

Contents

| | |
|-------------------------|-------|
| Executive Summary | iii |
| Acknowledgments | xi |
| List of Figures | xxi |
| List of Tables..... | xxiii |

CHAPTER 1: INTRODUCTION

| | |
|---|------|
| 1.1 Laboratory Mission and Policy..... | 1-1 |
| 1.2 Research and Discoveries..... | 1-2 |
| 1.3 History | 1-2 |
| 1.4 Facilities and Operations | 1-4 |
| 1.5 Location, Local Population, and Local Economy | 1-5 |
| 1.6 Geology and Hydrology | 1-7 |
| 1.7 Climate..... | 1-8 |
| 1.8 Natural Resources..... | 1-9 |
| 1.9 Cultural Resources..... | 1-11 |
| References and Bibliography | 1-12 |

CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

| | |
|--|------|
| 2.1 Integrated Safety Management, ISO 14001, and OHSAS 18001 | 2-1 |
| 2.2 Environmental, Safety, Security, and Health Policy..... | 2-3 |
| 2.3 Planning..... | 2-3 |
| 2.3.1 Environmental Aspects..... | 2-3 |
| 2.3.2 Legal and Other Requirements..... | 2-3 |
| 2.3.3 Objectives and Targets | 2-4 |
| 2.3.4 Environmental Management Programs..... | 2-4 |
| 2.3.4.1 Compliance | 2-4 |
| 2.3.4.2 Groundwater Protection..... | 2-4 |
| 2.3.4.3 Waste Management..... | 2-8 |
| 2.3.4.4 Pollution Prevention and Waste Minimization | 2-9 |
| 2.3.4.5 Water Conservation | 2-10 |
| 2.3.4.6 Energy Management and Conservation..... | 2-11 |
| 2.3.4.7 Natural and Cultural Resource Management Programs | 2-18 |
| 2.3.4.8 Environmental Restoration | 2-19 |
| 2.4 Implementing the Environmental Management System..... | 2-19 |
| 2.4.1 Structure and Responsibility | 2-19 |
| 2.4.2 Communication and Community Involvement..... | 2-20 |

| | | |
|---------|--|------|
| 2.4.2.1 | Communication Forums | 2-20 |
| 2.4.2.2 | Community Involvement in Cleanup Projects..... | 2-23 |
| 2.4.3 | Monitoring and Measurement | 2-23 |
| 2.4.3.1 | Compliance Monitoring..... | 2-24 |
| 2.4.3.2 | Restoration Monitoring..... | 2-26 |
| 2.4.3.3 | Surveillance Monitoring | 2-26 |
| 2.4.4 | EMS Assessments | 2-26 |
| 2.5 | Environmental Stewardship at BNL..... | 2-27 |
| | References and Bibliography | 2-28 |

CHAPTER 3: COMPLIANCE STATUS

| | | |
|---------|--|------|
| 3.1 | Compliance with Requirements..... | 3-2 |
| 3.2 | Environmental Permits | 3-2 |
| 3.2.1 | Existing Permits | 3-2 |
| 3.2.2 | New or Modified Permits | 3-5 |
| 3.2.2.1 | SPDES Permits | 3-5 |
| 3.2.2.2 | NYS Wetlands and Wild Scenic, Recreational Rivers Act..... | 3-5 |
| 3.2.2.3 | Title V Permit..... | 3-8 |
| 3.3 | NEPA Assessments | 3-8 |
| 3.4 | Preservation Legislation | 3-8 |
| 3.5 | Clean Air Act (CAA)..... | 3-8 |
| 3.5.1 | Conventional Air Pollutants | 3-8 |
| 3.5.1.1 | Boiler Emissions..... | 3-8 |
| 3.5.1.2 | Ozone-Depleting Substances | 3-9 |
| 3.5.2 | Hazardous Air Pollutants..... | 3-9 |
| 3.5.2.1 | Maximum Available Control Technology..... | 3-10 |
| 3.5.2.2 | Asbestos | 3-10 |
| 3.5.2.3 | Radioactive Airborne Emissions..... | 3-10 |
| 3.6 | Clean Water Act..... | 3-10 |
| 3.6.1 | Sewage Treatment Plant..... | 3-11 |
| 3.6.1.1 | Chronic Toxicity Testing | 3-14 |
| 3.6.2 | Recharge Basins and Stormwater | 3-14 |
| 3.7 | Safe Drinking Water Act..... | 3-18 |
| 3.7.1 | Potable Water | 3-18 |
| 3.7.2 | Cross-Connection Control..... | 3-20 |
| 3.7.3 | Underground Injection Control (UIC) | 3-20 |
| 3.8 | Preventing and Reporting Spills | 3-20 |
| 3.8.1 | Preventing Oil Pollution and Spills..... | 3-20 |
| 3.8.2 | Emergency Reporting Requirements | 3-23 |
| 3.8.3 | Spills and Releases..... | 3-23 |

| | |
|--|------|
| 3.8.4 Major Petroleum Facility (MPF) License | 3-24 |
| 3.8.5 Chemical Bulk Storage | 3-24 |
| 3.8.6 County Storage Requirements..... | 3-26 |
| 3.9 RCRA Requirements | 3-26 |
| 3.10 Polychlorinated Biphenyls..... | 3-27 |
| 3.11 Pesticides | 3-27 |
| 3.12 Wetlands and River Permits..... | 3-27 |
| 3.13 Protection of Wildlife | 3-28 |
| 3.13.1 Endangered Species Act..... | 3-28 |
| 3.13.2 Migratory Bird Treaty Act..... | 3-29 |
| 3.13.3 Bald and Golden Eagle Protection Act..... | 3-29 |
| 3.14 Public Notification of Clearance of Property | 3-30 |
| 3.15 External Audits and Oversight | 3-30 |
| 3.15.1 Regulatory Agency Oversight..... | 3-30 |
| 3.15.2 DOE Assessments/Inspections..... | 3-30 |
| 3.15.3 Environmental Multi-Topic Assessment..... | 3-30 |
| 3.15.4 Nevada National Security Site | 3-31 |
| 3.16 Agreements, Enforcement Actions, and Other Environmental Occurance Reports | 3-31 |
| References and Bibliography | 3-31 |

CHAPTER 4: AIR QUALITY

| | |
|---|------|
| 4.1 Radiological Emissions | 4-1 |
| 4.1.1 High Flux Beam Reactor..... | 4-1 |
| 4.1.2 Brookhaven Linac Isotope Producer..... | 4-2 |
| 4.1.3 Target Processing Laboratory..... | 4-3 |
| 4.1.4 Additional Minor Sources | 4-3 |
| 4.1.5 Nonpoint Radiological Emission Sources..... | 4-3 |
| 4.2 Facility Monitoring..... | 4-3 |
| 4.3 Ambient Air Monitoring | 4-4 |
| 4.3.1 Gross Alpha and Beta Airborne Activity..... | 4-4 |
| 4.3.2 Airborne Tritium | 4-4 |
| 4.4 Nonradiological Airborne Emissions..... | 4-5 |
| 4.5 Greenhouse Gas Emissions | 4-8 |
| References and Bibliography..... | 4-10 |

CHAPTER 5: WATER QUALITY

| | |
|---|-----|
| 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 | 5-3 |

| | |
|---|------|
| 5.3 Process-Specific Wastewater | 5-3 |
| 5.4 Recharge Basins..... | 5-6 |
| 5.4.1 Recharge Basins – Radiological Analyses | 5-7 |
| 5.4.2 Recharge Basins – Nonradiological Analyses..... | 5-7 |
| 5.4.3 Stormwater Assessment | 5-8 |
| 5.5 Peconic River Surveillance..... | 5-9 |
| 5.5.1 Peconic River – Radiological Analyses | 5-10 |
| 5.5.2 Peconic River – Nonradiological Analyses..... | 5-14 |
| References and Bibliography..... | 5-18 |

CHAPTER 6: NATURAL AND CULTURAL RESOURCES

| | |
|---|------|
| 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 Salamander Protection Efforts..... | 6-2 |
| 6.1.2.2 Banded Sunfish | 6-3 |
| 6.1.2.3 Migratory Birds | 6-4 |
| 6.1.3 Population Management..... | 6-5 |
| 6.1.3.1 Wild Turkey | 6-5 |
| 6.1.3.2 White-Tailed Deer..... | 6-5 |
| 6.1.4 Compliance Assurance and Potential Impact Assessment..... | 6-6 |
| 6.2 Upton Ecological and Research Reserve..... | 6-6 |
| 6.3 Monitoring Flora and Fauna | 6-6 |
| 6.3.1 Deer Sampling..... | 6-7 |
| 6.3.1.1 Cesium-137 in White-Tailed Deer..... | 6-7 |
| 6.3.2 Other Animals Sampled | 6-11 |
| 6.3.3 Fish Sampling | 6-11 |
| 6.3.3.1 Radiological Analysis of Fish..... | 6-11 |
| 6.3.3.2 Fish Population Assessment | 6-13 |
| 6.3.3.3 Non-Radiological Analysis of Fish..... | 6-13 |
| 6.3.4 Aquatic Sampling..... | 6-14 |
| 6.3.4.1 Radiological Analysis..... | 6-14 |
| 6.3.5 Peconic River Post-Cleanup Monitoring | 6-14 |
| 6.3.5.1 Sediment Sampling..... | 6-15 |
| 6.3.5.2 Water Column Sampling..... | 6-16 |
| 6.3.6 Vegetation Sampling | 6-17 |
| 6.3.6.1 Grassy Plants and Soil | 6-17 |
| 6.4 Other Monitoring..... | 6-17 |
| 6.4.1 Basin Sediments..... | 6-17 |

| | |
|---|------|
| 6.4.2 Chronic Toxicity Tests..... | 6-17 |
| 6.4.3 Radiological and Mercury Monitoring of Precipitation..... | 6-18 |
| 6.5 Wildlife Programs | 6-19 |
| 6.6 Cultural Resource Activities..... | 6-23 |
| References and Bibliography..... | 6-24 |

CHAPTER 7: GROUNDWATER PROTECTION

| | |
|--|------|
| 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 Programs..... | 7-2 |
| 7.4 Groundwater Monitoring Results | 7-3 |
| 7.5 Groundwater Treatment Systems..... | 7-7 |
| References and Bibliography..... | 7-10 |

CHAPTER 8: RADIOLOGICAL DOSE ASSESSMENT

| | |
|--|------|
| 8.0 Introduction | 8-2 |
| 8.1 Direct Radiation Monitoring | 8-2 |
| 8.1.1 Ambient Radiation Monitoring..... | 8-2 |
| 8.1.2 Facility Area Monitoring..... | 8-6 |
| 8.2 Dose Modeling | 8-9 |
| 8.2.1 Dose Modeling Program | 8-9 |
| 8.2.2 Dose Calculation Methods and Pathways..... | 8-11 |
| 8.2.2.1 Maximally Exposed Off-site and On-site Individual..... | 8-11 |
| 8.2.2.2 Effective Dose Equivalent | 8-11 |
| 8.2.2.3 Dose Calculation: Fish Ingestion..... | 8-11 |
| 8.2.2.4 Dose Calculation: Deer Meat Ingestion | 8-11 |
| 8.3 Sources: Diffuse, Fugitive, “Other” | 8-12 |
| 8.3.1 Remediation Work | 8-12 |
| 8.4 Dose from Point Sources | 8-12 |
| 8.4.1 Brookhaven Linac Isotope Producer..... | 8-12 |
| 8.4.2 High Flux Beam Reactor..... | 8-12 |
| 8.4.3 Brookhaven Medical Research Reactor..... | 8-12 |
| 8.4.4 Brookhaven Graphite Research Reactor | 8-13 |
| 8.4.5 Waste Management Facility | 8-13 |
| 8.4.6 Unplanned Releases | 8-13 |
| 8.5 Dose from Ingestion | 8-13 |

| | |
|--|------|
| 8.6 Dose to Aquatic and Terrestrial Biota..... | 8-13 |
| 8.7 Cumulative Dose | 8-14 |
| References and Bibliography..... | 8-14 |

CHAPTER 9: QUALITY ASSURANCE

| | |
|---|------------|
| 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 | 9-3 |
| 9.2.1.2 Preservation and Shipment | 9-3 |
| 9.2.2 Field Quality Control Samples..... | 9-3 |
| 9.2.3 Tracking and Data Management | 9-4 |
| 9.3 Sample Analysis | 9-4 |
| 9.3.1 Qualifications | 9-5 |
| 9.4 Verification and Validation of Analytical Results | 9-5 |
| 9.4.1 Checking Results..... | 9-6 |
| 9.5 Contract Analytical Laboratory QA/QC..... | 9-6 |
| 9.6 Performance or Proficiency Evaluations | 9-6 |
| 9.6.1 Summary of Test Results..... | 9-6 |
| 9.6.1.1 Radiological Assessments | 9-7 |
| 9.6.1.2 Nonradiological Assessments | 9-7 |
| 9.7 Audits..... | 9-7 |
| 9.8 Conclusion..... | 9-9 |
| References and Bibliography | 9-9 |
| Appendix A: Glossary | A-1 |
| Acronyms and Abbreviations | A-1 |
| Technical Terms | A-5 |
| Appendix B: Understanding Radiation..... | B-1 |
| Appendix C: Units of Measure and Half-Life Periods | C-1 |
| Appendix D: Federal, State, and Local Laws and Regulations Pertinent to BNL..... | D-1 |

List of Figures

| | | |
|--------------|--|------|
| Figure 1-1. | Major Scientific Facilities at BNL..... | 1-6 |
| Figure 1-2. | Major Support and Service Facilities at BNL..... | 1-7 |
| Figure 1-3. | BNL Groundwater Flow Map..... | 1-9 |
| Figure 1-4. | BNL Wind Rose (2014)..... | 1-10 |
| Figure 1-5. | BNL 2014 Monthly Mean Temperature versus 65-Year Monthly Average..... | 1-10 |
| Figure 1-6. | BNL 2014 Annual Mean Temperature Trend (65 Years)..... | 1-10 |
| Figure 1-7. | BNL 2014 Monthly Precipitation versus 65-Year Monthly Average..... | 1-10 |
| Figure 1-8. | BNL 2014 Annual Precipitation Trend (65 Years)..... | 1-10 |
| | | |
| Figure 2-1a. | Hazardous Waste Generation from Routine Operations, 1998 – 2014..... | 2-10 |
| Figure 2-1b. | Mixed Waste Generation from Routine Operations, 1998 – 2014..... | 2-10 |
| Figure 2-1c. | Radioactive Waste Generation from Routine Operations, 1998 – 2014..... | 2-10 |
| Figure 2-1d. | Hazardous Waste Generation from ER and Nonroutine Operations, 1998 – 2014..... | 2-11 |
| Figure 2-1e. | Mixed Waste Generation from ER and Nonroutine Operations, 1998 – 2014..... | 2-11 |
| Figure 2-1f. | Radioactive Waste Generation from ER and Nonroutine Operations, 1998 – 2014..... | 2-11 |
| Figure 2-2. | Annual Potable Water Use, 1999 – 2014..... | 2-17 |
| Figure 2-3. | BNL Building Energy Performance, 2014..... | 2-18 |
| | | |
| Figure 3-1. | Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2008 – 2014..... | 3-14 |
| Figure 3-2. | Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2008 – 2014..... | 3-15 |
| Figure 3-3. | Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2008 – 2014..... | 3-15 |
| Figure 3-4. | Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2008 – 2014..... | 3-15 |
| Figure 3-5. | Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2008 – 2014..... | 3-16 |
| Figure 3-6. | Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2008 – 2014..... | 3-16 |
| Figure 3-7. | Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2008 – 2014..... | 3-16 |
| | | |
| Figure 4-1. | Air Emission Release Points Subject to Monitoring..... | 4-2 |
| Figure 4-2. | BNL On-Site Ambient Air Monitoring Stations..... | 4-5 |
| Figure 4-3. | Airborne Gross Beta Concentration Trend Recorded at Station P7..... | 4-7 |
| | | |
| Figure 5-1a. | Schematic of BNL's Sewage Treatment Plant (Peconic River Discharge)..... | 5-3 |
| Figure 5-1b. | Schematic of BNL's Sewage Treatment Plant (Recharge Basin Discharge)..... | 5-3 |
| Figure 5-2. | BNL Recharge Basin/Outfall Locations..... | 5-7 |
| Figure 5-3. | Schematic of Potable Water Use and Flow at BNL..... | 5-9 |
| Figure 5-4. | Sampling Stations for Surface Water, Fish, and Shellfish..... | 5-13 |
| | | |
| Figure 6-1. | Deer Sample Locations, 2009 – 2014..... | 6-8 |
| Figure 6-2. | Comparison of Cs-137 Average Concentrations in Deer Meat, 2014..... | 6-12 |
| Figure 6-3. | Ten-Year Trend of Cs-137 Concentrations in Deer Meat..... | 6-12 |
| Figure 6-4. | Peconic River and Lower Lake, Carmans River Mercury Distribution in Fish Species (Minimum, Maximum, and Average Values)..... | 6-16 |

| | | |
|-------------|---|------|
| Figure 6-5. | Peconic River Sample Locations, 2014. | 6-20 |
| Figure 6-6. | Vegetation Sample Locations, 2014. | 6-21 |
| Figure 7-1. | Groundwater Flow and Water Table Elevation (December 2014) with Supply and Remediation Wells Shown. | 7-4 |
| Figure 7-2. | Extent of VOC Plumes. | 7-5 |
| Figure 7-3. | Extent of Radionuclide Plumes. | 7-6 |
| Figure 7-4. | Locations of BNL Groundwater Remediation Systems. | 7-9 |
| Figure 8-1. | On-Site TLD Locations. | 8-3 |
| Figure 8-2. | Off-Site TLD Locations. | 8-4 |
| Figure 8-3. | On-Site Neutron TLD Locations. | 8-8 |
| Figure 9-1. | Flow of Environmental Monitoring QA/QC Program Elements. | 9-2 |
| Figure 9-2. | Summary of Scores in the Radiological Proficiency Evaluation Programs. | 9-8 |
| Figure 9-3. | Summary of Scores in the Nonradiological Proficiency Evaluation Programs. | 9-8 |

List of Tables

| | | |
|-------------|---|------|
| Table 2-1. | EO 13514 Goals: Status Summary for Fiscal Year (FY) 2014. | 2-5 |
| Table 2-2. | BNL Pollution Prevention, Waste Reduction, and Recycling Programs. | 2-12 |
| Table 2-3. | BNL Recycled Program Summary, 2002-2014. | 2-16 |
| Table 2-4. | Summary of BNL 2014 Environmental Restoration Activities. | 2-22 |
| Table 2-5. | Summary of BNL 2014 Sampling Program Sorted by Media. | 2-24 |
| | | |
| Table 3-1. | Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL | 3-2 |
| Table 3-2. | BNL Environmental Permits. | 3-6 |
| Table 3-3. | Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001 (Peconic River). | 3-12 |
| Table 3-4. | Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001 (Groundwater) | 3-13 |
| Table 3-5. | Analytical Results for Wastewater Discharges to Outfalls 002, 005 - 008, and 010. | 3-18 |
| Table 3-6. | Potable Water Wells and Potable Distribution System: Analytical Results (Maximum Concentration, Minimum pH Value) | 3-21 |
| Table 3-7. | Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, and Micro-Extractables. | 3-22 |
| Table 3-8. | Applicability of EPCRA to BNL | 3-23 |
| Table 3-9. | Summary of Chemical and Oil Spill Reports. | 3-25 |
| Table 3-10. | Existing Agreements and Enforcement Actions Issued to BNL, with Status. | 3-32 |
| Table 3-11. | Summary of Other Environmental Occurrence Reports, 2014. | 3-32 |
| | | |
| 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 Ambient Air Monitoring Particulate Filters. | 4-6 |
| Table 4-4. | Ambient Airborne Tritium Measurements in 2014. | 4-8 |
| Table 4-5. | Central Steam Facility Fuel Use and Emissions (2005 – 2014). | 4-9 |
| | | |
| Table 5-1. | Tritium and Gross Activity in Water at the BNL Sewage Treatment Plant (STP). | 5-5 |
| Table 5-2. | Radiological Analysis of Samples from BNL On-Site Recharge Basins. | 5-8 |
| Table 5-3. | Water Quality Data for BNL On-Site Recharge Basin Samples. | 5-10 |
| Table 5-4. | Metals Analysis of Water Samples from BNL On-Site Recharge Basins. | 5-11 |
| Table 5-5. | Radiological Results for Surface Water Samples from the Peconic and Carmans Rivers. | 5-14 |
| Table 5-6. | Water Quality Data for Surface Water Samples Collected along the Peconic and Carmans Rivers. | 5-15 |
| Table 5-7. | Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers. | 5-16 |
| | | |
| Table 6-1. | New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL | 6-3 |
| Table 6-2. | Radiological Analyses of Deer Tissue. | 6-10 |
| Table 6-3. | Radiological Analysis of Fish from the Peconic River System and Carmans River, Lower Lake. | 6-13 |
| Table 6-4. | Metals Analysis of Fish from the Peconic River System and Lower Lake, Carmans River. | 6-15 |
| Table 6-5. | Mercury Analysis of Fish from the Peconic River System and Lower Lake, Carmans River. | 6-17 |
| Table 6-6. | PCB Analysis of Fish from BNL Portions of the Peconic River System. | 6-17 |
| Table 6-7. | Surveillance and Post Cleanup Monitoring Data for Aquatic Vegetation and Sediment from the Peconic River. | 6-18 |
| Table 6-8. | Post Cleanup Peconic River Water Column Monitoring. | 6-19 |
| Table 6-9. | Radiological Analysis of Grassy Vegetation and Associated Soils. | 6-22 |
| Table 6-10. | Precipitation Monitoring (Radiological and Mercury). | 6-22 |

| | |
|---|------|
| Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2014..... | 7-8 |
| Table 8-1. On-Site Direct Ambient Radiation Measurements for 2014..... | 8-5 |
| Table 8-2. Off-Site Direct Radiation Measurements for 2014..... | 8-7 |
| Table 8-3. Facility Area Monitoring, 2014..... | 8-7 |
| Table 8-4. Maximally Exposed Off-site Individual Effective Dose Equivalent From Facilities or Routine Processes, 2014..... | 8-10 |
| Table 8-5. BNL Site Dose Summary..... | 8-14 |