Chapter 1

Introduction

Brookhaven National Laboratory, a U.S. Department of Energy national laboratory, received the International Organization for Standardization (ISO) 14001 Certification in 2001 and is the first Office of Science national laboratory to obtain third-party registration to this globally recognized environmental management standard. Located in the center of the unique pine barrens ecosystem of Long Island, New York, Brookhaven National Laoratory is committed to conducting its mission of research and education in a safe and environmentally responsible manner. The Laboratory prepares this *Site Environmental Report* annually to summarize the status of its environmental programs and performance. This report also describes impacts, both past and present, that Laboratory operations have had on the environment. Chapter 1 describes the site's facilities, ecological resources, demographics, and history. Chapter 1 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 PURPOSE OF THIS REPORT

The U.S. Department of Energy (DOE) requires its facilities, including Brookhaven National Laboratory (BNL), to establish environmental programs and report annually on environmental performance. The *Site Environmental Report* (SER) is prepared in accordance with DOE Order 231.1, "Environment, Safety and Health Reporting," and confirms compliance with DOE Order 5400.5, "Radiation Protection of the Public and Environment." Additionally, DOE Order 5400.1, "General Environmental Protection Program," establishes the requirement for environmental protection programs. SERs inform BNL staff, DOE, regulators, and the public and provide an historical record of the environmental condition of the site.

The *2001 SER* describes the status and results of BNL's environmental protection programs for calendar year 2001. BNL has been preparing annual SERs continuously since 1968. In June 2001, BNL published *Radiological Emissions and Environmental Monitoring for Brookhaven National Laboratory, 1947–1961* (Meinhold and Meinhold 2001). Combined with *Radiological Environmental Monitoring Report for Brookhaven National Laboratory 1967–1970* (Meinhold and Hull 1998) and individual reports for the years 1962 through 1966, BNL has now recorded and compiled nearly all of its environmental history since the Laboratory's inception in 1947.

This chapter provides background material to support the technical information in the chapters that follow. Chapter 2 describes BNL's environmental management system and programs, including pollution prevention and environmental restoration. Chapter 3 summarizes BNL's compliance with the wide variety of environmental regulations and permits that govern site operations. Chapters 4 through 7 discuss specific programs and data by environmental media, including air (Chapter 4), water (Chapter 5), natural and cultural resources (Chapter 6), and groundwater (Chapter 7). Chapter 8 provides information on radiological dose to individuals and fauna. Chapter 9 describes how BNL ensures that the data used to monitor environmental impact are of high quality and accuracy. The appendices provide definitions of technical terms, an explanation of the concepts of radioactivity, radiological data methodologies, analytical methods and instrumentation used, identification of the groundwater monitoring wells, and the quality control tables associated with quality assurance.

The SER is available as a downloadable file on the BNL web page, and as a condensed version in a separate *Summary Booklet*, along with a CD version of this report (see inside front cover for ordering information). This information is available in several formats to provide easily accessible environmental information to BNL's stakeholders. The *Summary Booklet* provides information to visitors, students, and members of the public in support of BNL's educational and community outreach program.

1.2 MISSION

BNL's role for DOE is to produce excellent science and advanced technology in a safe, environmentally responsible manner with the cooperation, support, and appropriate involvement of the scientific and local communities. The four key DOE missions are Energy Resources, Science and Technology, Environmental Quality, and National Security. The elements of BNL's mission that support these key DOE missions are the following:

- To conceive, design, construct, and operate complex, leading-edge, user-oriented facilities in a safe, environmentally benign manner that is responsive to DOE and the needs of the international community of users.
- To carry out basic and applied research in long-term programs at the frontier of physical, chemical, life, and environmental sciences in support of DOE's missions.
- 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. BNL's policy is to integrate environmental

stewardship into all facets of the Laboratory's mission and operations. Figure 2-1 (in Chapter 2) shows BNL's Environmental Stewardship Policy, which represents the highest level of commitment to conducting research and operational activities in a manner that protects the ecosystem and the health of employees and the public.

1.3 OPERATIONS

Brookhaven National Laboratory conducts research in physics, biomedical, and environmental sciences, as well as in energy technologies. BNL also builds and operates major facilities available to university, industrial, and government scientists. BNL is 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.

BNL, home to many world-class research facilities and scientific departments, attracts resident and visiting scientists in many fields. Approximately 3,000 resident scientists, engineers, technicians, and support staff work at BNL. More than 4,000 academic and industrial researchers from all over the world visit the site each year to participate in scientific collaborations. Just a few of the scientific discoveries at BNL include promising cocaine addiction treatment, discovery of new subatomic particles, L-dopa used for medical treatments for Parkinson's disease, advances in biotechnology for cleaning up pollution, asbestos-digesting foam, advanced energy technology studies, the quiet jackhammer, and a patent for long-life rechargeable batteries. In 2001, BNL was ranked among the top five major institutions worldwide in terms of the impact of its environmental research, and DOE recognized BNL with three Energy 100 Awards for scientific and technological achievements that have contributed to society by helping consumers save money and improve their quality of life. The three areas of research recoginized were studies of drug addiction and drug action using the imaging technique called positron emission tomography (PET), the invention of the Flame Quality Indicator (a device that measures flame brightness in oil burners), and the development of techniques for preventing and diagnosing Lyme disease.

BNL's annual budget is approximately $450 million. Most of this budget directly supports the local economy through wages and purchases of materials and services. BNL is the largest employer in eastern Long Island. In fiscal year 2001, BNL purchased more than $24 million worth of supplies and services from Long Island businesses. Employee salaries, wages, and fringe benefits accounted for 57 percent, or $258 million, of BNL's total budget. Additionally, most of the 3,000 BNL employees live and shop locally in Suffolk County and throughout Long Island (see Section 1.5). 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 began operations in 1950. The BGRR was used for peaceful scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. The BGRR operated until 1969 and is now being decommissioned. Its capacity was replaced and surpassed in 1965 by the High Flux Beam Reactor (HFBR), which provided neutrons to researchers of all disciplines, from solid state physics to art history. During a scheduled maintenance shutdown in 1997, a leak in the HFBR's spent fuel storage pool was discovered. In November 1999, the Secretary of Energy made a decision to permanently close the HFBR.

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 positron emission tomography 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 currently operating. Due to a reduction of research funding, the BMRR conducted its last run on December 28, 2000. Since then, actions to place that facility in a safe, stabilized condition have been ongoing, and plans have been made to ship its spent fuel to DOE's Savannah River Site in the fall of 2002.

High-energy particle physics research at BNL began in 1952 with the Cosmotron, the first particle physics accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Nobel Prize–winning discovery in physics in 1957. In 1960, the Alternating Gradient Synchrotron (AGS), a much larger accelerator that surpassed the Cosmotron's capabilities, became operational. It has yielded many discoveries on new particles and phenomena, for which BNL researchers were awarded three additional Nobel Prizes in physics in 1976, 1980, and 1988. The AGS continues to operate. Another accelerator, the Tandem Van de Graaff, began operating in 1970 and continues operating to the present. In 1982, the National Synchrotron Light Source (NSLS) began operation. The NSLS guides charged particles in an orbit. As the electrons spin inside a hollow donut-shaped tube called an electron storage ring, they give off light called synchrotron light. This synchrotron light, which can be detected by specialized instruments, has many uses in both the physical and biological research sciences.

BNL's newest accelerator facility, the Relativistic Heavy Ion Collider (RHIC), began operation in 2000. This two-ringed particle accelerator has a circumference of 2.4 miles and has four detectors that are now recording full-energy collisions. The RHIC is expected to produce data that will give a clearer picture of what happens when gold ions collide at nearly the speed of light (Figure 1-1). The goal of this research is to recreate (on a microscopic scale) the hot, dense conditions that are thought to have existed when the universe first formed, so scientists can study the basic components of matter as they existed in its earliest form.

The RHIC is an example of BNL's commitment to fully integrate today's world-class science with world-class protection of the environment. In August 1999, the RHIC became the first facility at BNL and the first on Long Island to receive International Organization for Standardization (ISO) 14001 Environmental Management System certification (see Chapter 2 for details). In 2001, the entire BNL facility became ISO 14001 registered, becoming the first Office of Science national laboratory to obtain third-party registration to this globally recognized environmental standard.

It is unfortunate that historical operations and waste management practices at BNL led to releases of chemicals and radioactive materials that resulted in soil and groundwater contamination. In 1989, BNL was added to the federal Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) National Priorities List of environmentally contaminated sites identified for priority cleanup. In the past four years, BNL has made significant progress toward improving environmental

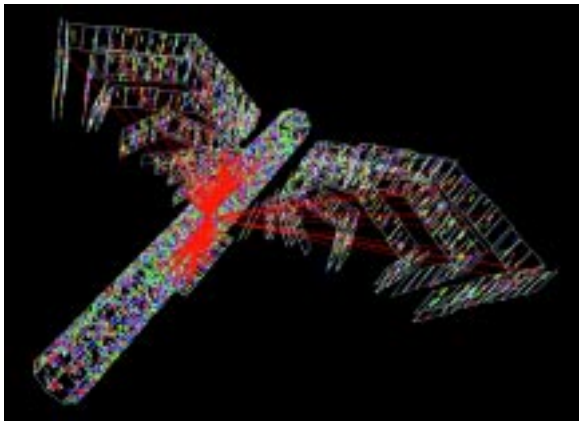

Figure 1-1. Collision Event Recorded by the PHOBOS Detector on July 18, 2001.

operations and remediating past contamination (see Chapter 2 for details). In 2001, BNL received an "Excellent" performance rating from DOE for its environmental, health, and safety operational performance, and BNL's Environmental Management System was rated "Outstanding," which is the highest possible ranking.

1.5 LOCATION AND LOCAL POPULATION

BNL is located near the geographical center of Suffolk County, Long Island, New York. BNL is in Brookhaven Township, about 60 miles east of New York City (Figure 1-2). Nearly one-third of the 1.43 million people who reside in Suffolk County live in Brookhaven Township (LIPA 2001). Figure 1-3 shows the population distribution on parts of Long Island. As with all townships on Long Island, there has been an increase in residential housing in Brookhaven Township in recent years, a trend that is expected to continue. More than 75 percent of BNL's approximately 3,000 employees live within a 15-mile radius of the Laboratory (Figure 1-4).

Approximately 150 people reside long-term in the apartments and cottages on site, and many of the 4,000 scientists who visit each year stay short-term in on-site housing. Figure 1-5 shows the housing capacity for on-site residents and visitors. In addition to the resident staff and visiting scientists, more than 25,000 visitors participated in educational and public outreach activities conducted on site during 2001.

Figure 1-2. Landsat 7 Image of Long Island *(courtesy of NASA).*

1.6 FACILITY AND OPERATIONS

Most of BNL's principal facilities are located near the center of the 5,265-acre site. The developed area is approximately 1,650 acres, consisting of approximately

- 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.

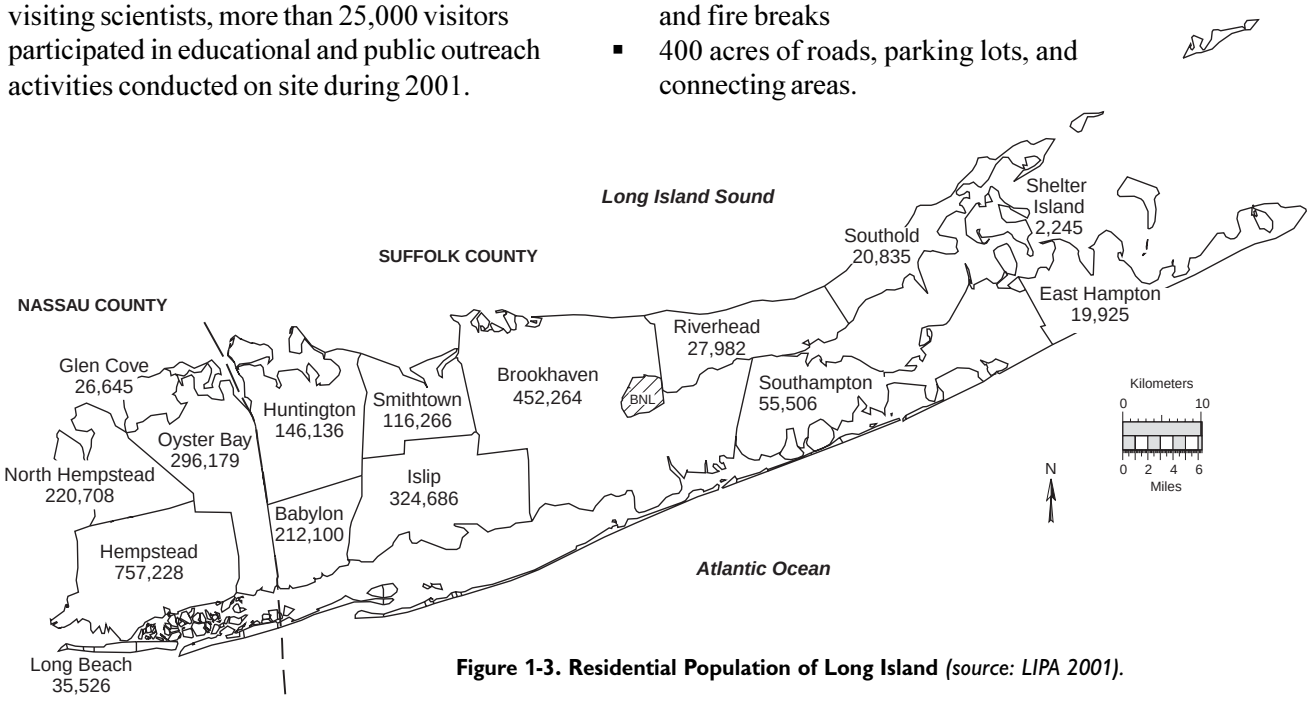

Figure 1-3. Residential Population of Long Island *(source: LIPA 2001).*

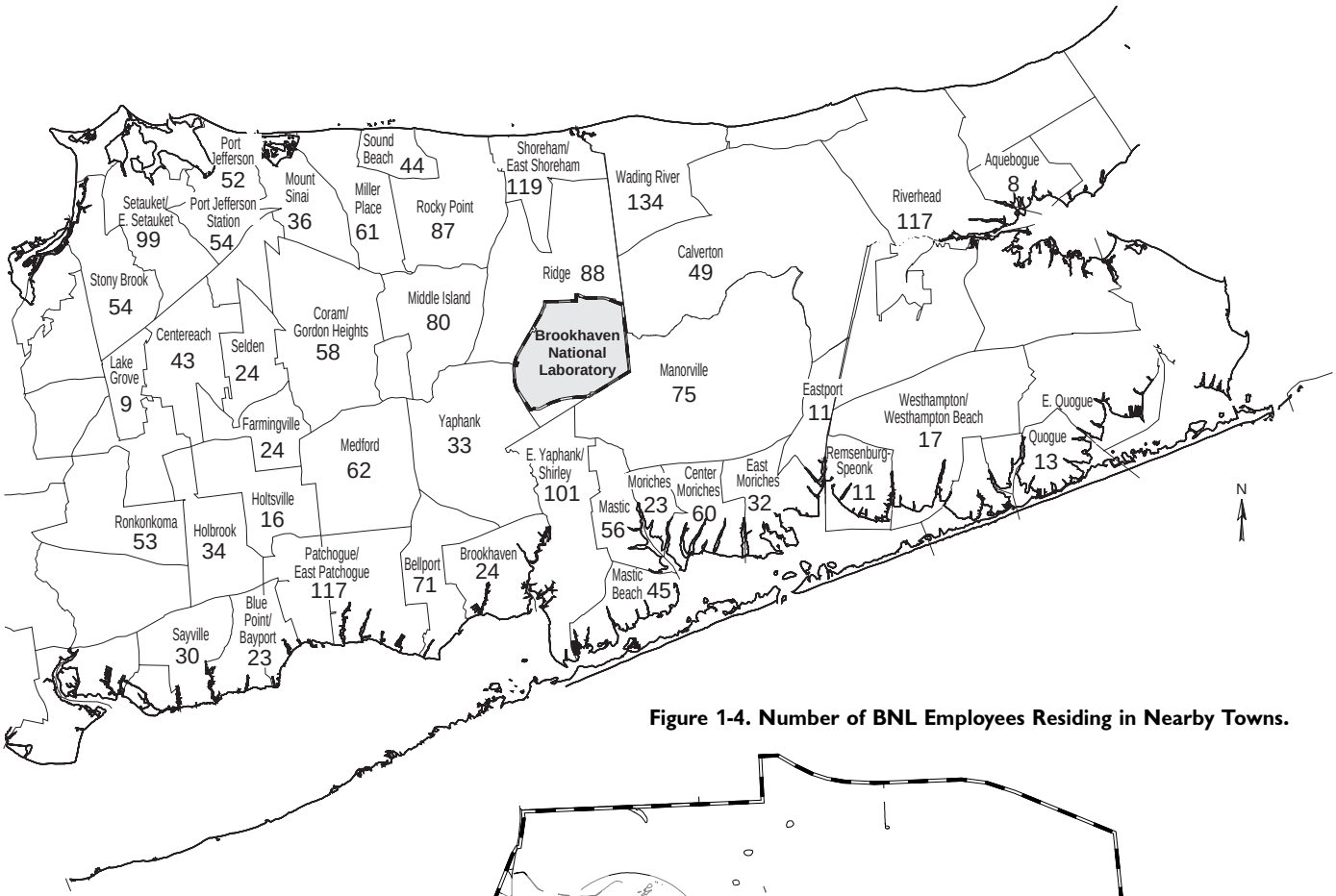

Figure 1-4. Number of BNL Employees Residing in Nearby Towns.

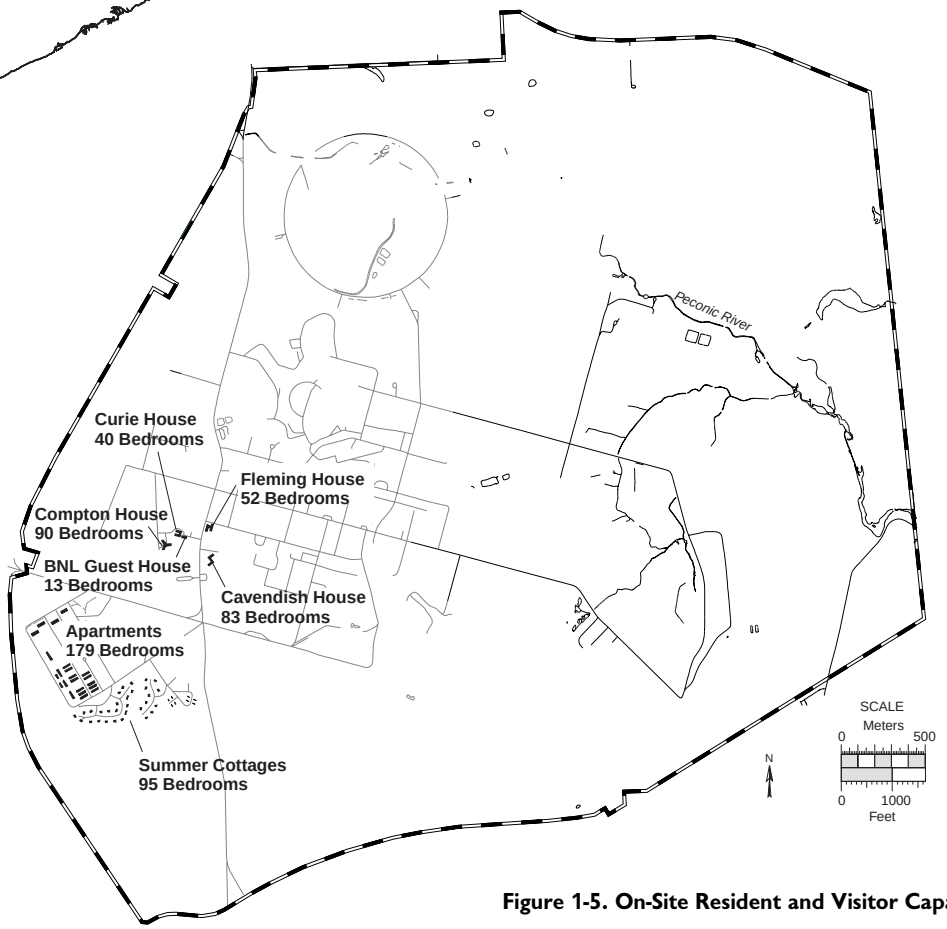

Figure 1-5. On-Site Resident and Visitor Capacity.

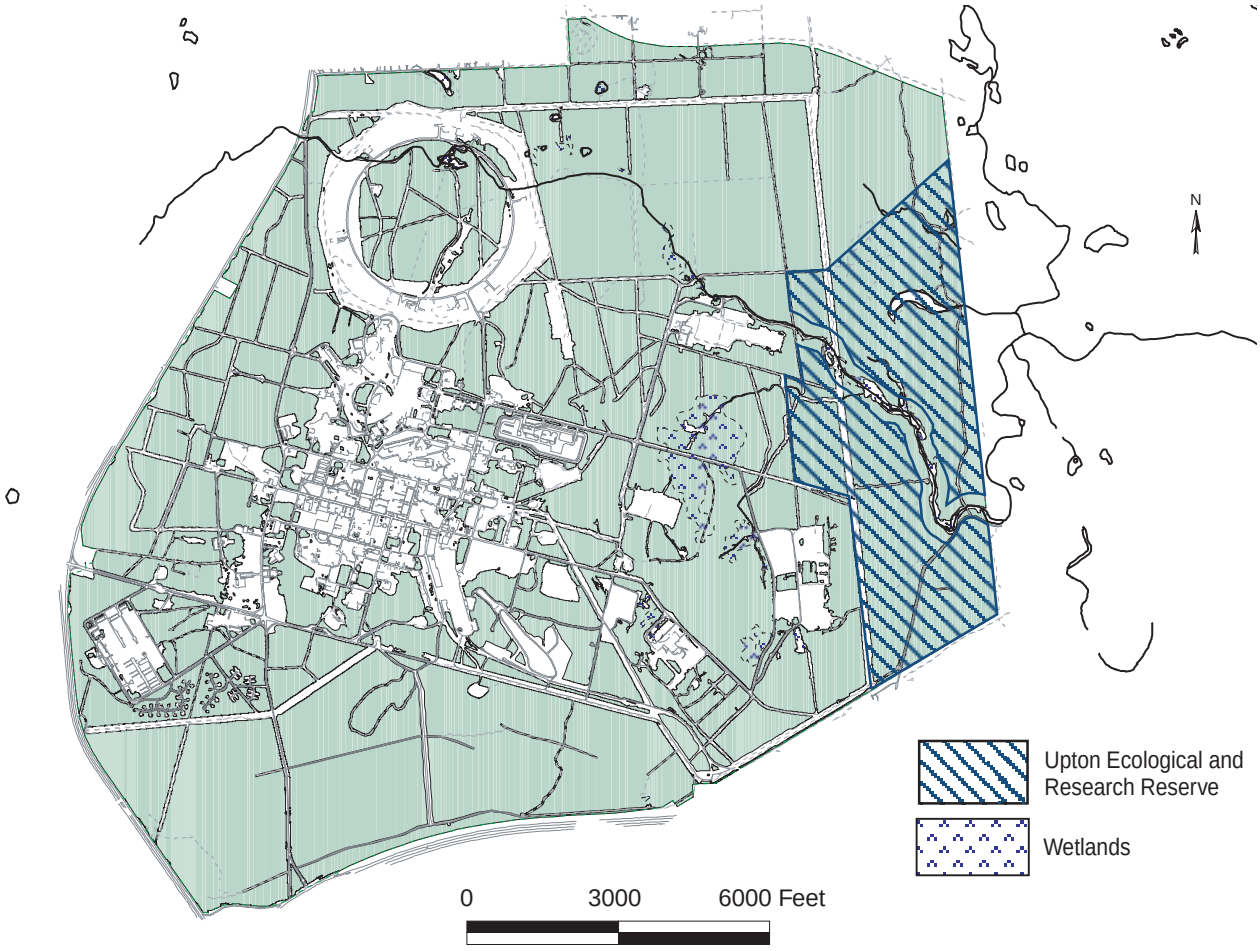

Figure 1-6. Upton Ecological Reserve.

The balance of the site, approximately 3,600 acres, is mostly wooded and represents native pine barrens ecology. In November 2000, DOE and the U.S. Fish and Wildlife Service (FWS) set aside 530 acres of the undeveloped land at BNL as the Upton Ecological and Research Reserve (Figure 1-6). More information about on-site natural resources, the reserve, and the plants and animals it protects can be found in Section 1.9 and in Chapter 6.

The major scientific facilities at BNL are shown and briefly described in Figure 1-7. As noted earlier, the three research reactors (the BGRR, the HFBR, and the BMRR) are no longer operational. In addition to the scientific facilities, numerous other facilities support BNL's science and technology mission by providing basic utility and environmental services (Figure 1-8):

- *Water Treatment Plant.* The potable water treatment facility has a capacity of 5 million gallons per day. (Actual 2001 usage averaged 2.13 million gallons per day; see Chapter 2 for more information.) 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 and are air-stripped 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 VOCs meet or exceed the standards.
- *Central Chilled Water Plant.* This facility provides chilled water sitewide for air conditioning and process refrigeration via a network of underground piping. The plant


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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 and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven Linac Isotope Producer facility.

3. AGS BOOSTER

The AGS Booster is a circular accelerator, 200 meters in circumference, that receives either a proton beam from the Llinac, or heavy ions from the Tandem Van de Graaff. The 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 Llinac 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. This interconnection permits ions of intermediate mass to be injected into the AGS where they can be accelerated to an energy of 15 GeV/amu. 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. 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 for physics experiments.

12. BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)

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

Figure 1-7. Major Scientific Facilities at Brookhaven National Laboratory.

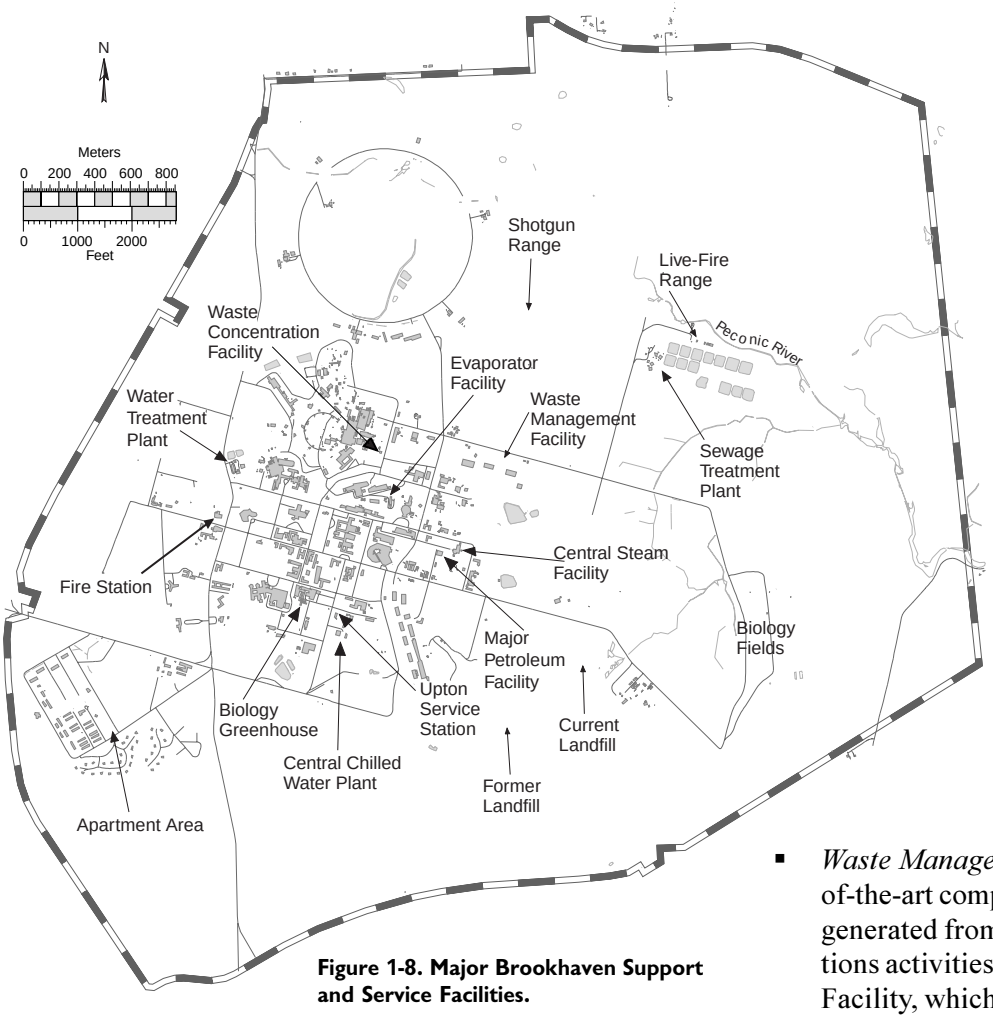


Figure 1-8. Major Brookhaven Support and Service Facilities.

has a large refrigeration capacity with once-through cooling, reducing the need for local refrigeration plants.

- *Central Steam Facility.* This is a dual fuel–fired plant that provides high-pressure steam for both facility and process heating sitewide. In 2001, fuel oil was the primary fuel; natural gas was the secondary fuel. Steam is conveyed to user facilities through a network of underground piping. Condensate is collected and returned to the facility for reuse, to conserve water and energy.
- *Major Petroleum Facility.* This provides reserve fuel for the Central Steam Facility during times of peak operation. With a total capacity of 2.3 million gallons, the Major Petroleum Facility stores predominantly No. 6 fuel oil. The 1997 conversion of some of the boilers at the Central Steam Facility to natural gas has significantly reduced BNL's reliance on oil as a fuel source.
- *Sewage Treatment Plant.* This plant 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 Sewage Treatment 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. See Chapter 3 for additional information on this facility and associated environmental permits.
- *Waste Management Facility.* This is a state-of-the-art complex for managing the wastes generated from BNL's research and operations activities. The Waste Management Facility, which opened in December 1997, was built with advanced environmental protection systems and features. It houses two areas that have permits from the New York State Department of Environmental Conservation for storing hazardous wastes prior to shipment for treatment and disposal at other permitted treatment, storage, and disposal facilities. See Chapter 2 for more information on BNL's waste management practices.
- *Fire Station.* The BNL Fire Department provides on-site fire prevention and response and handles situations involving hazardous materials, technical rescue, and medical emergencies. They maintain six response vehicles at the Fire Station and respond 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).

1.7 GEOLOGY AND HYDROLOGY

BNL lies 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 that 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 groundwater; with normal to above-normal precipitation, the river receives water from the aquifer. In general, the terrain of the BNL site is gently rolling, with elevations varying between 44 and 120 feet above 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 elevation areas in the central and western portions of the site.

The hydrology of this area is very 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 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, SCDHS 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. It is estimated 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 the U.S. Environmental Protection Agency. BNL uses approximately 2.13 million gallons of groundwater per day to meet potable water needs and heating and cooling requirements. Approximately 74 percent of the water pumped from BNL supply wells is returned to the aquifer through on-site recharge basins. About 19 percent is discharged into the Peconic River. Human consumption, evaporation (cooling tower and wind losses), and sewer line losses account for the remaining 7 percent. An additional 2.74 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 1-9). Pumping from on-site water supply wells also affects the direction and speed of groundwater flow, especially in the central, developed areas of the site. Two natural groundwater divides have been identified near BNL (Scorca *et al.* 1999). One divide is located approximately one-half mile north of BNL and a second divide transects portions of the site when the water table is high and the aquifer flows into the stream bed of the Peconic River. These divides define the boundaries of the area that contributes groundwater to the Peconic watershed.

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 terms, this means that it takes approximately 20 to 22 years for groundwater to travel from the central, developed area of the site to the BNL southern boundary. Chapter 7 provides details on BNL's comprehensive Groundwater Protection Management Program.

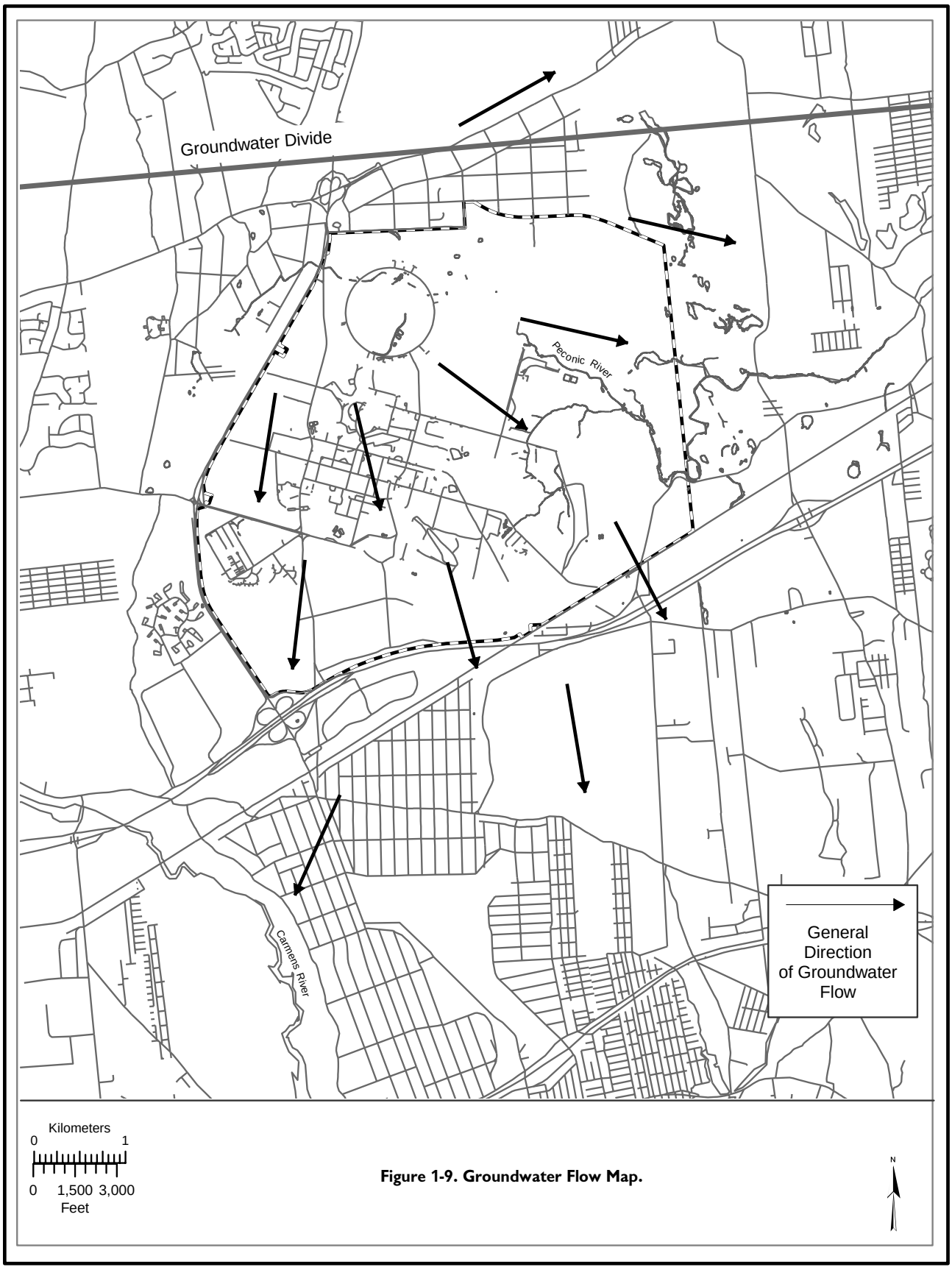


Figure 1-9. Groundwater Flow Map.

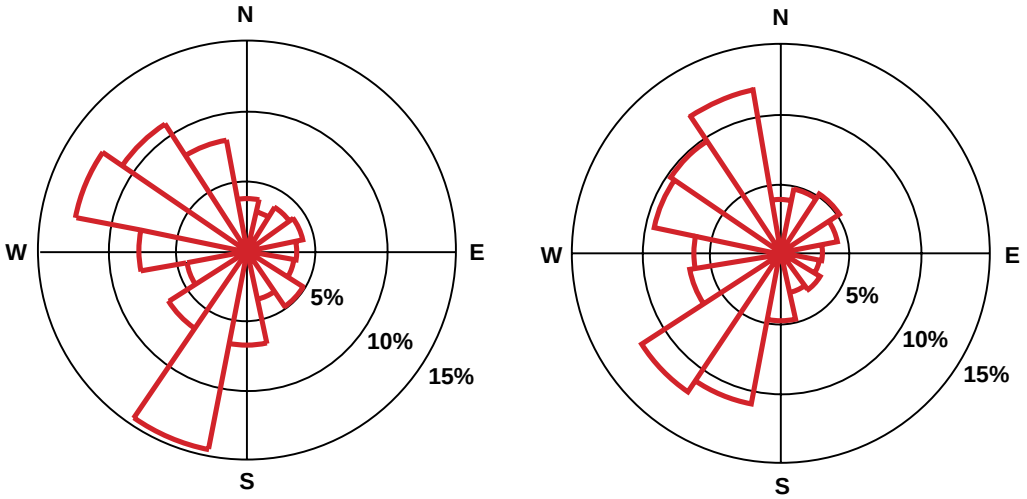
1.8 CLIMATIC DATA

The Meteorological Group at BNL has collected 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, Nagle 1978). Figure 1-10 shows the 2001 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 and 300 feet.

Year 2001 brought 51.2 inches of snow, 21.6 inches more than normal for the period. The sole blizzard of the year produced 15 inches of snow on March 5 and 6. The March total of 19 inches of snowfall was three times the average for the month.

The total precipitation for 2001 was 45.55 inches. Most of the precipitation occurred from March through September. The 10.37 inches of precipitation in March made it the wettest March recorded (the closest was the March 1953 total of 10.36 inches). April was drier than normal (2.03 inches, compared to the average 4.22 inches), and the late fall and winter months were drier than average. Overall, 2001 was slightly drier than average; the precipitation was 2.87 inches below the 53-year annual average of 48.42 inches, about 5.9 percent drier than average. Figures 1-11 and 1-12 present the 2001 monthly and the 53-year annual precipitation data.

The monthly mean temperature in 2001 was 52.3°F, ranging from a monthly mean low temperature of 29.4° F in January to a monthly mean high temperature of 74.3°F in August. The year 2001 was slightly warmer than average, 2.3°F above the 53-year annual average of 50.0°F; it was the fifth warmest year since BNL started recording weather statistics in 1949. In general, using a linear average, temperatures at BNL have increased 2.05°F over the past 53 years, compared to a worldwide average surface temperature increase of 0.5°F (0.3°C) over approximately the same time period (Jones *et al.* 1999). Figures 1-13 and 1-14 show the 2001 temperatures and the historical annual mean temperatures.



10-m level
Calm (< 0.5 m/s): 16.7%

90-m level
Calm (< 0.5 m/s): 0.2%

Explanation: The arrows formed by the wedges indicate wind direction. Each concentric circle represents a 5% frequency, that is, how often the wind is coming from that direction. The wind direction was measured at heights of 33 and 300 feet (10 and 90 meters). For example, this diagram indicates that the predominant wind direction at 33 feet (10 meters) was from the south-southwest.

Figure 1-10. Annual Wind Rose (2001).

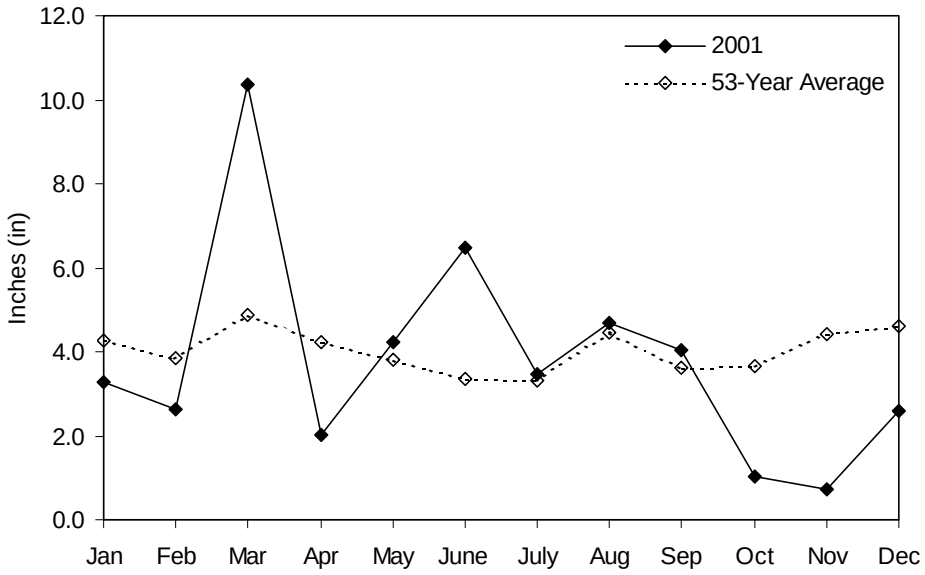


Figure 1-11. 2001 Monthly Precipitation versus 53-Year Monthly Average.

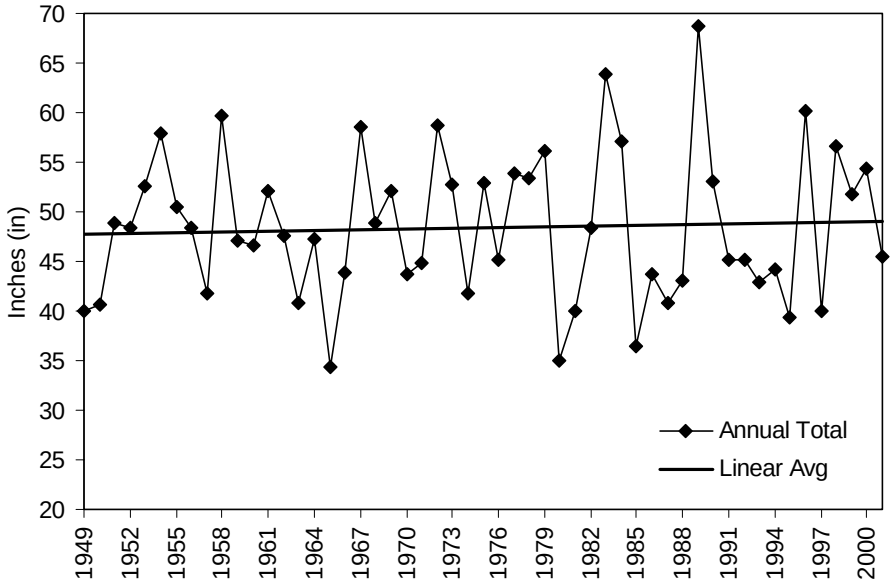


Figure 1-12. Annual Precipitation Trend (53 Years).

1.9 ECOLOGICAL RESOURCES

BNL is located in the oak/chestnut forest region of the Coastal Plain. BNL property constitutes about 5 percent of the 100,000-acre New York State–designated region known as the Central Pine Barrens. Additionally, part of the Peconic River running through BNL was designated "scenic" by the New York State Wild, Scenic, and Recreational River System Act (New York State 1972). As noted before, because of 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

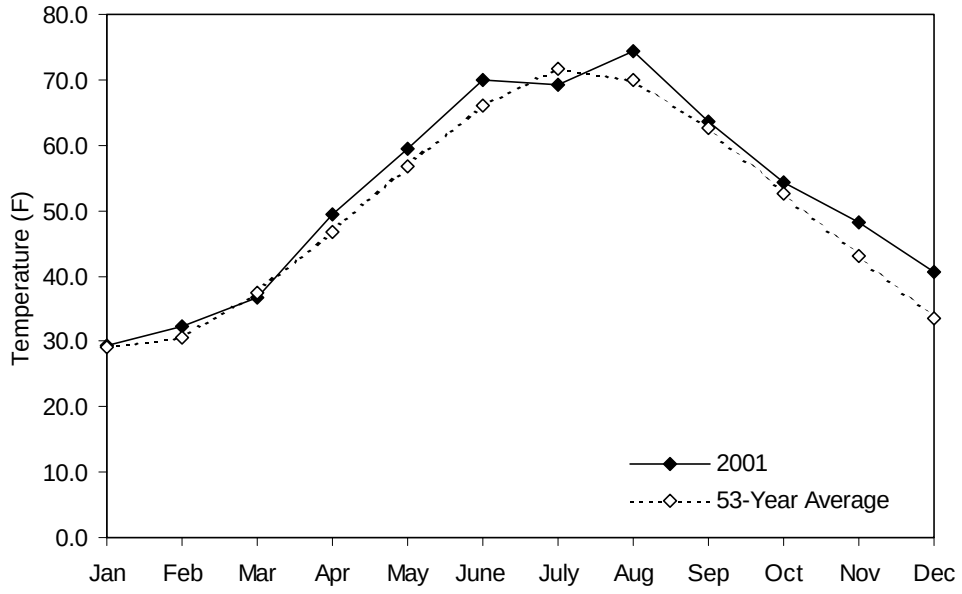


Figure 1-13. 2001 Monthly Mean Temperature versus 53-Year Monthly Average.

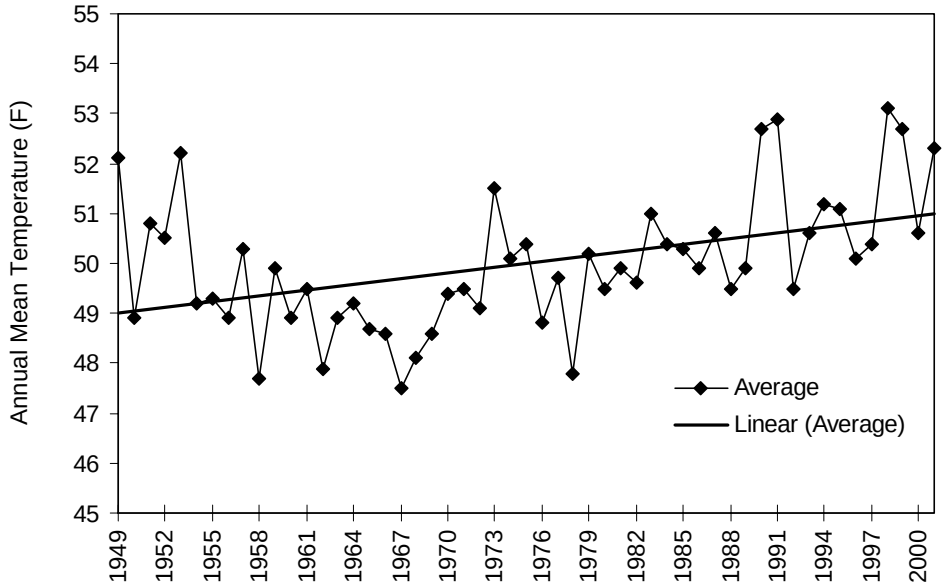


Figure 1-14. Annual Mean Temperature Trend (53 Years).

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; it was 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.

The 15 mammal species at BNL include species common to mixed hardwood forests and open grassland habitats. The white-tailed deer density is currently estimated at 140 per square mile. There were 85 per square mile estimated in 1992 (Thomlinson 1993) and 236 per square mile in 2000 (BNL 2001). The notable reduction in deer population between 2000 and 2001 is largely due to a combination of overpopulation, lack of acorns (a primary winter food), and significant snowfall in February and March of 2000.

At least 85 species of birds are known to nest at BNL, and an additional 130 species have been documented as "visiting" the site. These numbers are due to BNL's location in the Atlantic Flyway and the scrub/shrub habitats that offer food and rest to migratory songbirds. Open fields bordered by hardwood forests at the recreation complex are excellent hunting areas for hawks.

Permanently flooded retention basins and other watercourses support amphibians and aquatic reptiles. Nine amphibian and ten reptile species have been identified, as well as nine species of fish. Ecological studies at the BNL site have confirmed 15 breeding sites for the New York State endangered eastern tiger salamander (*Ambystoma t. tigrinum*) in vernal pools and some recharge basins. The New York State Department of Environmental Conservation listed the banded sunfish (*Eanneacanthus obesus*) as a threatened species in 1999. It 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 due to the potential that the appropriate habitat exists at the Laboratory. This small butterfly lays its eggs near lupine, where the caterpillars feed. Confirmation of this butterfly's presence will be attempted during its breeding season in 2002.

Other wildlife species of interest that inhabit this area include the wild turkey, red fox, eastern box turtle, and the red-tailed hawk. One New York State threatened plant is found on site: the stiff goldenrod (*Solidago rigida*). A discussion of the Laboratory's wildlife protection strategy can be found in Chapter 6.

In November 2000, DOE joined with the U.S. Fish and Wildlife Service to establish the Upton Ecological and Research Reserve. This action set aside 10 percent of BNL property for conservation and ecological research. The reserve permanently preserves a portion of the Central Pine Barrens, a unique ecosystem of forests and wetlands on Long Island. This area provides habitat for approximately 27 species that are endangered, threatened, or of special concern. DOE has committed to providing the FWS with $200,000 a year, over a five-year period, for land management activities and research in the Upton Ecological and Research Reserve. The partnership and funding created by DOE and FWS resulted in educational programs carried out jointly by the Laboratory, Suffolk County Community College, and FWS. A Technical Advisory Group, made up of local land management agencies, was formed in 2000. This committee assists BNL and FWS by providing technical expertise and input to the development of a Natural Resource Management Plan for the Laboratory. The Upton Reserve funded two research proposals submitted in 2001. More information about the reserve, natural resource management, plants, and animals can be found in Chapter 6.

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