 96 area (primarily PCE and lower concentrations of TCA, with TVOC values of up to 3,718 µg/L). TVOC concentrations up to 2,948 µg/L were observed at the Middle Road, and TVOC concentrations up to 1,471 µg/L were detected at the southern boundary. High levels of VOCs were also observed in wells in the Industrial Park, where TVOC levels ranged up to 1,613 µg/L (composed primarily of carbon tetrachloride and PCE).

Monitoring results also indicate that there is significant carbon tetrachloride and PCE contamination off site in the Upper Magothy aquifer in the vicinity of the Industrial Park and Carleton Drive in North Shirley. Characterization of the

Magothy aquifer in this area began in 2000 and was completed in 2002 (see Arcadis-Geraghty and Miller 2003). The characterization study included the installation of 22 temporary vertical profile wells and 13 permanent monitoring wells. The highest carbon tetrachloride and PCE concentrations occurred in well 000-130, with a maximum TVOC concentration of 295.8 µg/L. A comparison of the OU III plumes between 1997 and 2002 is provided in Figure 7-10. A summary of significant source areas and groundwater treatment areas is provided below.

OU III Central Area. A number of low-level (less than 100 µg/L) source areas and nonpoint source contamination have been identified within the developed central areas of the BNL site. These areas are monitored under the OU III Central project.

The monitoring well network established for the central area of the site consists of 21 wells. This network also is supplemented with Environmental Surveillance program wells that are used to monitor active research and support facilities. During 2002, VOC concentrations in most of the OU III Central wells were near or below the AWQS. Significant observations for 2002 are described below.

- Well 065-05 is screened in the shallow Upper Glacial aquifer and is located in the AGS area. TVOC concentrations in this well peaked at 123 µg/L in September 2000, and then decreased to 17 µg/L during the fourth quarter of 2001. TVOC concentrations continued to decrease in 2002, dropping to 5 µg/L by the fourth quarter. The VOCs are likely to have originated from historical discharges to cesspools near Building 914.
- Well 066-09 is located southeast of Building 830 and is screened in the shallow Upper Glacial aquifer. VOC concentrations, primarily TCA, significantly increased during late 2000 and early 2001, peaking at 112 µg/L TVOC in February 2001. VOC concentrations during the final three quarters of 2001 dropped to below the 5-µg/L AWQS. A preliminary investigation identified several potential sources in Building 830; however, a subsequent Geoprobe™ investigation during the summer of 2001 revealed little or no

VOC contamination near the building. During 2002, VOC concentrations remained below AWQS, with the exception of a single detection of trichlorofluoromethane at a concentration of 9 µg/L in the fourth quarter of the year.

- Well 083-02 is located near the intersection of Brookhaven Avenue and Upton Road and is screened in the mid to deep Upper Glacial aquifer. Since 1997, this well consistently has contained 10 to 25 µg/L of chloroform. Potential sources of this contamination may be in the AGS area of the site.
- Wells 109-03 and 109-04 serve as sentinel wells for Suffolk County's William Floyd Well Field and are near the eastern BNL site boundary. Toluene was detected in well 109-03 (screened in the deep Upper Glacial aquifer) at 5.3 µg/L in a sample collected in September 2002. Prior to this period, VOCs had not been detected at concentrations exceeding AWQS. When the well was re-sampled in October 2002, MTBE was detected at concentrations up to 7 µg/L. The AWQS for toluene is 5 µg/L, and is 10 µg/L for MTBE. The well was re-sampled in December by BNL and January 2003 by SCDHS. In both instances, no VOCs were detected. More frequent sampling of this well will be conducted by BNL and SCDHS during 2003. As in previous years, there were no detections of Laboratory-related radionuclides in these wells during 2002.

Building 96 Area. The OU III Remedial Investigation/Feasibility Study identified the Building 96 area as a significant source of the PCE detected in the OU III plume. This area encompasses four distinct areas: Building 96 and associated leaching structures; Building 96 Scrapyard; Former Building T-239 and associated leaching structures; and the former truck wash area.

An in-well air sparging system to remediate the Building 96 VOC source area began operations in February 2001. The Building 96 groundwater treatment system consists of four recirculation treatment wells. The VOC plume consists primarily of PCE and lower concentrations of TCA. The AWQS for PCE and TCA is 5

µg/L. During 2002, the Building 96 area VOC plume was monitored using 17 permanent wells and 12 temporary wells. The temporary wells were installed to help determine the extent of contamination remaining in the source area, and to redefine the western extent of the plume. Although VOC concentrations throughout most of the plume have declined significantly since the treatment system was installed, high concentrations of VOCs were detected in the northern section of the source area (north of treatment well RTW-1), with a maximum TVOC concentration of 3,718 µg/L in temporary well 085-313. These persistent high levels of VOCs appear to be coming from a silty layer that is slowly releasing the contaminants. BNL is planning to install additional monitoring wells, and will conduct an engineering study on the source term and alternative treatment technologies.

Carbon Tetrachloride UST Area. In April 1998, an inactive underground storage tank used to store carbon tetrachloride was excavated and removed. This tank was approximately 200 feet northeast of the Upton Service Station (at the corner of Rowland Street and Rochester Street). Although groundwater samples collected from a nearby well had shown low-level concentrations of carbon tetrachloride since 1995, samples collected in June 1998 revealed levels approaching 100,000 µg/L. The AWQS for carbon tetrachloride is 5 µg/L. The increase in contaminant concentration was probably due to the spillage of residual carbon tetrachloride during removal of the underground storage tank. A groundwater remediation system consisting of two extraction wells (EW-13 and EW-14) screened in the shallow Upper Glacial aquifer began operation in October 1999. A third extraction well (EW-15) installed in the downgradient segment of the plume began operation in December 2001. The effects of the pump-and-treat system on the source area are apparent in the sharp decline in carbon tetrachloride concentrations in wells near the former UST area.

The carbon tetrachloride contamination extends from the former UST southeast to the vicinity of the Weaver Road recharge basin, a distance of approximately 1,300 feet. The width of the plume, as defined by concentrations

greater than 50 µg/L, is approximately 120 feet. In 1999, carbon tetrachloride concentrations in groundwater immediately downgradient of the former UST were greater than 150,000 µg/L (in well 085-98). Carbon tetrachloride concentrations in this area steadily decreased following the start of groundwater treatment system pumping, and were only 158 µg/L during the fourth quarter of 2002. Carbon tetrachloride concentrations were also observed to decrease in wells near the Service Station. For example, carbon tetrachloride concentrations in well 085-17 dropped from 3,760 µg/L in February 2001 to 154 µg/L by the fourth quarter of 2002. Carbon tetrachloride concentrations continue to decline in the downgradient segment of the plume as a result of the treatment system. Carbon tetrachloride levels in well 095-279, which is near the southernmost extraction well EW-15, declined from nearly 600 µg/L in the second quarter of 2002, to 122 µg/L in the fourth quarter of 2002. Carbon tetrachloride was not detected in any of the sentinel wells in the vicinity of Weaver Drive.

Middle Road Treatment Area. Six groundwater extraction wells are used to hydraulically control the OU III VOC plume located near the Middle Road. This system began operating in October 2001. The Middle Road Monitoring Program consists of a network of 26 monitoring wells.

TVOC concentrations in plume core well 105-23, approximately 2,000 feet upgradient of RW-1 near Princeton Avenue decreased from 1,794 µg/L during 2001, to 420 µg/L in the fourth quarter of 2002. The highest TVOC concentrations are found immediately south of extraction wells RW-2 and RW-3, based on influent data for these wells and nearby monitoring wells. The highest TVOC concentration was 2,948 µg/L detected in well 113-17. Although this area of high level contamination is outside capture zones of the Middle Road extraction wells, it is expected to be captured by the OU III South Boundary system. TVOC concentrations in monitoring wells in the vicinity of RW-4 and RW-5 are below the AWQS.

Southern Boundary Treatment Area. Hydraulic control of the OU III plume at the site

boundary has been attained using seven extraction wells that pump water from the deep portions of the Upper Glacial aquifer to an air stripper for treatment. This system began operation June 1997. The seven recovery wells are screened at the depths showing the highest VOC concentrations. The effectiveness of the Southern Boundary treatment system is monitored using a network of 38 wells. Monitoring data have demonstrated that the distribution of the plume has changed since the south boundary pump-and-treat system began operation in 1997. The extraction well system has created breaks in segments of the plume, characterized by a region of low-level TVOC concentrations from south of the extraction wells to just south of the Long Island Expressway. High levels of VOCs continue to be detected in some south boundary monitoring wells and are likely due to slugs of high-level contaminants migrating from upgradient areas. During 2002, the highest TVOC concentration detected near the extraction well system was 1,471 µg/L in well 121-14, located between EW-4 and EW-5.

Western South Boundary Treatment Area. The Western South Boundary pump-and-treat system began operation in 2002. The system has two extraction wells and is designed to capture the western portion of the OU III VOC plume, which contains VOC concentrations generally less than 50 µg/L. This area is monitored using a network of 17 wells. The primary contaminants associated with this portion of the OU III plume are TCA, TCE, chloroform, and dichlorodifluoromethane (a freon). The maximum TVOC concentration during 2002 was 53 µg/L, in well 127-06.

Industrial Park Area. The OU III Industrial Park Treatment system was designed to contain and remediate the portion of the OU III plume existing between BNL's southern boundary and the Parr Industrial Park. This segment of the OU III plume consists primarily of carbon tetrachloride that is in the deep portions of the Upper Glacial aquifer and upper portion of the Magothy aquifer. A groundwater treatment system, consisting of seven in-well air stripping treatment wells, was initiated in the Industrial Park in 1999 to treat VOC contamination in the deep Upper Glacial aquifer.

The monitoring well network for this area consists of 39 wells that extend from the Industrial Park to Carleton Drive. These wells are used to monitor the effectiveness of the in-well air stripping groundwater treatment system. The highest VOC concentrations in the Industrial Park area during 2002 were observed between remediation wells UVB-4 and UVB-5, with the maximum concentration of 1,613 µg/L observed in monitoring well 000-262 during the fourth quarter. Wells that monitor the Upper Glacial aquifer downgradient of the treatment system, along Carleton Drive, showed stable or decreasing VOC concentrations during 2002, with a maximum TVOC concentration of 12.5 µg/L observed in well 000-274.

Two new groundwater remediation systems are being planned to clean up the southern extent of the OU III plume not remediated by the Industrial Park treatment system. The treatment systems will be located along the northern edge of the Town of Brookhaven Airport and along the Long Island Power Authority (LIPA) right-of-way south of Carleton Drive. These systems will be constructed by 2004.

North Street Monitoring. The North Street Monitoring Program (formerly known as OU I/IV Monitoring Program) addresses both a VOC plume that is primarily south of the site boundary and potential radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 Sump Outfall areas). A network of 25 wells monitors the downgradient portion of the OU IV, Former Landfill, Animal/Chemical Pits, and Glass Holes VOC plumes. Wells sampled under the OU III South Boundary and Industrial Park Programs are also utilized for mapping this plume.

The VOC plume extends from just south of the Chemical/Animal Hole area southward to the vicinity of Brookhaven Airport. The primary VOCs associated with this plume are carbon tetrachloride, PCE, and TCA. Historically the highest VOC concentrations (primarily carbon tetrachloride) have been detected in well 000-154 in the North Street area. TVOC concentrations greater than 1,000 µg/L were observed in 1997 and 1998 but have steadily declined since that

time as the high concentration segment has migrated southward. The leading edge of this high concentration segment is now being detected in well 000-153, as concentrations increased to nearly 150 µg/L in 2002. Detailed groundwater characterization data can be found in the *North Street Remedial Design Work Plan* (BNL 2002d) and the *OU III Airport Remedial Design Work Plan* (BNL 2002c).

The North Street VOC plume will be remediated using two groundwater treatment systems. The first system will consist of two extraction wells and four recharge wells located between Sleepy Hollow Road and North Street. This system will capture the higher concentration portion of the VOC plume within the Upper Glacial aquifer that contains TVOC concentrations greater than 50 µg/L. This system will help to minimize the potential for VOC migration to the Magothy aquifer. Details on the pre-design groundwater characterization and the planned groundwater treatment system can be found in the *North Street Groundwater Remediation System 90 Percent Design Report* (Arcadis-Geraghty and Miller 2002). This treatment system is scheduled to start operations in Spring 2004. The second groundwater remediation system is to be located at the Brookhaven Airport. This system will remediate the leading edge of the plume, as well as the leading edge of the OU III VOC plume to the west. Details on the proposed remediation system and pre-design characterization activities can be found in the *OU III Airport Groundwater Treatment System 90 Percent Design Documents* (J.R. Holzmacher 2002a). Construction of the system is scheduled to begin in April 2003.

Low levels of tritium have been detected off site in localized areas of the deep Upper Glacial aquifer since the monitoring program started in 1998, but at concentrations well below the 20,000 pCi/L drinking water standard. The maximum tritium concentration observed in 2002 was 1,070 pCi/L, in well 000-153. Tritium was also detected in seven of the 15 temporary vertical profile wells installed in 2001 and 2002. In six of the seven vertical profiles, tritium was detected at concentrations less than 1,000 pCi/L. The highest tritium concentration, 9,130 pCi/L,

was detected in temporary well 000-337 installed approximately 300 feet north of well 000-153. Potential sources for this tritium are located in the Former Landfill/Chemical/Animal Holes and OU IV Building 650 areas of the site.

7.6.3.2 OU III Radionuclide Plumes

HFBR Tritium Plume. In late 1996, tritium was detected in wells near the High Flux Beam Reactor. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed from the pool for off-site disposal, the spent fuel pool was drained, and the HFBR was removed from service in 1997. Also, numerous monitoring wells were constructed to characterize the tritium plume downgradient of the HFBR. In May 1997, operation of a three-well groundwater extraction system began. This system was constructed on Princeton Avenue approximately 3,500 feet downgradient of the HFBR to capture the leading edge of the tritium plume. Extracted water was recharged at the Remedial Action (RA) V recharge basin. Groundwater modeling predicts that the tritium plume will naturally attenuate to below drinking water standards before reaching the site boundary. Three years of monitoring data showed that the plume had reached a relative steady state due to natural attenuation and it was not growing significantly. As a result, the extraction system was turned off and placed on standby status in September 2000. The extraction system will be reactivated if tritium concentrations exceed 20,000 pCi/L at Weaver Drive.

The selected remedy for the HFBR tritium plume includes monitoring and low-flow extraction programs to prevent or minimize the plume's growth. During 2000 and 2001, low-flow extraction was applied to the highest concentration area of the plume. The low-flow extraction removed a total of 95,000 gallons of tritiated water that was sent off site for disposal. Tritium concentrations have remained below the 750,000 pCi/L trigger level for low flow pumping since April 2001.

A monitoring well network of 157 wells is used to monitor the extent of the plume. The extent of the tritium plume, determined from data

collected during the fourth quarter of 2002, is shown in Figure 7-11. Tritium concentrations in groundwater immediately south of the HFBR building continue to decrease. Concentrations in well 075-43 were only 22,600 pCi/L during the fourth quarter 2002. This is a significant reduction from the nearly 2,500,000 pCi/L observed in this well during 1999. During 2002, the highest concentration segment of the HFBR tritium plume was between Brookhaven Avenue and Rowland Street, with a maximum concentration of 254,000 pCi/L detected in temporary well 085-238 installed in the eastern end of Bell Avenue. The leading edge of the >20,000 pCi/L portion of the tritium plume is estimated to be in the vicinity of the Chilled Water Plant Road. There were no detections of tritium in excess of 1,000 pCi/L south of Weaver Drive during 2002.

WCF and BGRR-Area Sr-90 Plumes.

Historical waste handling operations at the Waste Concentration Facility and operations at the former BGRR and associated Pile Fan Sump and Stack resulted in the release of strontium-90 to the groundwater below these facilities. The strontium-90 plumes from these facilities are monitored using 61 wells. During 2002, additional groundwater characterization work was conducted in the BGRR area using 26 temporary wells (BNL 2002a).

There are two strontium-90 plumes, one emanating from the WCF and extending south approximately 1,500 feet to just south of Cornell Avenue, and the other beginning south of the BGRR and extending south approximately 600 feet toward Brookhaven Avenue (Figure 7-12). Variability in groundwater flow directions, due to changes in pumping and recharge patterns in the plume vicinity over time, has caused some lateral spreading of the contamination.

There are three areas where strontium-90 concentrations are greater than 50 pCi/L. These areas will be the focus of additional characterization efforts scheduled for late 2003. During 2002, the highest strontium-90 concentration was observed in WCF well 065-167, at 599 pCi/L. This well is located immediately downgradient of the WCF's former "D" tanks area.

The second area of high strontium-90 contamination is in the vicinity of the BGRR's

Below Ground Ducts (BGD), where a groundwater sample from a temporary well installed in August 2001 contained strontium-90 levels at 540 pCi/L. Strontium-90 concentrations greater than 50 pCi/L are estimated to extend south of the BGD area to just south of Cornell Avenue. Groundwater samples were obtained during 2002 from 26 temporary wells installed near the BGRR. Only two of 27 samples collected from the 26 temporary wells exceeded the 8 pCi/L drinking water standard, with concentrations of 12 pCi/L detected in each sample.

A third area of high strontium-90 concentrations was discovered in 2001 near the HFBR stack, in a temporary well, at a concentration of 392 pCi/L. Although there are currently no permanent monitoring wells in the HFBR stack area, strontium-90 concentrations greater than 50 pCi/L are estimated to extend from the stack area several hundred feet to the south.

7.6.4 Operable Unit IV

The Operable Unit IV area contains two significant source areas: the 1977 fuel oil/solvent spill site (AOC 5), and the Building 650 Sump and Sump Outfall area (AOC 6).

7.6.4.1 1977 Oil/Solvent Spill Site

In 1977, between 23,000 and 25,000 gallons of a mixture of Number 6 fuel oil and mineral spirits were released when a pipe ruptured as the contents of an underground storage tank were being transferred to aboveground storage tanks at the Central Steam Facility. The primary chemical contaminants that were found in the OU IV plume near this 1977 spill site were TCA, PCE, DCE, TCE, toluene, ethylbenzene, and xylenes. In addition, several small spills of Number 6 fuel oil from the CSF fuel unloading area were documented between 1988 and 1993; it also is suspected that small volumes of solvents such as PCE were released to the ground near the CSF.

From 1997 through 2001, BNL operated an air sparging/soil vapor extraction (AS/SVE) system to remediate soil and groundwater contaminated associated with the 1977 spill. The performance goals for soil cleanup were achieved in 1998 and the goals for groundwater cleanup

were met in August 2000. Groundwater monitoring was continued as per *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort – Work Plan, May 2001* (BNL 2001). A “Petition for Closure and Termination of Formal Post-Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System” was submitted in June 2002 (BNL 2002b). BNL is currently awaiting regulatory agency approval for system closure.

Quarterly sampling of the monitoring wells continued during 2002 as BNL awaited a decision from the regulatory agencies on system closure. There were several detections of VOCs exceeding the AWQS in wells 076-04 and 076-06. In well 076-04, 1,2,4-trimethylbenzene was detected at 6 µg/L (fourth quarter) and in well 076-06 also at 6 µg/L (third quarter). In well 076-06, 1,3,5-trimethylbenzene was detected at 10 µg/L (second quarter), 9 µg/L (third quarter), and 5 µg/L (fourth quarter). In well 076-04, m/p xylene was detected in the fourth-quarter sample.

VOCs were not detected above AWQS in the remainder of the wells in the monitoring program except for wells 076-19 and 076-185. These wells are located outside the area of influence of the AS/SVE system. The source of contamination in these wells is the Central Steam Facility.

7.6.4.2 Building 650 and 650 Sump Outfall Areas (AOC 6)

Building 650 was used as a decontamination facility for radioactively contaminated clothing and equipment. Drainage from an exterior heavy equipment decontamination pad was piped to a natural depression approximately 800 feet to the northeast, near recharge basin HO. As a result of these operations, soils and groundwater were contaminated at the decontamination pad and the sump outfall. The soils associated with the Building 650 sump outfall and the pipe leading to the outfall were excavated and disposed of off site during the spring and summer of 2002.

The overall extent of the Building 650 Sump Outfall strontium-90 plume (with concentrations greater than the 8 pCi/L drinking water standard) did not change significantly from 2000 to 2002 (Figure 7-13). The leading edge of the plume projected to be just north of the Major

Petroleum Facility. The highest strontium-90 concentrations were detected in well 076-13 at 27 pCi/L in August 2002. At Building 650, strontium-90 concentrations decreased from a maximum of 14 pCi/L in 2001 (in well 076-28, near the former decontamination pad) to less than 5 pCi/L in 2002.

7.6.5 Operable Unit V

Historically, Brookhaven's Sewage Treatment Plant received discharges of contaminants from routine operations. Releases of VOCs, metals, and radionuclides to groundwater occurred via the STP sand filter beds and discharges to the Peconic River. In addition, trace levels of pesticides were detected in some wells. The OU V monitoring program uses 34 monitoring wells downgradient of the STP. These wells monitor VOC and tritium contamination resulting from historical releases at the STP. Surveillance of groundwater quality near the STP filter beds and emergency holding pond areas is performed as part of the BNL Environmental Surveillance Program for the STP (see Section 7.5.2.1).

Volatile Organic Compounds, Metals, and Pesticides. The extent of the OU V VOC plume is shown in Figure 7-14. The highest TVOC concentration observed during 2002 was 12 µg/L in well 061-05, which is near the eastern site property boundary. The only individual VOCs detected at levels exceeding AWQS were TCE and 1,2-dichloropropane. TCE was detected in well 061-05 at concentrations up to 6.5 µg/L (the standard is 5 µg/L) and 1,2-dichloropropane was detected in shallow offsite well 600-25 at concentrations up to 1.7 µg/L (the standard for this compound is 1 µg/L). Because well 600-25 is shallow, it is likely that the 1,2-dichloropropane is from an offsite source.

As in past years, trace levels of several pesticides were detected during 2002. All concentrations were less than the applicable drinking water standards. Because these pesticides were detected in shallow offsite wells, their origin is likely from agricultural spraying at farms in the vicinity.

Aluminum, iron, manganese, sodium, and thallium were detected at concentrations above

applicable AWQS levels. Aluminum was detected in 11 wells above the AWQS of 0.2 mg/L, with the highest concentration (1.16 mg/L) detected in well 061-03. Iron was detected in 17 wells above the AWQS of 0.3 mg/L, with the highest concentration of 31.5 mg/L detected in well 050-02. Manganese was detected in seven wells above the AWQS of 0.3 mg/L, with the highest concentration (1.1 mg/L) detected in well 050-02. Sodium above the AWQS of 20 mg/L was detected in two wells, with the highest concentration in well 050-02 (25.7 mg/L). Thallium was detected in two wells at a maximum concentration of 0.0047 mg/L, which exceeds the AWQS of 0.0005 µg/L.

Radionuclides. Detectable levels of tritium were found in two wells near BNL's southeastern site boundary, but the concentrations were well below the drinking water standard of 20,000 pCi/L. A maximum tritium concentration of 2,300 pCi/L was detected in well 050-02. Tritium was not detected in any of the off-site monitoring wells. A detailed discussion on the distribution of tritium within the OU V area is provided in the 2002 BNL Groundwater Status Report (BNL 2003c). Gross alpha and gross beta levels were consistent with established background levels for the site.

7.6.6 Operable Unit VI, Biology Fields

Ethylene dibromide (EDB) was used as a fumigant in the BNL Biology Department's agricultural fields in the southeast portion of the site. Available records indicate that the application of EDB in this area took place in the 1970s. As the result of these historical releases of EDB, a contaminant plume (as defined by concentrations greater than the 0.05 µg/L drinking water standard for EDB) extends approximately 3,000 feet, from near BNL's southeastern site boundary to an area south of the Long Island Expressway (Figure 7-15). The leading edge of the plume is downgradient of wells 000-283 and 000-284. Additional sentinel wells to monitor the leading edge of the plume will be installed in 2003. The plume is located entirely in the deep Upper Glacial aquifer. The highest EDB concentration observed during 2002 was 4.6 µg/L, in well 000-284. The wells were also sampled for

radionuclides and, as in past years, no radionuclides were detected.

A groundwater remediation system to address the off-site EDB plume has been designed, and construction is planned for late 2003, with operations beginning in 2004. Detailed information on this remediation system is presented in the *OU VI EDB Plume Groundwater Remediation System 90 Percent Design Documents* (J.R. Holzmacher, Inc. 2002b).

7.7 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the Laboratory's Environmental Restoration Program is to remediate soil and groundwater contamination and prevent additional contamination from migrating off the BNL site. The cleanup goals are to: 1) prevent or minimize plume growth, and 2) reduce contaminant concentrations in the Upper Glacial aquifer to below regulatory standards within 30 years. In 2002, BNL continued to make significant progress in restoring groundwater quality at the site. Seven groundwater remediation systems were in operation by the end of 2002, with the addition of the OU III Western South Boundary system. Ten of the 17 planned groundwater treatment plants have been constructed. Two systems

remained in standby mode in 2002 as they substantially met their cleanup goals: the OU IV Air Sparging/Soil Vapor Extraction system, and the HFBR Pump and Recharge System. Compared to 2001, the total groundwater cleanup treatment capacity was increased from 2,575 gallons per minute (gpm) to 2,875 gpm. Ultimately, the total groundwater cleanup capacity will be approximately 4,500 gpm. Figure 7-16 shows the locations of the current and planned groundwater treatment systems. Table 7-4 provides a summary of pounds of VOCs removed and gallons of water treated during 1997–2002. During 2002, 720 pounds of VOCs were removed from the groundwater and more than one billion gallons of treated groundwater were returned to the aquifer. Detailed information on these treatment systems can be found in the *2002 BNL Groundwater Status Report* (BNL 2003c).

It is expected to take up to 10 years of aquifer treatment before widespread improvements in groundwater quality at BNL are achieved. Even so, some noticeable improvements in groundwater quality are evident in OU I South Boundary, OU III South Boundary, OU IV, Building 96, and the Carbon Tetrachloride area. Groundwater remediation

Table 7-4. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2002.

Remediation System	Start Date	1997– 2001		2002	
		Water Treated (Gallons)	VOCs Removed (Pounds)	Water Treated (Gallons)	VOCs Removed (Pounds) ^(d)
OU III South Boundary	June 1997	1,558,436,850	1,709	343,000,000	219
OU III Industrial Park	Sept. 1999	416,915,000	449	186,000,330	184
OU III Western South Boundary	Sept. 2002	Not in Service	0	74,287,000	10
Carbon Tetrachloride	Oct. 1999	88,337,300	241	34,461,000	86
OU I South Boundary	Dec. 1996	1,740,939,000	254	377,451,000	26
HFBR Tritium Plume ^(a)	May 1997	241,528,000	180	0	0
OU IV AS/SVE ^(b)	Nov. 1997	(c)	35	Not in Service	0
Building 96	Feb. 2001	24,238,416	35	45,000,000	11
Middle Road	Oct. 2001	55,353,550	39	281,000,000	184
Total		4,125,748,116	2,942	1,341,199,330	720

Notes:

^(a) System was shut down and placed in standby mode on September 29, 2000.

^(b) System was shut down on January 10, 2001.

^(c) Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed per cubic feet of air treated.

^(d) Values rounded to the nearest whole number.

CHAPTER 7: GROUNDWATER PROTECTION

activities are expected to continue until approximately 2030 to meet the ultimate cleanup objective.

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Radiological Dose Assessment

Brookhaven National Laboratory assessed the potential environmental radiological dose from scientific research activities for calendar year 2002. The radiological dose was calculated from ambient external sources, inhalation, ingestion, and skin absorption pathways to the hypothetical “maximally exposed individual” (MEI) at the BNL site boundary. The effective dose equivalents (EDEs) were found to be well below dose limits for the environment and members of the public that were set by the U.S. Environmental Protection Agency and the Department of Energy.

The average annual ambient external dose reading on site was 71 ± 15 mrem (710 ± 150 μ Sv) and off site was 66 ± 10 mrem (660 ± 100 μ Sv). Both measurements include contributions from cosmic and natural background sources. A statistical comparison of the average dose values from 41 on-site and 18 off-site thermoluminescent detectors indicated no additional dose contribution from BNL operations. The annual air pathway dose to the MEI was estimated as 0.086 mrem (0.86 μ Sv). The annual ingestion pathway doses to the MEI were estimated as 2.2 mrem (22 μ Sv) for venison and 0.25 mrem (2.5 μ Sv) mrem for fish caught at Donahue’s Pond. The total annual dose to the MEI from all pathways was estimated to be 2.54 mrem (25 μ Sv). In comparison, the annual EPA regulatory limit for the air pathway is 10 mrem (100 μ Sv) and the annual DOE limit from all pathways is 100 mrem (1,000 μ Sv).

Additionally, 10 on-site remediation and waste management projects were evaluated for radiological emissions to the environment. The dose impact from all BNL activities was found to be insignificant in comparison to natural background levels. Dose to aquatic and terrestrial biota at the site was screened and found to be well below the DOE limits.

8.1 DIRECT RADIATION MONITORING

The main purpose of external dose monitoring is to measure the dose to members of the public and uninvolved workers from direct gamma external radiation sources. BNL measures direct penetrating radiation exposures off site with the premise that off-site exposures are true background doses (i.e., no contribution from BNL operations). On- and off-site external doses are compared to each other (using the statistical t-test) to estimate the contribution from BNL operations above the natural background radiation.

Direct penetrating gamma radiation is measured using thermoluminescent dosimeters (TLDs). The principle of TLD operation is that when certain crystals are exposed to penetrating gamma radiation, impurities in the crystals’ low-temperature trapping sites for the electrons are excited to higher energy states. These electrons remain in a high-energy state at normal ambient temperature. When the TLDs are heated, electrons return to the lower state of energy. The electrons emit photon energy (i.e., light), which is measured with a photomultiplier tube; the light

intensity given out is directly proportional to the absorbed dose of radiation. The environmental TLDs used at BNL are composed of calcium fluoride and lithium fluoride. The accuracy of the TLDs is verified using known sources of radiation exposure and inter-comparison programs. The device that reads the dosimeter is calibrated to read *absorbed* dose—that is, quantity of energy deposited by radiation in the mass of the material.

8.1.1 Ambient Monitoring

To evaluate the potential impact from operations, TLDs are deployed at the BNL site and the surrounding communities, in 16 wind sectors. On-site TLD locations are selected based on the potential for exposure to gaseous plumes, atmo-

spheric particulates, and radiation-generating facilities. The BNL perimeter locations are posted with TLDs to assess potential impact at the Laboratory boundary. On- and off-site areas are divided into grids and the TLDs are assigned IDs based on these grids.

Forty-one TLDs were deployed on the BNL site and 18 were deployed off site in year 2002, as shown in Figures 8-1 and 8-2, respectively. An additional 30 control TLDs were stored in a lead-shielded container in Building 535; the average of these control TLDs (075-TLD4) is reported in Table 8-1 as a reference. Note that it is not possible to completely shield the control devices from all natural and cosmic radiation; therefore, small doses are measured by the control TLDs.

The on- and off-site TLDs are collected and read on a quarterly basis to determine the direct external radiation dose impact to members of the public and the environment.

In 2002, the TLD location identifiers were modified to accommodate the new Environmental Information Management System. The grid numbers were retained to preserve the historical link to previous TLD data, but the

suffixes were changed to “TLD” in the particular wind sector (for example, 011-400 was changed to 011-TLD1).

Table 8-1 shows the quarterly on-site radiation measurements. The on-site average external doses for the first, second, third, and fourth quarters were 19.9 ± 4.2 , 16.3 ± 4.0 , 15.3 ± 4.2 ,

Figure 8-1. On-Site TLD Locations.

Figure 8-2. Off-Site TLD Locations.

Table 8-1. On-Site Direct Radiation Measurements.

TLD#	Location	1 st	2 nd	3 rd	4 th	Average	Annual Dose
		Quarter	Quarter	Quarter	Quarter	2σ (95%)	2σ (95%)
(mrem)							
011-TLD1	Firebreak	19.6	15.4	12.7	NR	16 ± 7	64 ± 27
013-TLD1	North Firebreak	17.5	17.1	14.9	17.2	17 ± 2	67 ± 9
025-TLD1	Bldg. 1010 beam-stop 1	20.0	13.8	21.8	17.8	18 ± 7	73 ± 27
025-TLD4	Bldg. 1010 beam-stop 4	19.2	13.7	14.7	18.8	17 ± 5	66 ± 22
030-TLD1	NE Firebreak	17.9	14.7	12.9	18.5	16 ± 5	64 ± 21
034-TLD1	Bldg. 1008 collimator 2	19.7	17.5	14.0	17.8	17 ± 5	69 ± 19
034-TLD2	Bldg. 1008 collimator 4	18.5	14.3	17.2	18.9	17 ± 4	69 ± 16
037-TLD1	S-13	17.1	14.9	14.1	17.0	16 ± 3	63 ± 12
043-TLD1	North Access Road	19.6	18.3	14.6	19.0	18 ± 4	72 ± 18
043-TLD2	North of Met.	21.2	18.5	16.7	18.7	19 ± 4	75 ± 15
044-TLD1	Bldg. 1006	21.5	17.8	14.5	18.1	18 ± 6	72 ± 22
045-TLD1	Bldg. 1005S	19.4	15.8	15.3	19.1	17 ± 4	70 ± 17
049-TLD1	East Firebreak	19.1	14.1	13.1	16.9	16 ± 5	63 ± 21
053-TLD1	West Firebreak	21.3	17.2	15.6	19.8	18 ± 5	74 ± 20
063-TLD1	West Firebreak	20.1	17.2	15.5	20.6	18 ± 5	73 ± 19
066-TLD1	New HWM Facility	16.7	12.8	11.7	16.8	15 ± 5	58 ± 21
073-TLD1	West Met./Bldg. 51	22.1	16.6	NR	19.9	20 ± 5	78 ± 22
074-TLD1	Bldg. 197	22.1	19.8	15.9	21.0	20 ± 5	79 ± 21
074-TLD2	Bldg. 907	22.3	17.3	15.1	17.9	18 ± 6	73 ± 24
075-TLD3	Bldg. 356	25.9	20.7	21.6	29.8	25 ± 8	98 ± 33
080-TDL1	East Firebreak	19.7	13.8	14.7	19.5	17 ± 6	68 ± 24
082-TLD1	West Firebreak	21.9	16.0	16.6	20.3	19 ± 6	75 ± 22
084-TLD1	Tennis Courts	19.5	17.8	16.0	20.5	18 ± 4	74 ± 16
085-TDL2	Upton gas station	21.1	13.6	14.2	19.2	17 ± 7	68 ± 29
085-TLD1	TFCU (Credit Union)	23.3	17.7	16.5	19.7	19 ± 6	77 ± 23
086-TLD1	BERA ball fields	22.1	19.0	16.9	20.5	20 ± 4	79 ± 17
105-TLD1	South Firebreak	23.2	20.1	18.3	23.3	21 ± 5	85 ± 19
108-TLD1	Water Tower	17.1	16.7	15.2	18.5	17 ± 3	68 ± 11
111-TLD1	Trailer Park	17.5	14.7	14.9	18.6	16 ± 4	66 ± 15
122-TLD1	South Firebreak	17.0	14.5	13.2	19.2	16 ± 5	64 ± 21
126-TLD1	South Gate	20.8	16.6	14.8	18.4	18 ± 5	71 ± 20
P2		17.8	13.6	14.0	16.0	15 ± 4	61 ± 15
P4		18.2	15.1	14.5	18.1	16 ± 4	66 ± 15
P7		18.5	15.2	13.9	18.2	16 ± 4	66 ± 18
S5		17.6	17.5	13.4	19.3	17 ± 5	68 ± 20
Quarterly On-Site Average		19.9	16.3	15.3	19.2	18 ± 4	71 ± 15
Std. Dev. (2 Sigma)		± 4.2	± 4.0	± 4.2	± 4.6		
075-TLD4	Control TLD Average	9.9	9.6	11.4	10.5	10 ± 2	41 ± 6

Notes:

NR = TLD dose not reported

See Figure 8-1 for TLD Locations.

and 19.2 ± 4.6 mrem, respectively. The annual on-site external dose from all potential sources, including the contribution from cosmic and terrestrial radiation sources, was 71 ± 15 mrem.

Table 8-2 shows the quarterly off-site radiation measurements taken to determine the BNL contribution, if any, to external radiation

dose. The annual off-site average ambient dose was 66 ± 10 mrem. A statistical t-test showed no significant difference between the external dose averages off site (66 ± 10 mrem) and on site (71 ± 15 mrem). Conclusion: There was no measurable external dose contribution from BNL operations.

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

TLD#	Location	1 st	2 nd	3 rd	4 th	Average	Annual Dose
		Quarter	Quarter	Quarter	Quarter	2σ (95%)	2σ (95%)
(mrem)							
000-TLD4	Private Property	16.5	12.3	16.1	16.6	15 ± 4	62 ± 16
000-TLD5	Longwood Estate	18.6	13.9	13.7	18.3	16 ± 5	65 ± 21
000-TLD7	Mid-Island Game Farm	21.3	15.1	14.5	17.4	17 ± 6	68 ± 24
200-TLD2	Private Property	NP	NP	17.3	19.7	19 ± 3	74 ± 13
300-TLD2	Private Property	18.5	18.3	16.9	19.7	18 ± 2	73 ± 9
300-TLD3	Private Property	NP	NP	14.8	16.1	15 ± 2	62 ± 7
400-TLD1	Calverton Nat. Cem.	21.5	17.2	15.0	20.7	19 ± 6	74 ± 24
500-TLD1	Private Property	15.5	11.9	12.8	15.3	14 ± 4	56 ± 14
500-TLD2	Private Property	16.4	14.4	13.5	16.5	15 ± 3	61 ± 12
500-TLD4	Private Property	17.8	15.1	16.4	17.4	17 ± 2	67 ± 9
600-TLD3	Sportsmen's Club	16.0	15.1	14.1	17.0	16 ± 2	62 ± 10
700-TLD2	Private Property	19.5	13.8	15.2	17.1	16 ± 5	66 ± 19
700-TLD3	Private Property	20.2	13.3	13.5	17.9	16 ± 7	65 ± 27
700-TLD4	Private Property	NP	NP	15.2	17.9	17 ± 4	66 ± 15
800-TLD1	Private Property	19.4	14.2	14.7	16.3	16 ± 5	65 ± 18
800-TLD2	Private Property	20.0	15.0	16.2	18.5	17 ± 4	70 ± 18
800-TLD3	Suffolk Cty CD	17.0	14.2	14.3	16.9	16 ± 3	62 ± 12
999-TLD1	Private Property	20.1	13.9	12.9	16.4	16 ± 6	63 ± 25
Off-Site Average Std. Dev. (2 Sigma)							66 ± 10

Notes:

NP = TLD not posted for the quarter

See Figure 8-2 for TLD Locations.

8.1.2 Facility Area Monitoring

Six of the 41 on-site TLDs are facility area monitors (FAM). These TLDs were deployed at locations known to have radiological contamination and a much higher probability to contribute to the external radiation dose. Table 8-3 shows the external dose measured from the FAM TLDs. The TLDs posted at the S-6 location and on the fence of the old Waste Management area

(088-TLD1 through 088-TLD4) showed higher external dose than typical background dose in the vicinity. The higher external dose was attributed to the presence of radioactive materials, contaminated soils, and radioactive sources being repackaged for shipment to contractors' waste disposal sites. In comparison to data from previous years, exposures have generally decreased as the radioactive materials have been removed and shipped

Table 8-3. Facility Area Monitoring.

TLD#	Location	1 st	2 nd	3 rd	4 th	Average 2σ (95%)	Annual Dose 2σ (95%)
		Quarter	Quarter	Quarter	Quarter		
(mrem)							
S6		57.6	38.8	33.6	34.5	41 ± 22	165 ± 88
088-TLD1	OWMF-50' East/S-6	70.4	57.6	47.5	51.8	57 ± 20	227 ± 78
088-TLD2	OWMF-50' West/S-6	58.7	55.9	42.8	46.3	51 ± 15	204 ± 59
088-TLD3	OWMF-100' West/S-6	90.8	59.8	38.7	40.5	57 ± 47	230 ± 190
088-TLD4	OWMF-150' West/S-6	83.4	37.9	23.7	23.8	42 ± 55	169 ± 222
054-TLD1	Bldg. #914	62.4	84.5	13.3	18.7	45 ± 68	179 ± 270

Notes:

See Figure 8-1 for TLD Locations.

from this area. The old Waste Management facility is posted as a radiological area; only appropriately radiation-trained personnel wearing personal dosimeters are allowed inside the facility.

The FAM TLD near Building 914 (054-TLD1) showed 62.4 and 84.5 mrem for the first and second quarters, respectively, which is above the natural background radiation. The elevated readings during the first and second quarters were attributed to the sky-shine phenomenon during the operation of the Booster and beam transfer operation in Building 914.

8.1.3 Building 650 Sump Outfall Monitoring

The former Reclamation Facility, also known as Building 650, was originally constructed for decontaminating radioactively contaminated clothing and heavy equipment. The facility was designed so decontamination could occur inside and outside of the building. During the 1950s and 1960s, radioactively contaminated water from the outdoor steam cleaning operation collected in a drain in the middle of a sloping concrete pad known as the Building 650 Sump. It was assumed that the contaminated water from the Building 650 Sump drained into the sanitary sewer system or into underground tanks. However, an investigation revealed that the drainage pipe from the outdoor pad behind the building led to a storm water drainage system, which discharged to a natural depression in a wooded area, and not to the sewage treatment plant or the underground tanks. This area consequently had become radiologically contaminated. The Building 650 Sump Outfall area was fenced and posted as a radiological area to prevent unauthorized entry and was continuously monitored with TLDs, beginning in 1997. Excavation of soil and remediation work started in March 2002 and was completed in June 2002 under the Environmental Restoration Program as Operable Unit (OU) IV, Area of Concern (AOC) 6. After the soil was excavated, a minimum of 6 inches of clean fill was placed over the remediated areas. The ground will be hydro seeded to minimize erosion of the cover material. Radiological soil contamination in the Building 650 Sump Outfall area has been remediated to acceptable soil concentrations in accordance with interagency agreements (IAG)

among DOE, EPA, and New York State. The cleanup levels are also protective of groundwater quality. During the period of land use by the federal government, remediated sites are restricted but can be used to support industrial laboratory operations with proper operational engineered controls and permits. Federal ownership of the site is expected through the year 2055 and BNL site security limits public access to this site. Any transfer of this site must meet EPA requirements 120(h) of the Comprehensive Environmental Response, Conservation and Liability Act (CERCLA) to ensure that future users are not exposed to unacceptable levels of contamination. The performance of these controls will be assessed internally on an annual basis via BNL's Assessment Program (as discussed in Chapter 2). BNL and DOE are committed to notifying the IAG members of any failures of the Land Use/Institutional Control (LU/IC) promptly, in accordance with the Occurrence Reporting and Processing System or the Laboratory's internal reporting procedures.

8.2 AIR EMISSIONS

The EPA regulates emissions from DOE facilities under requirements set forth in 40 CFR 61, Subpart H, *National Emissions Standard for Hazardous Air Pollutants* (NESHAPs). This regulation specifies the compliance monitoring and requirements for reporting radiation doses received by members of the public from airborne radionuclides. The regulations mandate that no member of the public shall receive a dose from air emissions greater than 10 mrem (100 μ Sv) per year from DOE operations. The emissions monitoring requirements set forth in Subpart H of 40 CFR Section 61.93(b) include the use of a reference method for continuous monitoring at major release points (those with a potential to exceed 1 percent of the 10-mrem standard), and a periodic confirmatory measurement program for all other release points. The regulations also require DOE facilities to submit an annual NESHAPs report to EPA that describes the major and minor emission sources and dose to the maximally exposed individual (MEI). The dose estimates from various facilities are given in Table 8-4.

As part of the NESHAPs review process at BNL, all emission sources that have any potential to emit radioactive emissions are evaluated for compliance. Activities conducted by the Environmental Restoration Division (ERD) that might generate emissions are exempt under CERCLA from NESHAPs review, but these activities are monitored and assessed for any potential to release radioactive emissions, and to determine dose contribution, if any, to the environment and members of the public. A number of ERD and Waste Management (WM) operations were evaluated for NESHAPs compliance in 2002. EPA's approved dose modeling software was used in dose calculations (see Section 8.2.1 for details). Because this software was designed to treat all radioactive emission sources as continuous emissions that occur over the course of a year, it is not well suited for estimating short-term or acute releases. Consequently, it overestimates potential contributions to dose from short-term sources and its results can be considered "conservative"—that is, erring on the side of caution.

8.2.1 Dose Modeling Program

Compliance with NESHAPs regulations is demonstrated through the use of EPA's CAP88-PC (Clean Air Act Assessment Package-1988), version (v.) 2. This computer program uses a Gaussian plume model equation to estimate the average dispersion of radionuclides released from elevated stacks or diffuse sources (EPA 1992). The program calculates a final value for projected dose at the specified distance from the release point by computing dispersed radionuclide concentrations in air, rate of deposition on ground surfaces, and intake via food pathway (where applicable). The program supplies both the calculated effective dose equivalent (EDE) to the MEI and the collective population dose within a 50-mile radius of the emission source. The CAP88-PC model provides very conservative (overestimated) dose estimates, in most cases. For purposes of modeling the dose to the MEI, all emission points are located at the center of the developed portion of the BNL site. Calculations are based on low-level environmental releases and chronic intakes. Input parameters used in the model include radionuclide type, emission

rate in curies per year, stack parameters such as height and diameter, and emission exhaust velocity. Site-specific weather and population data are factored into the assessments. Weather data are supplied by measurements from BNL's meteorological tower; these include wind speed, direction, frequency, and temperature (details in Chapter 1). Population data used in the model are based on the Long Island Power Authority population survey (LIPA 1999). Because visiting researchers and their families may reside at the BNL on-site apartment area for extended periods of time, these residents are also included in the population file used for dose assessment.

8.2.2 Maximally Exposed Individual

The MEI is defined as a hypothetical person who resides at the site boundary and has a lifestyle such that no other member of the public could receive a higher dose. This person is assumed to reside 24 hours a day, 365 days a year at the BNL boundary in the downwind direction, and to consume significant amounts of contaminated fish and deer during the year. In reality, it is a highly unlikely, worst-case scenario that such a combination of maximized dose to any single individual would occur.

8.2.3 Dose from Diffuse (Nonpoint) and Other Sources

Diffuse sources are radioactive contaminants (emissions) released into the atmosphere that do not have a defined source point. Such sources are also known as nonpoint or area sources. BNL evaluated the following potential radiological diffuse sources in calendar year 2002.

8.2.3.1 Building 490

In addition to other scientific research, the Medical Department (Building 490) conducts radiotracer research on animals. The Medical Department synthesizes compounds with small amounts of radiotracers, typically 2 to 20 millicuries (mCi) of radioiodines (I-131), in Room 9-508. Approximately 24 experiments may be conducted over the course of a year, inside a Lucite enclosure that contains an activated carbon filter within a laboratory fume hood. Room 9-133C is used to inject chemical compounds labeled with tritium (half life: 12.28 years) and

carbon-14 (half-life: 5,730 years). The NESHAPs source term is based on the annual usage and inventory of nuclides listed by the department on the Assessment Form, as required by the *Radio-logical Airborne Emissions* SBMS subject area. The I-131 (half-life: 8.04 days) may be used 24 times per year, with a maximum activity of 20 mCi. Tritiated chemicals may also be used 24 times per year, with a maximum activity of 1 mCi. Up to 100 mCi of carbon-14 may be used.

In calculations, the modeling software assumes that 100 percent of the total inventory was released to the environment (a highly unlikely, worst-case scenario). The tritium-labeled chemicals and C-14 were in solution and therefore were corrected for chemical form with an emission factor to estimate potential airborne releases; radioiodines were treated as gases (i.e., 100 percent vented). The potential annual EDE from radiological emissions in Building 490, Rooms 9-508 and 9-133C was calculated by the program to be 3.89E-03 mrem to the MEI at the southeast boundary.

8.2.3.2 Soil Activation Studies

A nondestructive Soil Carbon Measurement (SCM) system is being developed at BNL to quantify carbon distribution in the top 50 cm of soil based on nondestructive, inelastic scattering of fast neutrons (INS). The SCM system will activate the soil using a double sealed 14 MeV neutron accelerator.

Based on this source term, the synopsis report from the CAP88-PC modeling program estimated an EDE of 4.48E-8 mrem to the MEI at the southeast boundary. Although this EDE is well below 1 percent of the 10 mrem standard, radioactive air emissions were monitored because BNL is committed to the environmental ALARA (as low as reasonably achievable) policy.

8.2.3.3 Building 901

The Chemistry Department (Building 901) uses radiotracers for neuroimaging research. The radiotracers are fabricated in the form of ^{11}C labeled compounds. The procedure is initiated by trapping the $^{11}\text{CO}_2$ in a molecular sieve and reacting it with hydrogen to convert it into $^{11}\text{CH}_4$. Then it is converted to ^{11}CN by reacting it with

NH_3 . The complete procedure is performed in a laboratory hood and the waste gases are collected in an 8-foot weather balloon encased in a secondary polyethylene bag. The ^{11}C collected in the weather balloon is decayed for ten half-lives and then vented to the outside. All of the work is performed in Room 112 (the Hot Lab) and in the processing area where the balloons are kept, known as the “cave area.” Alternatively, the waste may be vented to a soda lime trap inside the laboratory hood within a shielded Hot Cell for decay (ten half-lives). Fluorine-18, produced by irradiating ^{18}O water, is used as a tracer. An aqueous form of ^{18}F for subsequent experiments is extracted by transferring the mixture of ^{18}F and ^{18}O water into a resin column, then eluting ^{18}F off the column using potassium/calcium carbonate. The potential sources of emissions from this operation are ^{11}C (half-life: 20.38 minutes) and ^{18}F (half-life: 109.77 minutes).

The NESHAPs evaluation was completed with the assumption that the complete, undecayed source inventory was emitted. The CAP88-PC dispersion modeling program provided an EDE of 1.33E-02 mrem to the MEI at the southeast boundary. The EDE from the ^{11}C and ^{18}F emissions was well below 1 percent of the 10-mrem limit.

In actual fact (as opposed to the computer model), the radioactive emissions were minimized in accordance with BNL’s commitment to ALARA by decaying the emission gases for ten half-lives before discharging them to the environment. This process effectively eliminates emissions. Therefore, Building 901 is not included in Table 8-4.

8.2.3.4 Waste Management – BLIP Transfers

The Waste Management group has the responsibility to store, characterize, consolidate, and repack radioactive waste materials for shipment to an off-site disposal location. Up to 30 times in a year, WM transfers waste from the Brookhaven Linac Isotope Producer (BLIP). In a BLIP transfer, waste units the size of a 1-gallon paint can are moved from one shipping container to another. Because the cans may have loose radiological contamination on their outside surfaces that in the transfer pro-

Table 8-4. Effective Dose Equivalent from Facilities.

Building	Facility or Process	Construction Permit No.	MEI Dose (a) (mrem)	Notes (a)
463	Biology Facility	None	8.45E-11	(b)
490	Medical Research	BNL-489-01	1.17E-05	(b)
491	BMRR	None	ND	
510	Calorimeter Enclosure	BNL-689-01	ND	
555	Chemistry Facility	None	6.96E-14	(b)
725	National Synchrotron Light Source	None	1.22E-08	(b)
750	HFBR	None	1.25E-05	
801	Target Processing Lab	None	8.40E-08	
802B	Evaporator Facility	BNL-288-01	ND	(c)
820	Accelerator Test Facility	BNL-589-01	ND	(d)
865	Reclamation Building	none	1.78E-04	
919	Liquid Effluent Storage Tankers	None	ND	
931	BLIP	None	8.60E-02	
938	REF/NBTF	BNL-789-01	ND	(c)
942	AGS Booster	BNL-188-01	ND	(e)
—	RHIC	BNL-389-01	ND	
Total from BNL Operations			8.62E-02	
EPA Limit			10.0 mrem	

Notes:

(a) "Dose" as used in this table means effective dose equivalent in a year.

(b) Calculations are based on 40 CFR 61, Appendix D methodology.

(c) This has become a zero emission facility since the original permit.

(d) This facility is no longer in use.

(e) Booster ventilation system prevents air release through continuous air recirculation.

ND = No-dose facility: not operational and/or zero air emissions in 2002.

cess could generate airborne particulates, a NESHAPs evaluation is completed.

The transfer process is conducted in open space within Building 865 in the High Bay Area where a portable HEPA ventilation system protects radiological workers. In the modeling program, the source term is based on previous bioassay calculations for a radiological worker, actual results from breathing zone air (BZA) analyses, and maximum loose radiological contamination on the external surface of the BLIP transfer cans. The dose calculations were completed using standard air dispersion equations because most radionuclides are not available in the CAP88-PC library. The modeling program estimated an EDE of 3.59E-06 mrem to the MEI at the southeast location. The MEI dose calculated with the air dispersion equation was estimated to be 1.12E-05 mrem. The dose from the BLIP transfers was well below the annual limit as specified in 40 CFR 61, Subpart H, and below the 0.1 mrem limit that triggers the requirement for a NESHAPs permit from EPA with continu-

ous monitoring of the emission source. Therefore, only an annual administrative review of the emission source was required for the BLIP transfer operation.

8.2.3.5 Waste Management – Respirator Cleaning

The Respirator Cleaning Operation in Building 865 decontaminates and cleans radiologically and nonradiologically contaminated respirators for reuse. The cleaning process consists of two steps: decontamination and sanitization. The decontamination is conducted in Room 114 and consists of hand washing the respirator using a solution containing FK 300 Special Respirator Cleaner. The resultant wash fluid contains FK 300 cleaner, wash water, and low-level radioactive waste. The wash fluid is collected and transported to Building 811 for off-site disposal. The sanitation process consists of mechanically washing the respirator again with FK 300 cleaner. The resultant wash fluid consists of FK 300 cleaner and water. The water is discharged to the sanitary sewer system. The vapors and particulates

from this process could become airborne; therefore, a separate exhaust system with HEPA filter (EF-102) vents the air to the environment. One thousand respirators were decontaminated and sanitized in 2002.

A NESHAPs evaluation was completed for this cleaning operation. The source term was based on the Trigger Level Calculation Form for the most restrictive Annual Limit on Intake (ALI) for radiation workers. The synopsis report from the CAP88-PC, v. 2.0 modeling program estimated an EDE of $8.54\text{E-}5$ mrem to the MEI at the southeast boundary. A NESHAPs permit application was not required and only an annual administrative review of the Respirator Cleaning Operation is required.

8.2.3.6 Waste Management – Compacting

The compactor in Building 865 uses a hydraulic press to compress waste by applying 500,000 pounds of pressure per square inch. The compactor can accommodate a B-25 container, which has about 100 cubic feet of capacity. The compactor is primarily used for low-level radioactive waste streams (such as paper, plastic, personal protective equipment, glassware, etc.) generated from the scientific laboratories. The expected volume reduction ratio after compaction is about 4:1, which results in significant savings in disposal costs. During the compacting operation, there is a potential to generate airborne radionuclides; therefore, the compactor has its own exhaust system with a HEPA filtration system, which is inspected and maintained before each use.

The CAP88-PC, v. 2.0 modeling program estimated an EDE of $8.23\text{E-}08$ mrem to the MEI at the southeast location—again, a conservative (overestimated) value. Although this dose estimate is very low, the compacting operation requires an annual review to confirm the absence of radioactive materials in forms and quantities not conforming to prescribed specifications and limits.

8.2.3.7 Waste Management – Hot Cell

A project in 2002 entailed safely transferring and consolidating three cobalt-60 sources for shipment to the Hanford Site. These sources were stainless steel/cobalt “tabs” arranged in an array held together by a stainless steel basket and

shielded within a lead pig. The transfer and consolidation of the Co-60 sources was conducted inside the Hot Cell of Building 865. The first cobalt-60 source was labeled as a 5,600-curie source, with a width of 2 in., length about 6 to 12 in., and a quarter-inch thickness. It was manufactured by Oak Ridge National Laboratory in 1964. The second cobalt source was labeled as a 1,000-curie source and had about the same dimensions as the first source. The third source was labeled as a 2-curie source with dimensions of 6 in. long by 3 in. diameter.

Although there was a very small probability for loose surface contamination to spread outside of the Hot Cell, a NESHAPs evaluation was conducted to evaluate potential dose to members of the public. The synopsis report from the CAP88-PC, v. 2.0, modeling program estimated an $8.15\text{E-}08$ mrem EDE to the MEI at the northeast location.

8.2.3.8 Sewage Treatment Plant

During the remediation project to remove abandoned sanitary lines, radiological contamination was found in manholes MH-192 through MH-201. The sludge in the manholes was removed and packaged for disposal at a licensed facility. The CAP88-PC, v. 2.0 modeling program estimated an EDE of $2.30\text{E-}13$ mrem to the MEI at the southeast location.

8.2.3.9 Mercury-Tritium Diffusion Pump

The purpose of this project was to dismantle the mercury-tritium diffusion pump and to characterize its contents and repackage it for disposal. Before dismantling began, a NESHAPs evaluation was performed. This evaluation was based on the label, which showed that the pump contained 50 curies of tritium as of January 8, 1976—although it was likely that no tritium remained in the apparatus because it had coils open to the air. The label also stated that the pump contained 1,000 cc of mercury; this would be drained into a pan after the flanges were opened and the apparatus had been dismantled. The dose estimate from the CAP88-PC, v. 2.0 modeling program was $3.03\text{E-}04$ mrem EDE to the MEI at the southwest location. This EDE was well below 1 percent of the 10 mrem standard.

8.2.3.10 BGRR BGD Filter Removal

The Below Ground Duct (BGD), a part of the Brookhaven Graphite Research Reactor (BGRR) primary air cooling system, was constructed from steel-reinforced concrete. The BGD consists of two separate ducts, north and south, which are connected to the reactor exhaust air plenums. The Outlet Air Filters comprise a single filter bank in each of the north and south BGDs. Each of these filter banks contains a total of 320 filter elements, which are arranged in eight cells that form a “four V” configuration. Each filter cell contains 40 elements arranged five across and eight high. A recent radiation measurement taken at a distance of 1 foot from the filters was 1 roentgen per hour. The elements in the Outlet Air Filters were installed at the beginning of the reactor’s operation and were in use throughout the 18 years of its operation. The filters were characterized in the year 2000; contaminants of interest are Co-60, Cs-137, Sr-90, Am-241, U-234, U-235, U-238, Pu-238, Pu-239, and Pu-240.

The EDE from removal of the BGRR BGD filters was estimated by the modeling program as $3.53\text{E-}05$ mrem to the MEI at the southeast location. This potential EDE is well below the 10 mrem limit specified in 40 CFR 61, Subpart H, and below the 0.1 mrem limit that would necessitate a NESHAPs permit and continuous monitoring of the emission source. Even though it is not required, continuous monitoring of the duct/stack will be implemented to maintain a record of actual emissions and to monitor any unplanned releases. Also, a separate HEPA-filtered ventilation system will be installed in the Duct Service Building (Bldg. 708-T) and a fixative will be applied to the filter surfaces to further minimize emissions to the environment and potential dose to members of the public.

8.2.4 Dose from Point Sources

Point source descriptions are given in Chapter 4, but an update on BLIP emissions is appropriate here because the BLIP is the only point source with the potential to contribute dose to members of the public. In 2002, the BLIP operated over a period of 21 weeks. The proton beam average current was 86.2 microamperes. During this pe-

riod, 1,410 Ci of carbon-11 and 4,270 Ci of oxygen-15 gases were released. Tritium produced from activation of the target cooling water was also released, but in very small quantities. The decrease in oxygen-15 emissions, compared to 2001, (7,400 Ci) was primarily due to a decrease in operational period (35 weeks in 2001 compared to 21 weeks in 2002). The modeling program estimated the EDE to the MEI was $8.60\text{E-}02$ mrem.

Although a comparison to the previous year’s emissions shows that total emissions decreased in 2002, further reductions in emissions to the ambient air are being pursued as an objective for the BLIP facility. Moisture is the primary source of emissions (humidity from the hot cell’s cooling water). Therefore, a shroud seal was installed to enclose components of the assembly, which includes the cooling water surface (a 16-in. diameter shaft), the transfer cases for the target holder, the chain drive assembly (with motor supports), and any other associated appurtenances. The shroud seal should result in a significant decrease (about 28 percent) in gaseous emissions. When enough operational data have been collected, its efficiency will be assessed.

8.3 INGESTION PATHWAY

Deer and fish at or near BNL have the potential to accumulate radioactivity attributable to BNL operations. As discussed in Chapter 6, deer meat samples collected on the BNL site and less than 1 mile beyond the BNL site boundary were used to assess the potential dose impact to the MEI. To estimate the dose impact, it was assumed that the MEI consumed 15 pounds of fish and about 64 pounds of venison per year (NYSDOH 1999).

Thirty-eight samples of deer meat (flesh) were considered for dose calculations. Potassium-40 (K-40) and cesium-137 (Cs-137) were the two radionuclides detected in these samples. Potassium-40 is a naturally occurring radionuclide and is not related to BNL operations. The average K-40 concentrations were 3.0 ± 0.4 pCi/g in the flesh and 2.4 ± 0.4 pCi/g (wet weight) in the liver. The average Cs-137 concentrations were 1.5 ± 0.4 pCi/g in the flesh and 0.4 ± 0.08 pCi/g (wet weight) in the liver (average on BNL site and less than 1 mile radius). The potential

dose from consuming deer meat with the average C-137 concentration was estimated as 2.2 mrem (22 μ Sv) per year. This is about 22 percent of the health advisory limit of 10 mrem (100 μ Sv) established by the New York State Department of Health.

In 2001, fish sampling was suspended on site because years of fish sampling had depleted the population of larger fish. As a result, it would be necessary to take many smaller fish to obtain a sample sufficiently large to complete all analyses desired. The sample size (minimum 1 kg) for fish samples plays a critical role in sensitivities for the detection of specific radionuclides. BNL will continue with the suspension for up to three years to allow the on-site fish populations to recover and mature. In collaboration with the New York State Department of Environmental Conservation (NYSDEC) Fisheries Division, BNL maintains an ongoing program of collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. The only on-site sampling in 2001 was performed by New York State in the stretch of river immediately east of the last gauging station on BNL property to Schultz Road, and in Ice Pond just off the Peconic River east of BNL. In 2002, Chain Pickerel samples collected by NYSDEC at Donahue's Pond had the highest concentration of Cs-137, so these values were used to estimate EDE to the MEI (assuming consumption of 15 pounds of fish). The potential dose from consuming fish was estimated at 0.25 mrem (2.5 μ Sv) per year. It is highly unlikely that an individual would consume fish with the highest concentration and from this location, but these data were used to estimate dose as a worst-case scenario.

8.4 CUMULATIVE DOSE

Table 8-5 summarizes the potential cumulative dose from the BNL site. The total dose to the MEI from air and ingestion pathways was estimated to be 2.54 mrem (25 μ Sv), as shown in Table 8-5. In comparison, the EPA regulatory limit for the air pathway is 10 mrem (100 μ Sv) and the DOE limit from all pathways is 100 mrem (1,000 μ Sv). The effective dose was well below the DOE and EPA regulatory limits, and within normal background levels. The potential

dose from drinking water was not estimated, because most of the residents adjacent to the BNL site get their drinking water from the Suffolk County Water Authority.

To put the potential dose impact into perspective, a comparison was made with other sources of radiation. The annual dose from all natural background sources and radon is about 300 mrem (3 mSv). A chest x-ray results in 5 to 20 mrem per exposure. Using natural gas in homes yields about 9 mrem per year, cosmic radiation gives 26 mrem to humans, and natural potassium in the body gives about 39 mrem of internal dose. Even with conservative (overstated) estimates of dose from air pathways and the ingestion of local deer meat and fish, the cumulative dose from BNL operations was well below the dose that could be received from a single chest x-ray.

8.5 DOSE TO AQUATIC AND TERRESTRIAL BIOTA

DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, provides the guidelines for screening methods to estimate radiological doses to aquatic animals, terrestrial plants, and terrestrial animals using the environmental surveillance data. The RESRAD-BIOTA 1.0 biota dose screening program was used to evaluate compliance with the requirements for protection of biota specified in DOE Order 5400.5 (1990), *Radiation Protection of the Public and the Environment*, and proposed Rule 10 CFR 834, Subpart F (66 FR 25380). The terrestrial animal and plant dose was evaluated based on 410 pCi/kg of Cs-137 in soil at the P7 sampling location. The surface water concentrations used to evaluate biota dose were based on effluent readings taken just upstream of the Sewage Treatment Plant: 1.4 pCi/L for Cs-137, 640 pCi/L (maximum) for tritium, and 1.09 pCi/L for strontium-90. For the dose to aquatic animals, the highest Cs-137 concentration (800 pCi/kg, at Lower Lake, Carmens River) was used. The sum of aquatic animal dose was estimated to be 1.37E-3 rad and the sum of riparian animal dose was 3.24E-3 rad. Therefore, dose to aquatic animals was well below the 1-rad (10 mGy) limit. The doses to terrestrial animals and plants were estimated to be 3.78E-4 and

Table 8-5. BNL Site Dose Summary.

Pathway	Dose to Maximally Exposed Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose
Air	0.086 mrem (0.86 micro Sv)	<1%	0.33 person-rem
Water	None	None	None
Ingestion (fish)	0.25 mrem (2 micro Sv)	<1%	Not tracked
Ingestion (deer meat)	2.20 mrem (22 micro Sv)	2.2%	Not tracked
All pathways	2.54 mrem (25 micro Sv)	2.5%	0.33 person-rem

1.86E-4 rad, respectively, well below the biota dose limit of 0.1 rad (1 mGy).

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Quality Assurance

Quality assurance is an integral part of every activity at Brookhaven National Laboratory. BNL's Quality Assurance Program ensures that all environmental monitoring data meet quality assurance and quality control requirements. Samples are collected and analyzed in accordance with standard operating procedures that are designed to ensure samples are representative and data are reliable and defensible. Quality control in the analytical laboratories is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated as required by project-specific quality objectives before they are used to support decision making.

BNL uses the on-site Analytical Services Laboratory and four off-site contractor laboratories to analyze environmental samples. All analytical laboratories are certified by New York State for the tests they perform for BNL and are subject to oversight that includes state and national performance evaluation testing, review of quality assurance programs, and audits.

The three primary laboratories reporting radiological analytical data (BNL and two off-site laboratories) each scored 90 percent or better in state and federal performance evaluation programs. BNL's overall satisfactory score in radiological testing was 97 percent, an improvement over 2001. In nonradiological performance evaluation testing under the New York State Environmental Laboratory Approval Program (potable and nonpotable water), BNL received a satisfactory rating of 96.8 percent; the two off-site contractor laboratories scored 96.8 percent and 98.7 percent.

BNL's combined score of 96.2 percent "overall satisfactory" for the 573 radiological and nonradiological performance evaluation tests carried out in 2002 is considered excellent. The multilayered components of quality assurance monitored at BNL ensure that all analytical data reported for the Site Environmental Report 2002 are reliable and of high quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by DOE Order 5400.1 (1988), *General Environmental Protection Program*, BNL has established a Quality Assurance/Quality Control (QA/QC) Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent with the requirements of 10 CFR 830 Subpart A, "Quality Assurance Requirements," and DOE Order 414.1A

(2001), "Quality Assurance." Responsibility for quality at BNL starts with the Laboratory director and extends throughout the entire organization. The purpose of the BNL Quality Management (QM) System is to implement QM methodology throughout the various BNL management systems and associated processes to:

- Plan and perform BNL operations in a reliable and effective manner to minimize the

- impact on the environment, safety, and health of the public and staff
- Standardize processes and support continued improvement in all aspects of BNL operations
- Enable the delivery of products and services that meet or exceed our customers' requirements and expectations.

For environmental monitoring, QA is defined as an integrated system of management activities that includes planning, implementation, control, reporting, assessment, and continual improvement.

Quality Control activities measure each process or service against the QA standards. QA/QC practices and procedures are documented in detail in manuals, plans, and a comprehensive set of environmental monitoring standard operating procedures, or EM-SOPs (BNL 2002). Staff who must follow these procedures and plans are required either to sign off on the SOPs or receive training.

The ultimate goal of the environmental monitoring and analysis QA/QC program is to ensure that results are representative and defensible and that data are of the type and quality needed to verify protection of the Laboratory and community environment, as well as the public and BNL employees. 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.

First, BNL environmental scientists and engineers determine sampling requirements using the U.S. Environmental Protection Agency (EPA) Data Quality Objectives (or equivalent) process. During this process, the team project manager determines the type, amount, and quality of data needed to support decision making, legal requirements, stakeholder concerns, and technical information. Next, the team of scientists and engineers prepares an environmental monitoring plan or project-specific sampling plan that specifies the location, frequency, type of sample, analytical methods to be used, and a sampling schedule. These plans or the standard operating procedures also specify data acceptance criteria. Contracts with off-site analytical laboratories are established as necessary. Detailed SOPs direct sampling technicians on proper sample collection, preservation, and handling requirements. Field quality control samples are prepared as neces-

sary. Samples are analyzed in the field or at certified laboratories in accordance with SOPs. The results are then validated or verified in accordance with published procedures. Finally, data are reviewed and evaluated by environmental professionals and management in the context of expected results, related monitoring results, historical data, and applicable regulatory requirements (e.g., drinking water standards, permit limits, etc.). Data are then used to support decision making. Data are also reported and summarized in this annual Site Environmental Report, as required. Most of the data contained in this report are condensed and summarized from a separate document, *Year 2002 ASL Quality Assurance Report* (Scarpitta and Heotis 2003).

9.2 SAMPLE COLLECTION AND HANDLING

In 2002, environmental monitoring samples were collected as specified by SOPs, the *BNL Environmental Monitoring Plan, CY 2002 Update* (BNL 2002a), and project-specific work plans, as applicable. For example, the *BNL Groundwater Monitoring Program Quality Assurance Project Plan* (BNL 1999a) describes the QA program and QC requirements followed for groundwater monitoring. This plan documents organizational structure, documentation requirements, sampling requirements, field QA/QC sample collection, acceptance criteria, sample custody requirements, data validation procedures, and general data handling/database procedures. (Since almost half of all environmental monitoring samples collected for BNL are of groundwater, this chapter uses groundwater procedures for many of the examples.)

BNL has prepared sampling SOPs for all environmental media, including groundwater, surface water, soil, sediment, air, flora, and fauna (BNL 2002b). These procedures contain detailed information on how to prepare for sample collection; what type of field equipment to use and how to calibrate it; how to properly collect, handle, and preserve samples; and how to manage any wastes generated during sampling. The procedures ensure consistency between samples collected by BNL employees or outside contractors, whether those samples are collected under the environmental restoration or environmental surveillance programs.

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

9.2.1 Field Sample Handling

To ensure the integrity of samples, chain-of-custody (COC) was maintained and documented for all samples collected. A sample is considered to be in the custody of a person if any of the following rules of custody are met: a) the person has physical possession of the sample, b) the sample remains in view of the person after being in possession, c) the sample is placed in a secure location by the custody holder, or d) the sample is in a designated secure area. These procedures are outlined in EM-SOP-109, *Chain-of-Custody Procedure* (BNL 2002b). All environmental monitoring samples for 2002 maintained a valid COC from

the time of sample collection through sample disposal.

9.2.1.1 Custody and Documentation

The field sampling team leader was responsible for the care and custody of samples until they were transferred to a receiving group or analytical laboratory. Samples requiring refrigeration were placed immediately into a refrigerator or a cooler with cooling media, and kept under custody rules. The team member who maintained custody of the samples signed the COC form when relinquishing custody. The laboratory or group receiving the samples signed the COC form when accepting custody.

The sampling team is also required to maintain field logsheets and a bound, weatherproof logbook that records sample ID, collection time, description, and collection method, as well as notes on daily weather conditions, field measurements, and other appropriate site-specific observations.

9.2.1.2 Preservation and Shipment

Samples shipped to off-site laboratories were managed as follows. Before sample collection, the team prepared all bottle labels and put them on the appropriate containers, as defined in the QA Program Plan or applicable EM-SOPs. Appropriate preservatives were added to the containers before or immediately after collection; in appropriate cases, samples were refrigerated.

Sample preservation was maintained as required throughout shipping. If samples were sent via commercial carrier, a bill-of-lading was used. COC seals were placed on the shipping containers; their intact status indicated 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 and 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 EM-SOP-200, *Collection and Frequency of Field Quality Control Samples*

(BNL 2002b). Equipment (rinsate) blanks and trip blanks were generally collected for all media except air, soil, and flora and fauna.

An *equipment blank* is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool before sample collection. The rinsate is collected to demonstrate that the sampling tool was not contaminated. Equipment blank samples were collected, as needed, to verify the effectiveness of the decontamination procedures on nondedicated or reusable sampling equipment. For the groundwater monitoring program, equipment blanks were collected from the final rinse water that was generated during decontamination.

A *trip blank* is collected with each sampling event for samples being analyzed for volatile organic compounds (VOCs). Analysis of trip blanks shows whether sample bottles were contaminated during shipment from the factory, while in bottle storage during sample collection in shipment to the laboratory, or during analysis at a lab. For the groundwater monitoring program, trip blanks consist of an aliquot of reagent-grade water sealed in a sample bottle, prepared either by the analytical laboratory prior to shipping the sample bottles to BNL or by field sampling personnel. Under the groundwater monitoring program, trip blanks were included with all shipments of aqueous samples for VOC analysis.

Field blanks were collected to check for radiological and nonradiological cross-contamination that might occur during sample collection. For the groundwater monitoring program, one field blank was collected for every twenty samples or one per sampling round, whichever was more frequent. The field blanks are analyzed for the same parameters as the groundwater samples.

Contaminants in trip, field, and equipment blanks included methylene chloride, acetone, toluene, and phthalate esters. When these contaminants were detected, validation and/or verification procedures were used, where applicable, to qualify the associated data as “nondetected,” as described in procedures EM-SOP-203 through 212 (see Section 9.4). The results from blank samples collected during 2002 did not indicate any significant impact to the quality of environmental data. Typically, the only compounds detected in the blanks were tolu-

ene, chloroform, methylene chloride, and acetone. These compounds are commonly detected in blanks and do not pose significant problems with the interpretation of the analytical results because EPA has defined these analytes as common laboratory contaminants.

Field duplicate samples were analyzed to check the reproducibility of sampling and analysis. For the groundwater monitoring program, duplicates were collected for 5 percent of the total number of samples collected for a project per sampling round. There were 161 field duplicate samples collected during 2002 groundwater sampling that were all acceptable for input into the Environmental Information Management System (EIMS) database (BNL 2003). Field duplicate acceptability was based on EPA Region II guidelines (EPA 1996).

The relative percent difference between the sample and the duplicate for concentrations above the contract reporting limit is required to be below 20 percent (see Section 9.6.3 for more information on the relative percent difference statistic). Although there were several instances where individual compounds did not meet the 20 percent relative percent difference limit, the majority of parameters analyzed for those samples did meet the 20 percent requirement. This indicated that the field sampling personnel and the laboratories were performing the sample collection and analyses at a consistently high level of quality, meeting the data quality objectives.

Matrix spike and *matrix spike duplicate* analyses were performed to determine whether the sample matrix adversely affected the sample analysis. Matrix spikes are used to evaluate the effect of the sample matrix on the accuracy and precision of a specific analysis. They were performed at a rate of approximately one per 20 samples collected or per project requirements. For groundwater samples, no significant matrix effects were observed.

9.2.3 Tracking and Data Management

9.2.3.1 Sample Tracking

Environmental Monitoring Program samples and analytical results were tracked in the EIMS. Tracking began when a sample was recorded on

a COC. Copies of the COC form and supplemental forms were provided to the project manager or the sample coordinator and forwarded to the data coordinator to be entered into the EIMS. Each analytical laboratory also maintains its own internal sample tracking system.

9.2.3.2 Data Management

Data management procedures are in place to govern tracking, validation, verification, and distribution of the analytical data. When samples were shipped to an analytical laboratory, COC information was entered into the EIMS. Following sample analysis, the laboratory provided the results to the project manager or designee and, when applicable, to the validation subcontractor in accordance with that laboratory's contract.

9.2.3.3 Distribution of Analytical Data

Once data were entered into the EIMS, reports were generated by one of two means. Project personnel and DOE-Brookhaven Area Office staff have a data query tool that allows access to all analytical sample results and printed reports. If a project required a special report format, the data management group was contacted to design and print it.

9.3 SAMPLE ANALYSIS

Environmental samples were analyzed either by the on-site BNL Analytical Services Laboratory (ASL) or by one of four contractors whose selection is discussed in Section 9.3.2.

All samples were analyzed according to EPA-approved methods, where such methods exist. Where no EPA-approved methods exist, standard industry methods were approved by BNL personnel. In addition, sampling technicians performed field analyses for parameters such as temperature, conductivity, pH, dissolved oxygen, and turbidity.

Samples sent off site for radiological analyses were those requiring methods (either EPA or DOE) that ASL does not perform, such as actinide analyses in soil, vegetation, animal tissue, and water. Most samples used to verify compliance with permitting requirements were sent off site, as were samples requiring semivolatile organic analysis or the toxicity characteristic

leachate procedure (TCLP). In addition, when demand exceeded ASL capacity, some samples to be tested for strontium-90, metals, and polychlorinated biphenyls (PCBs) were sent to a contractor laboratory.

9.3.1 ASL Qualifications

BNL's ASL performs approximately 5,000 radiological and nonradiological (organic/inorganic) analyses per year on environmental samples to support both environmental monitoring and facility operations. The ASL is certified by the New York State Department of Health (NYSDOH) and the EPA National Environmental Laboratory Accreditation Program (NELAP) for tritium, gross alpha/beta, and gamma in potable and nonpotable water analysis in several matrices, all of which are approved EPA methods. Additional qualifications are discussed in Section 9.6.

9.3.2 Contractor Lab Qualifications

BNL procured and maintained contracts with the following off-site laboratories:

- General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes
- H2M Lab in Melville, New York, for nonradiological analytes
- Severn-Trent Lab (STL) in Newburgh, New York, Connecticut, and St. Louis, Missouri, for radiological and nonradiological analytes
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes.

The process of selecting contractor laboratories involves a number of factors: 1) their record on proficiency evaluation (PE) tests, 2) pre-selection bidding, 3) post-selection auditing, and 4) their adherence to their own QA/QC programs. Once a contract has been awarded, the laboratory must follow the QA requirements and analytical and QC requirements in the BNL Statement of Work. Routine QC procedures that labs must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. All the analytical labs that BNL uses are certified by

NYSDOH for the relevant analytes. The laboratories also are subject to PE testing (Section 9.7) and audits.

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject either to data verification or data validation performed in accordance with established procedures, when the data quality objectives of the project require this step. The data verification process involves checking for common errors associated with analytical data. The following criteria 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.
- *Incorrect test method* - The analysis was not performed according to a method required by the contract.
- *Poor recovery* - The analyte or radioisotopes added to the sample prior to laboratory processing were not recovered at the recovery ratio required by the contract.
- *Insufficient QA/QC data* - Supporting data received from the analytical laboratory were insufficient to allow validation of results.
- *Incorrect minimum detection limit (MDL)* - The laboratory reported extremely low levels of analytes as "less than minimum detectable," but the contractually required limit was not used.
- *Invalid COC* - There was a failure to maintain proper custody of samples, as documented on chain-of-custody forms.
- *Instrument failure* - The instrument did not perform correctly or was broken.
- *Preservation requirements not met* - The requirements identified by the specific analytical method were not met or properly documented.
- *Contamination of samples from outside sources* - These possible sources include sampling equipment and personnel.
- *Matrix interference* - Analysis was affected by dissolved inorganic/organic materials in the matrix.

- *Incomplete data package or report*—Some information was missing.

Data *validation* is a more exhaustive process that includes all the verification checks as well as checks for less common errors, including calibration that was not conducted as required, internal standard errors, transcription errors, and calculation errors.

The amount of data that is checked varies, depending on the environmental media and on the data quality objectives for each project. Data for some projects, such as long-term groundwater monitoring, may be verified only, not validated. Data from initial investigations receive the more rigorous validation testing, performed on 20 percent to 100 percent of the analytical results. The results of the verification and validation process are entered into the EIMS.

9.4.1 Verifying and Validating ASL Results

For samples analyzed by BNL's ASL in 2002, the QA officer or group leader verified that all analytical batches fulfilled internal QA/QC acceptance criteria. These criteria, which include precision, accuracy, recovery, instrument background checks, and stable instrument efficiency performance, are fully described in ASL's *QA Program Plan* (BNL 1999b). All QA/QC data were reviewed before ASL results were reported.

9.4.2 Verifying and Validating Off-Site Results

A subject matter expert in either radiological analyses or analytical chemistry reviewed a percentage of the 2002 results from off-site labs depending on project-specific data quality objectives. Nonradiological data analyzed off site were verified and validated using EPA Contract Laboratory Program guidelines (EPA 1992, 1996). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 1997, DOE 1994).

9.5 ANALYTICAL LABORATORY QA/QC

Sample results for environmental restoration and environmental surveillance were analyzed by the on-site ASL, or by one of the off-site contract labs: STL, GEL, Chemtex, or H2M.

For ASL analyses, procedures for calibrating instruments, analyzing samples, and assess-

ing quality control (Appendix D) are consistent with EPA methodology. QC checks that were performed include 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. The ASL supervisor, QA officer, or group leaders reviewed all ASL analytical and QA results before data were reported. More details of the ASL QA program are in Section 9.6.

Off-site contractor laboratories that perform radiological and chemical analyses for BNL also are required to maintain stringent QA programs. Their contracts specify analytes, methods, required detection limits, and deliverables—which include standard batch QA/QC performance checks. As part of the contract lab selection process, contract labs were required to provide BNL with copies of their QA/QC manuals, as well as their QA program plans.

A nonconformance report was generated when discrepancies were found in field sampling designs, documented procedures, COC, data analyses, data processing systems, QA software, or when failures in PE testing occurred. Following an investigation into the root cause, corrective actions were made and tracked to closure.

9.6 ASL INTERNAL QUALITY ASSURANCE PROGRAM

This section further describes the QA requirements for analytical activities conducted as part of the 2002 BNL Environmental Monitoring Program and the results of QA checks. ASL's nonradiological chemical group is certified by the NYSDOH Environmental Laboratory Approval Program (ELAP) to perform analyses utilizing EPA Methods 524 and 624 for volatile organic analytes, in potable and wastewaters, respectively. Thirty-seven VOCs are currently provided for analysis with Method 624 (for ground and wastewaters), an additional 26 new analytes since 1998. EPA Method 524 (for potable water) includes 63 organic analytes and was a new addition to ASL's capabilities. Metals are analyzed utilizing both atomic absorption spectroscopy and inductively coupled plasma/

mass spectroscopy by EPA methods. ASL is certified for analyses of 17 metals (the entire ELAP list) in potable water as well as 21 metals in wastewater. Certification for three anions has been established for potable and wastewaters using EPA Method 300.

In May 1999, ASL issued its own *QA Program Plan* (BNL 1999b) following EPA Region II guidelines (EPA 1998). Twenty-five internal operating procedures maintained by ASL were revised in 2001 and four were added in 2002. The QA procedures followed at ASL include daily instrument calibrations, efficiency and background checks, and routine tests for precision and accuracy. A detailed description of these activities can be found in the document titled *Year 2002 Quality Assurance Report of the Analytical Services Laboratory* (Scarpitta and Heotis 2003). A brief summary of that report is given below.

9.6.1 Radiological Instrument Calibrations

ASL operates eight high-purity germanium gamma detectors. Each detector was calibrated daily for energy and instrument efficiency using a NIST-traceable cesium-137 standard. Geometry efficiency calibrations were performed annually. Efficiency is the measure by which radiological decaying events are converted into observable counts (counts per minute). During 2002, all eight gamma detectors performed well within the EPA acceptance limit of 1 keV of the 662 keV centroid peak. One gamma detector was out of service for repair during the month of July.

ASL operates two gross alpha/beta (GAB) detectors and two liquid scintillation spectrometers for tritium analysis. Instrument background and count-time were used to determine the “minimum detection limit” (MDL) of a radiological analyte. In 2002, there was no unusual drift or variability in instrument background for alpha, beta, and tritium, based on the mean background count-rates (and one standard deviation) values. Instrument efficiencies were determined daily, using a calibration standard, and averaged for the calendar year.

9.6.2 Upgrades

In 2002, ASL made the following six upgrades and repairs:

- New Tennelec alpha/beta counter plus software upgrade - April
- Tennelec LB 5140 electronic board repair - May
- Preventative Maintenance of Liquid Scintillation Analyzer, Unit 4 - May
- Purchased Dell Optiplex GX260 WIN 2000 Pro Computer for Gamma System
- Canberra GC8021 HPGe Detector (s/n 2007029) restored - August
- GC/MS Agilent system brought on-line.

9.6.3 Accuracy and Precision

Accuracy is the percent difference between a measured value and its known (expected) value. Precision is the percent difference between two measured values. The measure of batch precision is the “relative percent difference” statistic. This is defined as the absolute difference between two results, divided by the average of both results, multiplied by 100. Typically, a radioactive tracer solution (i.e., “spike”) is added to either a routine sample or tap water sample as a means of determining both precision and accuracy. In the case of nonradiological analyses, the spike is a known amount of a given analyte added to a sample and the accuracy is stated as “percent recovery”: the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

9.6.3.1 Gross Alpha/Beta

For gross alpha/beta, the relative percent difference was determined for each batch of analyses performed. Tap water was spiked with known amounts of americium-241 (for alpha) and strontium/yttrium-90 (for beta) in order to determine batch precision. The acceptance criterion for batch precision is a relative percent difference less than 20 percent (for activity concentrations that are five times greater than the method MDL). During 2002, gross alpha/beta batch precision for all 534 batches tested was within the acceptable range; no batches were rejected.

9.6.3.2 Tritium

Tritium precision was determined for 267 batches processed in 2002. ASL utilizes three sampling protocols for differing sample volumes

(i.e., 7 mL distilled, 7 mL undistilled, and 1 mL undistilled). Blind proficiency evaluation test scores for tritium were satisfactory. Two batches were rejected for tritium in 2002, corresponding to a rejection rate of 0.7 percent.

9.6.3.3 Strontium-90

The eight batches of strontium-90 processed in 2002 all met standard precision and accuracy requirements. There were two rejected batches of the eight processed, after which the batches were repeated and found acceptable.

9.6.3.4 Nonradiological Organic and Inorganic Analyses

Method precision was determined for 14 VOCs, three anions (discussed below), and 21 metals processed by ASL in 2002. With the exception of two metals, all analytes had relative percent differences within ASL's internal acceptance limit of ± 20 percent. The three standard deviation uncertainties were also within the EPA acceptance criteria.

ASL has an internal QC program for the ion chromatography, Inductively Coupled Plasma Mass Spectroscopy (ICP/MS), and atomic absorption methods used for inorganic analyses. Several QC checks were performed for each batch of metals and anions. For the 21 certified metals analyzed by ASL, beryllium and aluminum exceeded the three standard deviation EPA acceptance criteria for recovery. For these two metals, this was attributable to a single daily excursion that resulted in an overall three-sigma standard deviation value that was higher than acceptable. For this reason, analytical data for aluminum and beryllium from the months in question were "qualified" but still usable.

The ASL has an internal QC program for the gas chromatography/mass spectroscopy method used for 14 primary VOCs. Recoveries and 99 percent confidence intervals were determined for approximately 74 independent VOC batches. Average recoveries for all of the 14 analytes were within their target ranges of ± 25 percent for both EPA 524.0 and EPA 624.0 methods.

The 99 percent confidence intervals for surrogate recoveries were also determined for four analytes in 2002. The recovery for 4-

bromofluorobenzene, toluene, and dibromofluoromethane were within three-sigma acceptance criteria. All surrogate recoveries were within EPA acceptance limits.

9.7 PROFICIENCY EVALUATION TESTING

As in prior years, ASL and three contractor laboratories (GEL, STL, and H2M) participated in several national and state proficiency evaluation (PE) testing programs. Results of those PE tests provide information on the quality of a laboratory's analytical capabilities.

During 2002, ASL, GEL, STL, and H2M participated in either the NYSDOH ELAP (for radiological and nonradiological PE testing) or the DOE Environmental Measurements Laboratory (EML) Quality Assessment Program (for radiological PE testing only). Both H2M and STL also participated in the Analytical Products Group (APG) PE Testing program. All laboratories participated in at least one proficiency evaluation program, although several labs participated in multiple programs. The results from these blind, independent tests are discussed in Section 9.7.1.

Effective December 21, 1998, EPA terminated its PE programs for both radiological and nonradiological analytes. To replace that program, ASL, GEL and STL chose Environmental Resource Associates (ERA) private, independent PE programs. H2M participates in both the ERA and APG programs.

PE test data are not presented in this report for the fourth contractor, Chemtex Laboratory, because there is no ERA or NYSDOH PE testing program for the specific analytes analyzed by this laboratory. Chemtex performed three chemical analyses for BNL on the following analytes: tolyltriazole, polypropylene-glycol-monobutyl-ether, and 1,1-hydroxyethylidene-diphosphonic acid.

9.7.1 Summary of Test Results

Figures 9-2 and 9-3 summarize the 2002 scores of BNL's ASL and the three contractor laboratories that participated in the mandatory DOE EML program (for radiological analytes only) and the NYSDOH ELAP, as well as the voluntary ERA program. The bar graphs of

Figure 9-2. Radiological Proficiency Evaluation Scores in U.S. DOE and ERA Programs.

Figure 9-3. Nonradiological Proficiency Evaluation Scores in ELAP, ERA, and Independent Programs.

Figures 9-2 and 9-3 summarize all tabulated radiological and nonradiological results (as percentage scores) that were “Acceptable,” “Warning (But Acceptable),” or “Not Acceptable,” for each analytical laboratory, by PE test program. A Warning is considered “Satisfactory,” being within two and three standard deviations of the target value. (An Overall Satisfactory score is the sum of results rated as Acceptable and those

rated as Warning, divided by the total number of results reported.) A Not Acceptable rating reflects a result that is greater than three standard deviations of the target value. Tabulated results are presented in the ASL’s *2002 Annual QA Report* (Scarpitta and Heotis, 2003).

During 2002, the NYSDOH ELAP did not provide radiological samples for PE testing. The ASL’s Overall Satisfactory score on radiological

PE tests in ERA and mandatory DOE EML radiological program was 96.2 percent, whereas BNL's off-site contractor laboratories, GEL and STL, scored 97.8 percent and 100 percent, respectively. In the voluntary ERA radiological program, BNL, STL, and GEL achieved scores of 96.4 percent, 95.8 percent and 90.5 percent, respectively.

For nonradiological results, the Overall Satisfactory results ranged from 94.7 percent to 98.7 percent for BNL, H2M, GEL, and STL in the ERA, APG, and NYSDOH testing programs.

BNL's combined score of 96.2 percent Overall Satisfactory on the 573 radiological and nonradiological PE tests performed in 2002 is considered excellent.

9.7.2 Radiological Assessments

Both ASL and GEL participated in the DOE EML Quality Assessment Program and the ERA radiological program. Results are discussed below.

9.7.2.1 EML Radiological Results

Overall, ASL's performance in the EML program was Satisfactory in 97.7 percent of the analyses performed on four matrices (air, vegetation, water, and soil). Thirty-two of 43 analyses (74.4 percent) were within established DOE EML limits, showing acceptable agreement with the known value. Ten results (23.3 percent) were within warning limits, also earning Satisfactory status. One analysis (2.3 percent) exceeded the acceptance limits, as shown in Figure 9-2.

Figure 9-2 also presents GEL's performance, which was Satisfactory (acceptable or within warning limits) in 97.8 percent of the analyses performed on the four matrices (air, vegetation, water, and soil). Seventy-seven of 92 analyses (83.7 percent) were within EML's acceptance limit; 13 of 92 analyses (14.1 percent) were within upper and lower warning limits, demonstrating satisfactory agreement; two analyses exceeded the acceptance limits.

STL participated in the EML program, with 72 analyses of 90 found acceptable (80 percent) and 18 within warning limits (20 percent). This corresponds to an overall passing score of 100 percent.

9.7.2.2 ELAP Radiological Results

There were no samples provided by the NYSDOH ELAP for radiological testing in 2002.

9.7.2.3 ERA Radiological Results

ASL, STL, and GEL participated in the ERA radiological performance evaluation studies. ASL's overall score for the 28 results reported in 2002 was 96.4 percent, with one unacceptable gamma result (cesium-137). GEL's overall score in the ERA radiological PE studies was 90.5 percent, whereas STL's overall score was 95.8 percent.

9.7.3 Nonradiological Assessments

During 2002, ASL, GEL, STL, and H2M participated in the NYSDOH ELAP, which certifies laboratories that test for nonpotable water, potable water, and solid wastes. Note that STL has three labs: one in Missouri, one in Connecticut, and one in New York. Although participation in the ERA water supply and water pollution studies is not required for New York State certification, ASL and GEL also participated in the ERA evaluation. These results are summarized in Figure 9-3.

9.7.3.1 ELAP Nonpotable Water Results

Of the 121 results reported for ASL, there were five Not Acceptables, earning ASL an Overall Satisfactory score of 95.9 percent. GEL did not participate in ELAP because they are NELAP Certified. H2M reported 587 results, with eight Not Acceptables, scoring 99.5 percent. STL's three labs reported 1,315 results and scored 97.5 percent.

9.7.3.2 ELAP Solid and Hazardous Waste Chemistry

ASL scored 100 percent in this category for the 14 results reported for the NYSDOH ELAP Solid and Hazardous Waste Chemistry Proficiency Program.

9.7.3.3 ELAP Potable Water Results

In the potable water category of the NYSDOH ELAP, BNL's ASL reported 143 results with four Not Acceptables, earning an Overall Satisfactory score of 97.2 percent. H2M reported 256 results with seven Not

Acceptables, generating a score of 97.3 percent. STL's three labs reported 748 results with 31 Not Acceptables, earning a score of 95.9 percent.

9.7.3.4 Voluntary PE Studies

GEL and Brookhaven's ASL participated in the voluntary ERA water pollution and water supply performance evaluation studies. For these studies combined, ASL reported 224 results: 210 Acceptables, three within Warning limits, and 11 Not Acceptables. The Overall Satisfactory score for ASL in ERA's water supply and water pollution studies was 95.1 percent. GEL reported 735 results, with 687 Acceptables, two Check for Errors, and 46 Not Acceptables. GEL's score in these voluntary PE studies was 93.7 percent.

STL (St. Louis and Connecticut) and H2M Labs participated in the Analytical Products Group (APG) and ERA PE Testing programs. Results in these two independent programs are labeled as "IND" on the bar graph in Figure 9-3 for these two laboratories. STL's overall passing score was 94.7 percent, whereas H2M's overall passing score was 96.8 percent.

9.8 AUDITS

In addition to PE testing, BNL conducts a program of internal and external audits to verify the effectiveness of the environmental sampling, analysis, and database activities. Contractor laboratories are subject to audits by BNL personnel at the time of contract renewal. To verify competence in analytical methodology and implementation of a comprehensive QA program, the contractor laboratories are also audited periodically by the ASL, the Quality Programs and Services Office, or the Environmental Restoration Program staff. There were no audits performed for off-site laboratories that reported data in this SER, since they were still under the last year of a three-year contract.

9.9 BNL DEER INVESTIGATION

In April 2002, a positive bias was found in one of eight gamma detectors used to measure ^{137}Cs in deer meat. Details are presented in an ASL technical paper (ASL 2002) titled "*Positive Bias in One of Eight HPGe Detectors Used to*

Measure ^{137}Cs in Deer at Brookhaven National Laboratory." A summary is provided below.

One of eight BNL High Purity Germanium (HPGe) gamma detectors was found to give a factor of 2.5 (high) bias in cesium-137 measurements for a road-killed deer in the vicinity of the lab. The initial cesium-137 deer activity concentration was 21 pCi/g (wet weight), with an MDL of 0.03 pCi/g. Blind recounts of the original sample yielded the same result for two separate measurements made on the same detector. Results were reported to the Suffolk County Department of Health Services (SCDHS), NYSDEC, and EPA, and disseminated to the public.

Because the BNL-reported activity concentration exceeded the NYSDEC threshold for cesium-137 in deer (6.7 pCi/g wet weight), the NYSDOH then received and analyzed a portion of the same sample. Their results indicated a cesium-137 concentration of just 8.4 pCi/g (wet weight).

After a DOE Occurrence Report was filed, an internal assessment was conducted at BNL with the following findings (1 through 5) and recommendations (6 and 7) for enhancing the Deer Program:

1. BNL's on-site laboratory, the ASL, is NY State and US EPA NELAP Certified.
2. All SOPs were properly followed and samples were not routinely spiked.
3. Gamma Proficiency Testing Scores in the NYS DOH ELAP, U.S. DOE/EML QAP, and Environmental Resource Associates programs were excellent in 2001.
4. The suspect detector is a 10-year-old "top-looker" that differs from the other state-of-the-art detectors, which are "bottom lookers."
5. For solid matrices, the eight ASL gamma detectors were geometry-calibrated using standard 300 mL aluminum cans filled with either 100 or 200 grams of a NIST traceable soil-equivalent resin material following EML-HASL 300 procedures. For the suspect detector, the difference in density between the soil calibration matrix (1.2/pCi/g) and actual deer sample (0.7/pCi/g) caused a factor of 2.5 high bias because there was a 1-inch air space in the 300 mL soil calibration geometry can (half-filled with 200 gm

material), but not in the 300 mL deer sample can (fully packed with 200 gm of material). This air space was not a factor in cesium-137 results obtained after later counting the deer sample using the other ASL soil-calibrated detectors.

6. Program enhancements would include recalibrating the eight detectors using sealed 300 mL cans containing 100 and 200 grams of a commercially available NIST traceable deer-equivalent resin material spiked with cesium-137 (and other gamma-emitters).
7. Additional QA/QC would include using an Environmental Measurements Laboratory Quality Assurance Program vegetation sample, containing known amounts of cesium-137 and K-40, as a standard reference material. This sample would be counted weekly on all detectors to obtain estimates of precision and accuracy in lieu of spiking samples.

In summary, ASL internal QC checks on instrument performance indicated that all detectors were within EPA acceptance criteria for energy calibration. Blind PE testing scores in EML and ERA Programs in 2001 showed that ASL can accurately measure cesium-137 (and other gamma emitters) in a variety of matrices. The re-count of the suspect deer sample at BNL in July 2002, using all gamma detectors recalibrated with a deer-equivalent spiked resin material, showed statistically equivalent results compared to NYSDOH measurements performed in March 2002.

9.10 CONCLUSIONS

Detailed data on quality control results for all analyses conducted at BNL's ASL are presented in ASL's *Year 2002 QA Report* (Scarpitta and Heotis 2003). That report presents tables and figures depicting instrument calibration, efficiency, background checks, precision, and accuracy testing. Overall, QC checks were consistently within the EPA guidelines of ± 20 percent.

Detailed data on external performance evaluation testing for the ASL and the three BNL contractor laboratories are also presented in the *Year 2002 QA Report*. Overall, the three laboratories reporting radiological analytical data in the *Site*

Environmental Report 2002 (ASL, STL, and GEL) each had combined satisfactory results of 95 percent or better in both state and federal performance evaluation programs. For nonradiological performance evaluation testing, ASL and the three BNL contractor laboratories (H2M, GEL, and STL) all scored better than 95 percent in the NYSDOH ELAP evaluations. BNL's combined Overall Satisfactory score of 96.2 percent on the 573 radiological and nonradiological PE tests performed in 2002 is considered excellent.

Based on implementation and evaluation of the QA/QC program, it can be concluded that the analytical data reported in the *Site Environmental Report 2002* are reliable and of high quality.

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CHAPTER 9: QUALITY ASSURANCE

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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.

AGS	Alternating Gradient Synchrotron	DQO	data quality objective
ALARA	as low as reasonably achievable	DWS	drinking water standards
AMSL	above mean sea level	EA	environmental assessment
AOC	area of concern	EDB	ethylene dibromide
APG	Analytical Products Group	EDE	effective dose equivalent
ARPA	Acheological Resource Protection Act	EDTA	ethylenediaminetetraacetic acid
AS/SVE	air sparging/soil vapor extraction	EE/CA	Engineering Evaluation/Cost Analysis
ASL	Analytical Services Laboratory (BNL)	EIMS	Environmental Information Management System
AUI	Associated Universities, Incorporated	ELAP	Environmental Laboratory Approval Program
BAF	Booster Applications Facility	EML	Environmental Measurements Laboratory
BAO	Brookhaven Area Office	EMS	Environmental Management System
BGRR	Brookhaven Graphite Research Reactor	EPA	U.S. Environmental Protection Agency
BLIP	Brookhaven Linac Isotope Producer	EPCRA	Emergency Planning and Community Right-to-Know Act
BMRR	Brookhaven Medical Research Reactor	ER	environmental restoration
BNL	Brookhaven National Laboratory	ERA	Environmental Resource Associates
BOD	biochemical oxygen demand	ERD	Environmental Restoration Division
Bq	becquerel	ES	environmental surveillance
Bq/g	becquerel per gram	ES&H	environment, safety, and health
Bq/L	becquerel per liter	ESD	Environmental Services Division
BSA	Brookhaven Science Associates	ESH&Q	Environment, Safety, Health, and Quality Directorate
Btu	British thermal units	FFCA	Federal Facilities Compliance Act
CAA	Clean Air Act	FIFRA	Federal Insecticide Fungicide and Rodenticide Act
CAP	Clean Air Act Assessment Package	FWMF	Former Waste Management Facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act	FY	fiscal year
CFR	U.S. Code of Federal Regulations	FWS	U.S. Fish and Wildlife Service
Ci	curie	GAB	gross alpha beta
CO	certificate to operate	GC/ECD	gas chromatography/electron capture detector
COC	Chain of custody	GC/MS	gas chromatography/mass spectrometry
Cs	cesium	GEL	General Engineering Laboratory
CSF	Central Steam Facility	GIS	Geographical Information System
CT	carbon tetrachloride	GWh	gigawatt hour
CWA	Clean Water Act	H2M	one of the contract labs
CY	calendar year	HEPA	high efficiency particulate air
DCA	1,1-dichloroethane	HFBR	High Flux Beam Reactor
DCE	1,1-dichloroethylene	HTO	tritiated water (liquid or vapor)
DCG	derived concentration guide	I	Iodine
DDD	dichlorodiphenyldichloroethane	IAEA	International Atomic Energy Agency
DDE	dichloroethylene	IAG	Interagency Agreement
DDT	dichlorodiphenyltrichloroethane	IC	ion chromatography
DMR	Discharge Monitoring Report	ICP/MS	inductively coupled plasma/mass spectrometry
DOE	U.S. Department of Energy	ISO	International Organization for Standardization
DOE BAO	U.S. Department of Energy, Brookhaven Area Office	ISOCS	In-Situ Object Counting System
DOE CH	U.S. Department of Energy, Chicago Operations Office		

APPENDIX A: GLOSSARY

K	potassium	P2	pollution prevention
kBg	kilobecquerels	Pb	lead
kWh	kilowatt hours	PCB	polychlorinated biphenyl
LED	light emitting diode	PCE	tetrachloroethylene (or perchloroethylene)
LIE	Long Island Expressway	pCi/g	picocuries per gram
Linac	Linear Accelerator	PE	performance evaluation
MBtu	thousand British thermal units	PET	positron emission tomography
MMBtu	million British thermal units	ppb	parts per billion
MDL	minimum detection limit	ppm	parts per million
MEI	maximally exposed individual	QA	quality assurance
MGD	million gallons per day	QAPP	quality assurance program plan
MOA	Memorandum of Agreement	QC	quality control
MPF	Major Petroleum Facility	RA	removal action
MPN	most probable number	RACT	Reasonable Available Control Technology
MRC	Medical Research Center	RCRA	Resource Conservation and Recovery Act
mSv	millisievert	RHIC	Relativistic Heavy Ion Collider
MTBE	methyl tertiary butyl ether	ROD	record of decision
MW	megawatt	RPD	relative percent difference
µg/L	micrograms per liter	SARA	Superfund Amendments and Reauthorization Act
mg/L	milligrams per liter	SBMS	Standards Based Management System
NA	not analyzed	SCDHS	Suffolk County Department of Health Services
NCRP	National Council on Radiation Protection and Measurements	SDWA	Safe Drinking Water Act
ND	not detected or no dose	SER	Site Environmental Report
NEPA	National Environmental Policy Act	SNS	standard not specified
NESHAPs	National Emission Standards for Hazardous Air Pollutants	SO ₂	sulfur dioxide
NHPA	National Historic Preservation Act	SOP	standard operating procedure
NIST	National Institute for Standards and Technology	SPCC	spill prevention control and countermeasures
NO ₂	nitrogen dioxide	SPDES	State Pollutant Discharge Elimination System
NO _x	nitrogen oxides	Sr	Strontium
NOEC	no observable effect concentration	STL	Severn Trent Laboratories
NPDES	National Pollutant Discharge Elimination System	STP	Sewage Treatment Plant
NR	not required	SU	standard unit
NS	not sampled	Sv	sievert
NSLS	National Synchrotron Light Source	SVOC	semivolatile organic compound
NT	not tested	t _{1/2}	half-life
NYCRR	New York Codes, Rules, and Regulations	TBq	trillion Becquerels
NYS	New York State	TCA	1,1,1-trichloroethane
NYS AWQS	New York State ambient water quality standard	TCE	trichloroethylene
NYS DWS	New York State drinking water standard	TCLP	toxicity characteristic leaching procedure
NYSDEC	New York State Department of Environmental Conservation	TKN	Total Kjeldahl nitrogen
NYSDOH	New York State Department of Health	TLD	thermoluminescent dosimeter
NYSHPO	New York State Historic Preservation Office	TSCA	Toxic Substances Control Act
O ₃	ozone	TVDG	Tandem Van de Graaff
ORC	oxygen-releasing compound	TVOC	total volatile organic compounds
ORPS	Occurrence Reporting and Processing System	UIC	underground injection control
OU	operable unit	USI	unreviewed safety issues
PAAA	Price Anderson Acts Amendment	UST	underground storage tank
		VOC	volatile organic compound
		WAC	waste acceptance criteria
		WCF	Waste Concentration Facility
		WMF	Waste Management Facility
		WTP	Water Treatment Plant

Technical Terms

These definitions reflect the typical manner in which the terms are used for this specific document and may not apply to all situations. For definitions and descriptions of the various environmental regulations, see Chapter 3.

A

accuracy - The degree of agreement of a measurement with an accepted reference or true value. It is 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 products - A material that has become radioactive through the process of activation.

activity - Synonym for radioactivity.

Administrative Record - A collection of documents established in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program. Consists of information upon which the CERCLA lead agency bases 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.

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

air sparging - A method of extracting volatile organic compounds from the groundwater *in situ* (i.e., in place) using compressed air. The vapors are typically collected using a soil vapor extraction system.

air stripping - A process whereby volatile organic chemicals are removed from contaminated water by forcing a stream of air through the water in a vessel. The contaminants are evaporated into the air stream. The air may be further treated before it is released into the atmosphere.

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 elements such as radon emit alpha radiation.

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.

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

anthropogenic radionuclides - Radionuclides produced as a result of human activity (i.e., human-made).

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.

area of concern (AOC) - Under the Comprehensive Environmental Response, Compensation and Liability Act (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 into the environment of a hazardous substance, pollutant, or contaminant (including radionuclides). 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.

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

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, cosmic radiation, or human-made radiation sources, including fallout.

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

beta radiation - Beta radiation is composed of charged particles emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is slightly more penetrating than alpha, but may be stopped by materials such as aluminum or Lucite panels. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

biochemical oxygen demand (BOD) - 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.

blank - A sample (usually reagent grade water) in the same type of container 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).

C

cap - A layer of material, such as clay or a synthetic material (like Gunite™), used to prevent rainwater from penetrating and spreading contaminated materials. 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, CCl₄.

chain-of-custody (COC) - 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.

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.

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 potable water.

closure - Under the Resource Conservation and Recovery Act (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.

cocktail - a mixture of chemicals used for scintillation counting.

Code of Federal Regulations (CFR) - A codification of all regulations developed and finalized by federal agencies in the Federal Register.

collective effective dose equivalent - A measure of health risk to a population exposed to radiation. It is the sum of the effective dose equivalents 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 Effective Dose Equivalent received over a 50-year period following the internal deposition of a radionuclide. It is expressed in rem or sieverts.

composite sample - A sample of an environmental medium that contains a certain number of sample portions collected over a period of time. The samples may be collected from the same location or different locations. They may or may not be collected at equal time intervals over a predefined period of time (e.g., 24 hours).

confidence interval - A numerical range within which the true value of a measurement or calculated value lies. In this report, radiological values are shown with a 95% confidence interval, i.e., there is a 95% probability that the true value of a measurement or calculated value lies within the specified range.

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 that is used to cool machinery and equipment. Contact cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal. Non-contact cooling water is water used for cooling purposes but has no direct contact with any process material or final product. Process wastewater cooling water is water used for cooling purposes that may have become contaminated through contact with process raw materials or final products.

curie (Ci) - A quantitative measure of radioactivity. One Ci of activity is equal to 3.7×10^{10} decays per second.

D

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.

Department of Energy (DOE) - The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. DOE has responsibility for the national laboratories and the science and research conducted at these laboratories, including Brookhaven National Laboratory.

derived concentration guide (DCG) - 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 have been established by DOE in Order 5400.5, *Radiation Protection of the Public and the Environment*. (1990, change 2, 1/7/93).

disposal - Final placement or destruction of waste.

dosimeter - A portable detection device for measuring the total accumulated exposure to ionizing radiation.

downgradient - In the direction of groundwater flow from a designated area; analogous to “downstream.”

E

effective dose equivalent (EDE) - A value used to express the health risk from radiation exposure to a tissue or tissues 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. It is equal to the sum of the doses to different organs of the body multiplied by their respective weighting factors. It includes the sum of the effective dose equivalent due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of radionuclides. EDE is expressed in units of rem or sieverts.

effluent - Any liquid discharged to the environment, including stormwater runoff at a site or facility.

emissions - Any gaseous or particulate matter discharged to the atmosphere.

environment - Surroundings in which an organization operates (including air, water, land, natural resources, flora, fauna, and humans) and their interrelation.

environmental aspect - Elements of an organization's activities, products, or services that can interact with the environment.

environmental assessment (EA) - A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA identifies a “significant” impact (as defined by the National Environmental Policy Act [NEPA]), an Environmental Impact Statement is required.

environmental impact - Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services.

Environmental Information Management System - A database system used to store, manage, verify, protect, retrieve, and archive BNL's environmental data.

environmental media - Includes air, groundwater, surface water, soil, flora and fauna.

environmental monitoring or surveillance - Sampling for contaminants in air, water, sediments, soils, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

Environmental Protection Agency (EPA) - The federal agency responsible for developing and enforcing environmental laws. Although state regulatory agencies may be authorized to administer environmental regulatory programs, EPA generally retains oversight authority.

ethylene dibromide (EDB) - A colorless, nonflammable, heavy liquid with a sweet odor; slightly soluble in water, soluble in ethanol, ether, and most organic solvents. It was used as an additive in leaded gasoline, as a soil and grain fumigant, and in waterproofing preparations. 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. The U.S. Department of Health and Human Services has determined that ethylene dibromide may reasonably be anticipated to be a carcinogen.

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.

feasibility study (FS) - 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.

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 radionuclides. 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" to identify a specific nuclide.

grab sample - A single sample collected at one time and place.

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 on a metal mold.

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.

hazardous waste - Toxic, corrosive, reactive, or ignitable materials that can negatively affect 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 the Resource Conservation and Recovery Act (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.

hot cell - Shielded and air controlled facility for the remote

handling of radioactive material.

hydrology - The science dealing with the properties, distribution, and circulation of natural water systems.

I

inert - Lacking chemical or biological action.

influent - Liquid (e.g., 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 other sources (e.g., a sewage treatment plant).

ionizing radiation - Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, x-rays, neutrons. High doses of ionizing radiation may produce severe skin or tissue damage.

isotope - Two or more forms of a chemical element having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or 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 radionuclides.

M

maximally exposed individual (MEI) - 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.

mean sea level (MSL) - The average height of the sea for all stages of the tide. Used as a benchmark for establishing groundwater and other elevations.

minimum detection limit (MDL) - 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% confidence).

mixed waste - Waste that contains both a hazardous waste component regulated under Subtitle C of the Resource Conservation and Recovery Act (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.

N

nuclide - A species of atom characterized by the number of protons and neutrons in the nucleus.

O

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 emissions (e.g., smoke) other than water reduce the transmission of light and obscure the view of an object in the background.

operable unit (OU) - 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 operable unit can receive specific investigation and a particular remedy may be proposed. A Record of Decision (ROD) is prepared for each operable unit (*see* Record of Decision).

Occurrence Reporting and Processing System (ORPS) - A process and reporting system for identifying, categorizing, notifying, investigating, analyzing and reporting events or conditions discovered at the BNL site to DOE.

outfall - The place where wastewater is discharged.

oxides of nitrogen (NO_x) - All oxides of nitrogen, except nitrous oxide, which is expressed as nitrogen dioxide (NO₂).

ozone (O₃) - A very reactive form of oxygen formed naturally in the upper atmosphere and providing 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

percent recovery - For analytical results, the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

permit - An authorization issued by a federal, state or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including the Resource Conservation and Recovery Act (RCRA), Clean Air Act (CAA), Clean Water Act (CWA), and Toxic Substances Control Act (TSCA). They grant permission to operate, to discharge, to construct, etc. 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.

pollution prevention (P2) - 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.

polychlorinated biphenyls (PCBs) - 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.

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 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

qualifier - A letter or series of letter codes indicating that the associated value is estimated. A qualified value is an estimated value.

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

quality control (QC) - 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.

R

radioactive series - A succession of nuclides, 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.

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.

Record of Decision (ROD) - A document that records a regulator agency's decision for the selected remedial action. The ROD also includes a responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the ROD is finalized, remedial design and implementation can begin.

relative percent difference - A measure of precision, expressed by the formula: $RPD = [(A-B)/(A+B)] \times 200$, where A equals the concentration of the first replicate; and B equals the concentration of the second replicate.

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. This is a risk-based value used to estimate the potential health effects to an exposed individual or population.

remedial (or remediation) alternatives - Options considered under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) for cleaning up contamination at a site, such as an operable unit (OU) or area of concern (AOC). Remedial actions are long-term activities that stop or substantially reduce releases, or prevent possible releases, of hazardous substances that are serious but not immediately life-threatening. See also feasibility study (FS) and record of decision (ROD).

remedial investigation (RI) - An investigation that includes extensive sampling and laboratory analyses to characterize the nature and extent of contamination, define the pathways of migration, and measure the degree of contamination in surface water, groundwater, soils, air, plants, and animals. Information gathered during the RI attempts to fully describe the contamination problem at the site so that the appropriate remedial action can be developed.

removal actions (RA) or 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 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and that are not inconsistent with the final remedial action. Under CERCLA or Superfund, the U.S. Environmental Protection Agency may respond to releases or threats of releases of hazardous substances by starting a removal action. The purpose of the removal action is to stabilize or clean up an incident or site that poses an immediate threat to public health or welfare. Removal actions differ from remedial actions. However, removal actions must contribute to the efficiency of future remedial actions.

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).

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.

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 (Sv) - 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.

skyshine - Radiation emitted over an open-topped shielded enclosure and reflected by air so as to radiate people on the outside.

sludge - Semisolid residue from industrial or water treatment processes.

soil vapor extraction - An *in situ* (in place) method of extracting volatile organic chemicals from soil. The chemicals are extracted by applying a vacuum to the soil and collecting the air, which can be further treated to remove the chemicals or discharged to the atmosphere.

sole source aquifer - An area defined by the U.S. Environmental Protection Agency 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.

spallation - The process by which a high energy particle striking a nucleus causes fragments to be ejected from the nucleus. The resulting atom is usually radioactive.

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; the U.S. Department of Energy; and BNL staff.

Standards-Based Management System (SBMS) - A document management tool used to develop and integrate systems, and to demonstrate BNL's conformance to requirements to perform work safely and efficiently.

State Pollution Discharge Elimination System (SPDES) - A program under which permits are issued by the state to regulate wastewater discharges. The permit specifies the maximum discharge limits for the parameters present in the particular discharge.

stripping - A process used to remove volatile contaminants from a substance (*see also* air stripping).

sump - A pit or tank that catches liquid runoff for drainage or disposal.

T

thermoluminescent dosimeter (TLD) - A device used to measure radiation dose to occupational workers or radiation levels in the environment.

total volatile organic compounds (TVOC) - A sum of all individual VOC concentrations detected in a given sample.

trichloroethylene (TCE) (also, 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 to people when inhaled or ingested, or through skin contact, and can damage vital organs, especially the liver (*see also* volatile organic compounds).

tritium - The heaviest and only radioactive nuclide of hydrogen, with a half-life of 12.3 years and a very low energy radioactive decay (beta emitter).

U

underground injection control (UIC) - A hole with vertical dimensions greater than its largest horizontal dimensions; used for disposal of waste water.

underground storage tank (UST) - 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

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.

volatile organic compounds (VOCs) - Secondary petrochemicals, including light alcohols, acetone, trichloroethylene, perchloroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride. These potentially toxic chemicals are used as solvents, degreasers, paints, thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential for human exposure. Due to their widespread industrial use, they are commonly found in soil and groundwater.

W

waste minimization - An action that avoids or reduces the generation of waste by source reduction, reduces the toxicity of hazardous waste, improves energy usage, or recycling. This action is consistent with the general goal of minimizing present and future threats to human health, safety, and the environment. Associated with pollution prevention, but more likely to occur after the waste has already been generated.

water table - The water-level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.

watershed - The region draining into a river, a river system, or a body of water.

APPENDIX A: GLOSSARY

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.

wind rose - A diagram that shows the frequency of wind from different directions at a specific location.

Concepts of Radioactivity

This section introduces some of the basic concepts of radioactivity. It is designed to provide the general reader with an overall understanding of the radiological sections of this report. A discussion of the analyses used to qualitatively quantify radioactive material, the common sources of radioactivity in the environment, and how they contribute to an individual's radiation dose are provided. Some general statistical concepts are also presented, along with a discussion of radionuclides of environmental interest at BNL.

RADIOACTIVITY

The atom is the basic constituent of all matter and is one of the smallest units into which matter can be divided. Each atom is composed of a tiny central core of particles, or nucleus, surrounded by a cloud of negatively charged particles called electrons. Most atoms in the physical world are stable, meaning that they are not radioactive. However, some atoms possess excess energy, which causes them to be physically unstable. In order to become stable, an atom rids itself of this extra energy by casting it off in the form of charged particles or electromagnetic waves, known as radiation.

COMMON TYPES OF RADIATION

The three most important types of ionizing radiation are described below:

Alpha - An alpha particle is identical in makeup to the nucleus of a helium atom, consisting of two neutrons and two protons. Alpha particles have a positive charge and have little or no penetrating power in matter. They are easily stopped by materials such as paper and have a range in air of only an inch or so. Naturally occurring radioactive elements such as uranium and radon daughters emit alpha radiation.

Beta - Beta radiation is composed of particles that are identical to electrons. As a result, beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha but may be stopped by materials such as aluminum foil and Lucite™ panels. They have a range in air of several feet. Naturally occurring radioactive elements such as potassium-40 (K-40) emit beta radiation.

Gamma - 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. X-rays are similar to gamma radiation.

NOMENCLATURE

Throughout this report, radioactive elements (also called radionuclides) are referred to by a name followed by a number, e.g., cesium-137. The number following the name of the element is called the mass of the element and is equal to the total number of particles contained in the nucleus of the atom. Another way to specify the identity of cesium-137 is by writing it as Cs-137, where 'Cs' is the chemical symbol for cesium as it appears in the standard Periodic Table of the Elements. This type of abbreviation is used in the text and many of the data tables in this report.

SOURCES OF RADIATION

Radioactivity and radiation are part of the earth's natural environment. Human beings are exposed to radiation from a variety of common sources, the most significant of which are listed below.

Cosmic - Cosmic radiation primarily consists of charged particles that originate in space, beyond the Earth's atmosphere. This includes 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. The average dose from cosmic radiation to a person living in the United States is about 26 mrem per year.

Terrestrial - Terrestrial radiation is released by radioactive elements present in the soil since the

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem).

Sources: NCRP Report No. 93 (NCRP 1987).

formation of the Earth about five billion years ago. Common radioactive elements contributing 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 about 28 mrem per year.

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. Human ingestion of radionuclides can occur when contaminated plant matter or animals that consume contaminated plant matter are eaten. Most exposure to inhaled radioactive material results from breathing the decay products of naturally occurring radon gas. The average dose from eating foods to a person living in the United States is about 40 mrem per year; the average dose from radon product inhalation is about 200 mrem per year.

Medical - Millions of people every year undergo medical procedures that utilize radiation. Such procedures include chest and dental x-rays, mammography, thallium heart stress tests, and tumor irradiation therapies. The average dose from nuclear medicine and x-ray examination procedures in the United States is about 14 and 39 mrem per year, respectively.

Anthropogenic - Sources of anthropogenic (man-made) radiation include consumer products such as static eliminators (containing polonium-210), smoke detectors (containing americium-241), cardiac pacemakers (containing plutonium-238), fertilizers (containing isotopes of the uranium and

thorium decay series), and tobacco products (containing polonium-210 and lead-210). The average dose from consumer products to a person living in the United States is 10 mrem per year (excluding tobacco contributions).

DOSE UNITS

The amount of energy that radiation deposits in body tissues or organs, when corrected for human risk factors, is referred to as dose equivalent or, more generally, as dose. Radiation doses are measured in units of rem. Since the rem is a fairly large unit, it is convenient to express most doses in terms of millirem (1,000 mrem = 1 rem). To give a sense of the size and importance of a 1 mrem dose, Figure B-1 indicates the number of mrem received by an individual in one year from natural and background sources. These values represent typical values for residents of the United States. Note that the alternate unit of dose measurement commonly used internationally and increasingly in the United States is the sievert, abbreviated Sv. One Sv is equivalent to 100 rem. Likewise, 1 millisievert (mSv) is equivalent to 100 mrem.

The unit used to express the quantity of radioactive material in a sample is the curie (Ci). This is a measure of the rate at which radioactive atoms are transformed to stable atoms. Since the curie is a relatively large unit (3.7×10^{10}) for measuring environmental samples, the picocurie (pCi) is often used. This unit is equal to one trillionth of a Ci, or 0.037 decays per second. The alternate unit for quantifying radioactivity is the becquerel, abbreviated Bq. One becquerel is equal to 1 decay per second. Additional units of measure and their conversion factors can be found on the inside of the back cover of this report.

TYPES OF RADIOLOGICAL ANALYSIS

The quality of environmental air, water, and soil with respect to radioactive material can be assessed using several types of analysis. The most common analyses are described below. **Gross alpha** - Alpha particles are emitted 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 magnitude of alpha-emitting radionuclides that may be present in a sample.

Gross beta - This is the same concept as described above, except that it applies to the measurement of beta particle activity.

Tritium - Due to the nature of the radiation, a low energy beta particle, emitted from the tritium atom, it is detected and quantified by liquid scintillation counting method. (More information on tritium is presented in the next section.)

Strontium-90 - Due to the nature of the radiation emitted by strontium-90, a special analysis is required. Samples are chemically processed to separate and collect any strontium atoms that may be present. The collected atoms are then analyzed separately. (More information on strontium-90 is presented in the next section.)

Gamma - This analysis technique identifies specific radionuclides. 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" to identify a specific nuclide.

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 will yield a slightly different result each time; a single measurement is, therefore, not definitive. To account for this phenomenon, the concept of uncertainty is applied to radiological data. In this report analysis results are displayed with $x \pm y$ format, where x is the result and $\pm y$ is the 95 percent confidence interval of the result. That is, there is a 95 percent probability that the true value of x lies between $x + y$ and $x - y$. Conversely, there is a 5 percent probability that the true value of x lies outside of this range.

Negative values - There is always a small amount of natural radiation in the environment. The instruments used in the laboratory to measure radioactivity in BNL site environmental media are sensitive enough to measure the natural, or background, radiation along with any contami-

nant radiation in a sample. To obtain a true measure of the contaminant level in a sample, the natural (or background) radiation level must be subtracted from the total amount of radioactivity measured by an instrument. 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, a negative result is generated. The negative results are reported because they are essential when conducting statistical evaluations of data.

RADIONUCLIDES OF ENVIRONMENTAL INTEREST

Several types of radionuclides are found in the environment at BNL due to historical operations and include the following:

Strontium-90 - Strontium-90 is a beta-emitting radionuclide with a half-life of 28 years (i.e., after 28 years only one half of the activity from the original remains). It is found in the environment principally as a result of fallout from aboveground nuclear weapons testing. (Fallout refers to the deposition of radionuclides on soils and water bodies as a result of being dispersed high into the Earth's atmosphere during nuclear explosions.) Strontium-90 released in the 1950s and early 1960s is still present in the environment today due to its long half-life. Additionally, nations that were not signatories of the Nuclear Test Ban Treaty of 1963 have conducted tests that have contributed to the global strontium-90 inventory. This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

The data in this environmental report are reported by method of analysis. Because strontium-90 requires a unique method of analysis, it is reported as a separate parameter in the data tables. The level of sensitivity for detecting strontium-90 using state-of-the-art analysis methods is quite low (less than 1 pCi/L), which makes it possible to detect strontium-90 at levels that are indicative of the environmental sources described above.

Tritium - Among the radioactive materials that are used or produced at BNL, tritium has re-

ceived the most public attention. Tritium exists in nature and is formed when cosmic radiation from space interacts with the gaseous nitrogen in the Earth's upper atmosphere. Approximately 4 million Ci ($1.5\text{E}+5$ TBq) per year are produced in the atmosphere in this way, with the total global quantity being about 70 million Ci ($2.6\text{E}+6$ TBq) at any given time (NCRP 1979). As a result of the 1950s and early 1960s aboveground weapons testing program, the global atmospheric tritium inventory was increased by a factor of about 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 exit signs and wrist watches (exit signs may each contain as much as 25 Ci [925 GBq] of tritium). It 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.

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 kBq/L) (NCRP 1979). Approximately the same concentration was measurable in precipitation. Today, the level of tritium in surface waters in New York State is below 200 pCi/L (7.4 kBq/L) (NYSDOH 1993), 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. This beta radiation has a very low energy when compared to the emissions of most other radioactive elements. The body's outer layer of dead skin cells easily stops tritium beta radiation and therefore, only when taken into the body, can tritium cause an exposure. Tritium may be taken into the body by inhalation, ingestion, or absorption 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 credible exposures.

Environmental tritium is found in two forms: (1) gaseous elemental tritium and (2) tritiated water (or water vapor), in which at least one of the hydrogen atoms in the H_2O water molecule has been replaced by a tritium atom (hence, its shorthand notation HTO). All tritium released from BNL sources is in the form of HTO.

Cesium-137 - Cesium-137 is a man-made, fission-produced radionuclide with a half-life of 30 years. It is found in the environment as a result of past aboveground nuclear weapons testing and can be observed in the upper levels of environmental soils at very low concentrations, usually less than 1 pCi/g (0.04 Bq/g). It is a beta-emitting radionuclide, but can be detected by gamma spectroscopy by the gamma emissions of its decay product, barium-137m.

SCIENTIFIC NOTATION

Since many of the numbers used in measurement and quantification in this report are either very large or very small, many zeroes would be required to express their value. Because this is inconvenient, scientific notation is used as a kind of numerical shorthand. Scientific notation is based on the principle of representing numbers in multiples of ten. For example, the number one million could be written as 1,000,000. Alternatively, this number could be written in scientific notation as 1×10^6 . That is, "one times ten raised to the sixth power." Since even this shorthand can be cumbersome, it can be reduced even further by using the capital letter E to stand for 10^x , or "ten raised to the power of some value x." Using this notation, 1,000,000 would be represented as 1E+06. Scientific notation is also used to represent very small numbers like 0.0001, which can be written as 1×10^{-4} or 1E-04. This notation is used in the text and some tables in this report.

PREFIXES

Another method of representing very large or very small numbers without the use of many zeroes is to use prefixes to represent multiples of ten. For example, the prefix "milli" means that the value being represented is one thousandth of a whole unit, so that one-milligram is

equal to one thousandth of a gram. See table inside back cover.

DEFINITION OF RADIOLOGICAL TERMS

Radiological terms are used throughout this report where radiation and radioactive material are discussed. The definitions of commonly used radiological terms are found in Appendix A.

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Radiological Data Methodologies

DOSE CALCULATION - ATMOSPHERIC RELEASE PATHWAY

The effective dose equivalent for low levels of airborne radioactive materials dispersed into the environment was calculated for each of the 16 compass sectors using the CAP88-PC, version 2.0 dose model program (EPA 1992). Site meteorology data were used to calculate annual dispersions for the midpoint of a given sector and distance. Facility-specific radionuclide release rates (in curies per year [Ci/yr]) were also used. All annual site boundary and collective dose values were generated using the CAP88-PC v.2 computer code, which calculates the total dose due to contributions from the immersion, inhalation, and ingestion pathways. The dose and risk estimates were based on low levels of chronic intake of radionuclides.

DOSE CALCULATION - FISH INGESTION PATHWAY

To estimate the effective dose equivalent from the fish consumption pathway, the following procedure was used:

Intake.

The average fish consumption for an individual engaged in recreational fishing in the Peconic River was based on a study done by the New York State Department of Health (NYSDOH 1996), which estimates the consumption rate at approximately 15 pounds (7 kg) per year.

Activity in Flesh.

Radionuclide data for fish samples were all converted to picocuries per gram (pCi/g) wet weight, since this is the form in which the fish are caught and consumed.

Dose Factor.

DOE Order 5400.5 (1990) 50-year committed dose equivalent factors (in rem per microcurie [rem/μCi] intake) were applied. The committed dose equivalent factor for Cs-137 is 5.0E-02 rem/μCi.

Calculation:

$$\begin{aligned} \text{Dose (rem/yr)} &= \text{Intake (kg/year)} \\ &\times \text{Activity in Flesh (}\mu\text{Ci/kg)} \\ &\times \text{Dose Factor (rem/}\mu\text{Ci)} \end{aligned}$$

DOSE CALCULATION - DEER MEAT CONSUMPTION

This calculation is performed in exactly the same way as shown in the previous section. The same DOE Order 5400.5 dose conversion factors are used. The only change is the estimate of total pounds ingested during the course of a year. For deer meat, the consumption rate of 64 pounds (29 kg) per year is based on the Environmental Protection Agency *Exposure Factors Handbook* (EPA 1996).

RADIOLOGICAL DATA PROCESSING

Radiation events occur in a random fashion such that if a radioactive sample is counted multiple times, a distribution of results will be obtained. This spread, known as a Poisson distribution, will be centered about a mean value. If counted multiple times, the background activity of the instrument (the number of radiation events observed when no sample is present) will also be seen to have a distribution of values centered about a mean. The goal of a radiological analysis is to determine whether the sample in question contains activity in excess of the instrument or method blank background. Since the activity of the sample and the background are both Poisson distributed, subtraction of background activity from the measured sample activity results in a value that may 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 the sample contains activity that is truly greater than the instrument background.

Identifying a sample as containing activity greater than background, when it actually does not have activity present, is known as a Type I error. As with most laboratories, the BNL Analytical Services Laboratory sets its acceptance of a Type I error at 5 percent when calculating the MDL for a given analysis. That is, for any value that is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity. Values that are less than

the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all validated or verified radiological data are reported, regardless of their value.

At very low sample activity levels that are close to the instrument background, 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 average (mean) value result. Subsequent analysis may produce a sample net result that is positive. All results must 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 Procedure*, NCRP Report No. 58 (NCRP 1985), and the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, DOE/EH-0173T (1991). Typical MDLs for the various analyses performed on environmental and effluent samples are shown in Tables C-1, C-2, and C-3.

Table C-1. Typical Minimum Detection Limits for Gross Activity and Tritium Concentrations in Water.

Analysis	Aliquot (mL)	MDL (pCi/L)
Gross alpha	100	4
	200	1
Gross beta	100	9
	200	2
Tritium	1	3,900
	7	350

Table C-2. Typical Minimum Detection Limits for Gamma Spectroscopy Analysis.

Nuclide	300 g Soil (mCi/mL)	300 mL Water (mCi/mL)	3L Marinelli (mCi/mL)
Be-7	7E-08	1E-07	1E-08
Na-22	9E-09	1E-08	1E-09
K-40	2E-07	2E-07	2E-08
Sc-48	1E-08	1E-08	3E-08
Cr-51	8E-08	1E-07	1E-08
Mn-54	8E-09	1E-08	1E-09
Mn-56	2E-07	3E-07	2E-08
Co-57	7E-09	9E-09	1E-09
Co-60	1E-08	1E-08	1E-09
Zn-65	2E-08	2E-08	2E-09
Cs-134	1E-08	1E-08	1E-09
Cs-137	9E-09	1E-08	1E-09
Ra-226	3E-08	3E-08	4E-08
Th-228	2E-08	3E-08	1E-07
Br-82	1E-08	2E-08	8E-08
I-131	9E-09	1E-08	3E-09
I-133	1E-08	2E-08	3E-09

Note: All MDLs shown above are approximate. For gamma spectroscopy, the MDL of the analysis is dependent upon several variables, such as the efficiency of the particular detector and the activity of the sample. These factors will vary between analyses and instrumentation.

Table C-3. Typical Minimum Detection Limits for Chemical Analyses by BNL Analytical Services Lab and Off-Site Analytical Laboratories.

Constituent	BNL Laboratory	Offsite Laboratories
Ag	0.025	0.010
Cd	0.0005	0.005
Cr	0.005	0.010
Cu	0.050	0.025
Fe	0.075	0.100
Hg	0.0002	0.0002
Mn	0.050	0.015
Na	1.0	5.0
Pb	0.005	0.003
Zn	0.02	0.020
Ammonia-N	NA	0.02
Nitrite-N	NA	0.01
Nitrate-N	1.0	NA
Specific Conductance	10 mmhos/cm	NA
Chlorides	4.0	NA
Sulfates	4.0	NA
1,1,1-trichloroethane	0.002	0.005
trichloroethylene	0.002	0.005
tetrachloroethylene	0.002	0.005
chloroform	0.002	0.005
chlorodibromomethane	0.002	0.005
bromodichloromethane	0.002	0.005
bromoform	0.002	0.005
benzene	0.002	0.005
toluene	0.002	0.005
xylene	0.002	0.005

Notes:

All concentrations in mg/L except where noted.

NA = Not Applicable (Laboratory does not perform analysis for constituent)

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.

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Instrumentation and Analytical Methods

The Analytical Services Laboratory (ASL) is divided into radiological and nonradiological sections to facilitate analysis of specific parameters in each category. The methods and instrumentation for each category are briefly described below. Only validated and regulatory referenced methods were used during the analysis. All samples were collected and preserved by trained technicians according to appropriate referenced methods. Qualified and trained analysts performed each of the different analyses.

RADIOLOGICAL ANALYTICAL METHODS

The ASL is certified by the New York State Department of Health (NYSDOH) for gross alpha, gross beta, gamma, tritium, and strontium-90 (non-potable water). The following is a description of the radiological analytical methods.

GROSS ALPHA AND GROSS BETA ANALYSIS - WATER MATRIX - EPA 900.0

Water samples are collected in four-liter polyethylene containers by BNL sampling teams and preserved at the time of collection by acidification to pH 2 using nitric acid. Effluent or surface stream samples of 100 ml are extracted for analysis. Groundwater samples are typically analyzed using a 200-mL aliquot. The aliquot is evaporated to near-dryness in a glass beaker. Two drops of concentrated nitric acid are added, after which the solids are polished down the side of the beaker. The sample is transferred to a stainless steel planchet. Four drops of 10 percent Triton-X are added to the sample before it completely evaporates on a hot plate. The planchets are placed in a drying oven at 105°C for a minimum of 2 hours; removed to a desiccator and allowed to cool; and weighed and counted in a gas-flow proportional counter for 50 minutes. Groundwater samples are counted for 200 minutes. Samples are normally processed in batch mode. The first sample of each batch is a background, for which the count rate is subtracted from the raw data before computing net

activity concentration. System performance is checked daily with NIST-traceable standards: americium-241 for alpha, and strontium-90 for beta. Spiked duplicates are performed within each batch of samples to determine precision and accuracy.

GROSS ALPHA AND GROSS BETA ANALYSIS - AIR PARTICULATE MATRIX

Air particulate samples are collected on 50-mm glass fiber filters at a nominal flow rate of 15 liters per minute. At the end of the collection, the filters are returned to the analytical laboratory for assay. After a one-week holding time, filters are counted once in a gas flow proportional counter for 50 minutes. This delay permits the short-lived radon/thoron daughters to decay. The first sample of each batch is a blank filter whose count rate is subtracted from the raw data before calculating net activity concentration. The system's performance is checked daily with National Institute for Standards and Technology (NIST) traceable standards: americium-241 for alpha and strontium-90 for beta.

TRITIUM ANALYSIS - WATER MATRIX - EPA 906.0

Water samples are collected in glass containers. No preservatives are added before collecting the sample. Effluent and surface stream samples, as well as groundwater samples, are analyzed using a 7-mL aliquot. Potable-water samples (as well as other samples requiring a low minimum detection limit) are distilled following the method outlined in EPA Method 906.0 (EPA 1980), and a 7-mL aliquot is analyzed. Liquid scintillation cocktail is added to the aliquot so that the final volume in the liquid-scintillation-counting vial is 7 mL of sample plus 10 mL of cocktail. Samples then are counted in a low-background liquid-scintillation counter for 50 minutes. Samples are normally processed in batch mode. The first sample of each batch is a steam-distilled water background that is subtracted from the raw data before calculating the net activity concentration.

The second sample in each batch is a NIST-traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, quenching, and efficiency of the sample matrix are factored into the final net concentrations for each sample. Spiked duplicates are performed within each batch of samples to determine precision and accuracy.

TRITIUM ANALYSIS - AIR MATRIX

Concentration of tritium in ambient and facility air is measured by drawing the air through a desiccant at a rate of approximately 200 cc/min. At the end of each collection period, typically one week, the desiccant is brought to the analytical laboratory for processing. It is heated in a glass manifold system. Dedicated glassware are used for environmental samples. The desiccant, containing moisture from the sampled air, is heated using an electric mantle, and the evaporated moisture is condensed by a water-cooled glass condenser. The total volume of water collected is determined gravimetrically. A 7-mL aliquot of this water is then assayed for tritium content. If the desiccant contains less than 7-mL of condensed liquid, a 1-mL aliquot is used. Liquid scintillation cocktail is then added to the aliquot so that the final volume in the counting vial is 17-mL. Samples are then counted in a low-background liquid-scintillation counter for 50 minutes. If a 1-mL aliquot was used, liquid scintillation cocktail is added to the vial so that the final volume is 11-mL. These samples are counted for 100 minutes. Samples are normally processed in batch mode. The first sample of each batch is a steam-distilled water background whose count rate is subtracted from the raw data before computing net activity concentration. The second sample in each batch is a NIST-traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, water recovery, air sample volume, quenching and efficiency for the sample matrix are factored into the final net concentrations for each sample. Spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

STRONTIUM-90 ANALYSIS

Strontium-90 analyses are currently performed on water. Groundwater samples are processed inhouse using either DOE Method RP500, which utilizes a crown ether to selectively separate strontium from the acidified sample matrix or an ion exchange resin method. The strontium is eluted from the resin or filtration disk using dilute nitric acid. The resulting eluent is evaporated on a 5 cm stainless steel planchet and the sample counted in a gas-flow proportional counter. Samples are prepared in batches, including a standard and a method blank in each batch. Chemical recovery is determined for each sample by the recovery of strontium carbonate. NIST-traceable strontium-90 standards are used to calibrate and verify the performance of the counting instrument. Samples are counted once after a two-week radiological in-growth time.

Potable water samples, as well as samples of solids, are shipped to a contractor laboratory, which is certified to perform the EPA (1980), 905.0 method for strontium-90 in drinking water. This method employs time consuming and costly wet-chemistry techniques to isolate strontium from the sample. Samples are counted twice to verify strontium-90 and yttrium-90 in-growth. Samples are typically processed in a batch. Backgrounds and system performance are verified with each batch. Chemical recoveries are determined by either gravimetric or gamma-emitting strontium-85 standard addition techniques.

GAMMA SPECTROSCOPY ANALYSIS – EPA 901.1

Surface, potable, and groundwater surveillance samples are typically of 4 liters and are placed in polyethylene bottles acidified to pH 2 with nitric acid. Samples are then measured into a 4-L Marinelli™ beaker and counted on a calibrated gamma spectroscopy detector for 50,000 seconds. Air-particulate filters and air-charcoal canisters are counted directly on the calibrated gamma spectroscopy detector for 10,000 seconds. Soil, vegetation, and aquatic biota are all processed following collection. Typically, a 100-, 200-, or 300-gram aliquot is taken, placed in a Teflon-lined aluminum can,

Table D-1. ASL Certified Organic Analytes.

EPA 624 Analytes			
Bromoform	1,1-Dichloroethane	Trichloroethene	1,1,2-Trichloroethane
Chloromethane	2-Butanone	1,2-Dichloropropane	Tetrachloroethene
Vinyl Chloride	Chloroform	Bromodichloromethane	2-Hexanone
Bromomethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	Dibromochloromethane
Chloroethane	Dibromofluoromethane	4-Methyl-2-pentanone	MTBE
Trichlorofluoromethane	Carbon Tetrachloride	cis-1,3-Dichloropropene	Chlorobenzene
1,1-Dichloroethene	Benzene	p-Bromofluorobenzene	Ethylbenzene
Acetone	1,2-Dichloroethane	Toluene	m/p-xylene
Methylene Chloride	All Dichlorobenzenes	trans-1,3-Dichloropropene	o-Xylene
trans-1,2-Dichloroethene			
EPA 524.2 Analytes			
Dichlorodifluoromethane	Chloroform	1,1,2-Trichloroethane	4-Chlorotoluene
Chloromethane	1,1,1-Trichloroethane	Tetrachloroethene	Tertbutylbenzene
Vinyl Chloride	Carbon Tetrachloride	m,p-xylene	1,2,4-trimethylbenzene
Bromomethane	1,1-Dichloropropene	1,3-dichloropropane	sec-Butylbenzene
Chloroethane	Benzene	Dibromochloromethane	p-Isopropyltoluene
Trichlorofluoromethane	1,2-Dichloroethane	1,2-dibromoethane	n-Butylbenzene
1,1-Dichloroethene	o-Xylene	1,1,1,2-Tetrachloroethane	1,3-Dichlorobenzene
Chlorobenzene	Trichloroethene	Bromoform	1,4-Dichlorobenzene
Methylene Chloride	1,2-Dichloropropane	Isopropylbenzene	1,2-Dichlorobenzene
trans-1,2-Dichloroethene	Dibromomethane	Bromobenzene	1,2-Dibromo-3-Cl-propane
1,1-Dichloroethane	Bromodichloromethane	1,1,2,2-Tetrachloroethane	1,2,4-Trichlorobenzene
2,2-Dichloropropane	cis-1,3-Dichloropropene	n-Propylbenzene	Hexachlorobutadiene
cis-1,2-Dichloroethene	Styrene	1,2,3-Trichloropropane	Naphthalene
Bromochloromethane	Toluene	2-Chlorotoluene	1,2,3-trichlorobenzene
Ethylbenzene	Trans-1,3-Dichloropropene	1,3,5-trimethylbenzene	

and directly counted. For gamma spectroscopy analyses, overnight backgrounds are counted once per week, with calibration and background checked daily. Analytical results reflect net activity that has been corrected for background and efficiency for each counting geometry used.

NONRADIOLOGICAL ANALYTICAL METHODS

The ASL is certified by NYSDOH ELAP for purgeable aromatics, purgeable halocarbons, PCBs, anions, and metal compounds, in both potable and wastewater matrices, using EPA 524, EPA 624, EPA 200.8, EPA 245.2, EPA 236.1, EPA 273.1, and EPA 300.0 methods. Tables D-1 and D-2 list the non-radiological organic and inorganic NYSDOH ELAP certified analytes, respectively.

PURGEABLE AROMATICS AND PURGEABLE HALOCARBONS

Water samples are collected in 40 mL glass vials with removable teflon-lined caps without any headspace, and acidified 1:1 HCl to pH <2.0. Samples are stored at 4°C and analyzed within 14 days. Thirty eight purgeable compounds

Table D-2. ASL Certified Metals and Anions.

Metals	Instrument	Method
Aluminum	ICP/MS	EPA 200.8
Antimony	ICP/MS	EPA 200.8
Arsenic	ICP/MS	EPA 200.8
Barium	ICP/MS	EPA 200.8
Beryllium	ICP/MS	EPA 200.8
Cadmium	ICP/MS	EPA 200.8
Chromium	ICP/MS	EPA 200.8
Cobalt	ICP/MS	EPA 200.8
Copper	ICP/MS	EPA 200.8
Iron	AAS	EPA 236.1
Lead	ICP/MS	EPA 200.8
Manganese	ICP/MS	EPA 200.8
Mercury	AAS	EPA 245.2
Molybdenum	ICP/MS	EPA 200.8
Nickel	ICP/MS	EPA 200.8
Selenium	ICP/MS	EPA 200.8
Silver	ICP/MS	EPA 200.8
Sodium	AAS	EPA 273.1
Thallium	ICP/MS	EPA 200.8
Vanadium	ICP/MS	EPA 200.8
Zinc	ICP/MS	EPA 200.8
Anions	Instrument	Method
Chloride	IC	EPA 300.0
Nitrate	IC	EPA 300.0
Sulfate	IC	EPA 300.0

Notes:

ICP/MS = Inductively Coupled/Mass Spectrometry

AAS = Atomic Absorption Spectrometry

IC = Ion Chromatography

(including: benzene, toluene, ethyl benzene, **total** xylenes, chloroform, 1,1-dichloroethane, 1,1-dichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, trichloroethylene, chlorobenzene, carbon tetrachloride, methyl chloride and acetone) are analyzed under this category following EPA Method 624 protocols using Gas Chromatography/Mass Spectrometry (GC/MS). There are currently two Hewlett-Packard™ GC/MS instruments used to analyze purgeable organic compounds. Since groundwater under BNL is classified as a sole source aquifer under the Safe Drinking Water Act and Class GA groundwater by the New York State Department of Environmental Conservation (NYSDEC), the detection limits reported for the compounds are close to NYS drinking water standards and the ambient water quality standard. EPA drinking water Methods 524.2 and 624 are used to analyze water, based on the project manager's data quality requirements.

The method involves purging a 25-mL aliquot of the sample with ultra pure helium in a specially designed sparger using the Purge and Trap technique. Each sample is spiked with a known concentration of internal standards and surrogates before purging to facilitate identifying, quantifying, and determining the extraction efficiency of analytes from the matrix. The purged analytes are trapped onto a specially designed trap and thermally desorbed onto the capillary chromatographic column by back flushing the trap with helium. Individual compounds are separated with a temperature program of the GC and enter the mass spectrometer where they undergo fragmentation to give characteristic mass spectra. The unknown compounds are identified by comparing their mass spectra and retention times with reference compounds and quantified by internal standard method. The quantitation data are supported by extensive Quality Assurance/Quality Control, such as tuning the mass spectrometer to meet bromofluorobenzene criteria, initial and continuing calibrations verifying daily response factors, method blanks, surrogate recoveries, duplicate analysis, matrix spike and matrix spike duplicate analysis, and reference standard analysis to verify the daily working standard.

PCB ANALYSIS

The ASL is NYSDOH Certified for PCB Aroclors 1016, 1221, 1232, 1242, 1248, 1254 and 1260. Samples are collected in 50-100 mL glass containers with Teflon™-lined lids and stored at 4°C and analyzed within 30 days. Transformer oil, mineral oil, hydraulic fluid, waste oil and spill wipe-samples are analyzed for PCBs using gas chromatography-dual electron capture detector (GC-ECD) method. This method is similar to EPA SW-846 Method 8082 and is targeted to identify and quantify seven different mixtures of PCB congeners in samples.

The method consists of diluting a known weight of the sample with isooctane and removing the interfering compounds with one or more aliquots of concentrated sulfuric acid until the acid layer is almost colorless. The entire oil matrix and other interfering polar compounds are selectively removed from the sample, leaving the PCBs in isooctane solvent.

There is currently a single GC-ECD instrument for analyzing PCB. The PCBs found in the samples are identified and quantified by comparing the retention times and chromatographic patterns with the standards. Methods blanks, duplicates, spikes, calibration, and reference check standards are run as part of Quality Assurance/Quality Control.

ANIONS

Chloride, nitrate-N, and sulfate are analyzed using Dionex™ Ion-chromatography (IC) with ion suppression and conductivity detection technique. Samples from monitoring wells are collected in 100-mL polyethylene bottles, cooled to 4°C, and analyzed within 28 days. For nitrate in drinking water analysis, samples are analyzed within 48 hrs. Holding times were exceeded for nitrate analysis of some nonpotable monitoring well samples, but the depletion of nitrate is expected to be negligible.

The anions are passed through an anion-exchange polymer column and eluted with carbonate/bicarbonate solution. Then the eluent passes through a membrane suppressor, where the background contribution from the eluent is suppressed, improving signal to noise ratio and

detection limits. The target anions are then detected by conductivity meter.

Initially, the system is calibrated with standards to define its working range. The target anions in the samples are identified and quantified by comparing the retention times and areas with the standards. Method blanks, duplicates, replicates, spikes, and reference standards are routinely analyzed as part of Quality Assurance/Quality Control.

METALS

Samples are collected in 500-mL glass bottles and stabilized with ultra-pure nitric acid to a pH of <2. The samples are analyzed within 6 months, except for mercury, which is analyzed within 26 days.

Iron and sodium are analyzed with a Perkin-Elmer atomic absorption spectrometer. Using the flame technique, the sample containing the target element is nebulized and atomized in an oxy-acetylene flame. At the same time, a beam of light from an element-specific hollow cathode lamp corresponding to the absorption frequency of target element is passed through the flame. The atomized element absorbs the energy specific to that element from the cathode lamp and the intensity of absorption is proportional to the concentration of the element in the sample. Calibration curves establish the linearity of the system and samples are quantified by comparing with standards.

Fourteen of the seventeen elements offered for certification in potable water by NYSDOH ELAP are analyzed by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS). Iron and sodium are detailed in the preceding paragraph, and mercury in the following. Including aluminum, cobalt, molybdenum and vanadium, for which only wastewater certification is available, there are eighteen elements analyzed by the ICP/MS technique. Aqueous samples are nebulized, and introduced into a radio frequency argon plasma, at temperatures reaching 8000°K. The de-solvated, atomized analytes are ionized to

predominantly singly-charged cations, which are identified and quantified by the use of a quadrupole mass spectrometer. Isobaric and polyatomic ion interferences are corrected using elemental interference equations based on natural isotopic abundances. Internal standardization eliminates or minimizes instrument drift and matrix-induced signal suppressions and enhancements. Using this technique, sub-part per billion sample detection limits are achievable.

Using a cold-vapor technique for mercury, a 100-mL aliquot of the sample is digested with potassium permanganate/persulfate oxidizing solution at 95°C for two hours to oxidize any organically bound and/or monovalent mercury to mercury (II) oxidation state. Excess oxidizing agent is destroyed with hydroxylamine hydrochloride. The mercuric ion later is reduced to elemental mercury with excess stannous chloride, which is purged with argon into the absorption cell. The absorption is directly proportional to the concentration of mercury in the sample. All the atomic absorption techniques involve initial calibrations to define the calibration range, continuing calibrations, method blanks, duplicates, replicates, matrix spikes, and reference standard analysis as a part of Quality Assurance/Quality Control.

In the fall of 2000, a Leeman PS 200 II automated mercury analyzer was added. This unit enables improved detection limits (<0.1 µg/L), and a more stable baseline than previous instrumentation. This has resulted in improved data quality.

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2002 Site Environmental Report Reader Response Form

The annual Site Environmental Report (SER) summarizes the status of BNL's on-site environmental programs and performance and restoration efforts, as well as any impacts, past and present, that Laboratory operations have had on the environment.

Brookhaven National Laboratory welcomes your comments, suggestions for improvements, or any questions you may have. Please fill in the information below, and mail your completed survey to:

Brookhaven National Laboratory
Environmental and Waste Management Services Division
Attention: SER Project Coordinator
Building 120
P.O. Box 5000
Upton, NY 11973-5000

Name _____

Address _____

Phone _____

Email _____

Comments, Suggestions, or Questions

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

SER Project Coordinator
Environmental and Waste Management Services Division
Building 120
Brookhaven National Laboratory
PO Box 5000
Upton, NY 11973-5000

Helpful Information on Units of Measure and Conversions

UNITS OF RADIATION MEASUREMENT AND CONVERSIONS

U.S. System	International System	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad	gray (Gy)	1 rad = 0.01 Gy
rem	sievert (Sv)	1 rem = 0.01 Sv

APPROXIMATE METRIC CONVERSIONS

When you know	multiply by	to obtain	When you know	multiply by	to obtain
centimeters (cm)	0.39	inches (in.)	in.	2.54	cm
meters (m)	3.28	feet (ft)	ft	0.305	m
kilometers (km)	0.62	miles (mi)	mi	1.61	km
kilograms (kg)	2.20	pounds (lb)	lb	0.45	kg
liters (L)	0.264	gallons (gal)	gal	3.785	L
cubic meters (m ³)	35.32	cubic feet (ft ³)	ft ³	0.03	m ³
hectares (ha)	2.47	acres	acres	0.40	ha
square kilometers (km ²)	0.39	square miles (mi ²)	mi ²	2.59	km ²
degrees Celcius (°C)	1.8 (°C) + 32	degrees Fahrenheit (°F)	°F	(°F - 32) / 1.8	°C

SCIENTIFIC NOTATION USED FOR MEASUREMENTS

Multiple	Decimal Equivalent	Notation	Prefix	Symbol
1×10^3	1,000	E+03	kilo-	k
1×10^{-2}	0.01	E-02	centi-	c
1×10^{-3}	0.001	E-03	milli-	m
1×10^{-6}	0.000001	E-06	micro-	μ
1×10^{-9}	0.000000001	E-09	nano-	n
1×10^{-12}	0.000000000001	E-12	pico-	p

CONCENTRATION CONVERSIONS

1 ppm = 1,000 ppb
1 ppb = 0.001 ppm = 1 μg/L*
1 ppm = 1 mg/L = 1000 μg/L*

* For aqueous fractions only.

2002 SITE ENVIRONMENTAL REPORT ■ Brookhaven National Laboratory