Chapter 1

Introduction

Brookhaven National Laboratory (BNL) hosts thousands of visitors each year, from world renowned scientists conducting research at Brookhaven's unique science facilities, to local school children learning about the mysteries of the universe and our environment. As a U.S. Department of Energy national laboratory located in the center of the unique pine barrens ecosystem of Long Island, New York, BNL 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 any impacts both past and present that BNL research operations may have had on the environment. Chapter 1 describes BNL's facilities, ecological resources onsite, and the human populations nearby. It also discusses local site characteristics in terms of geology, hydrology, and climate. This introduction provides background material for the technical information in the chapters that follow.

1.1 PURPOSE OF THE SITE ENVIRONMENTAL REPORT 2000

The U.S. Department of Energy (DOE) requires its facilities, including Brookhaven National Laboratory (BNL), to report annually on environmental performance. The *Site Environmental Report* (SER) is prepared in accordance with DOE Order 231.1 (1995) and DOE Order 5400.1 (1988). The SER describes the status and results of BNL's environmental protection programs for calendar year 2000. BNL has been preparing annual SERs since 1968; consequently, the 2000 SER is part of a continuing record of the Laboratory's environmental activities and impacts. The SER also serves a function beyond complying with DOE requirements – it communicates environmental information to BNL staff, DOE, regulators, and the public.

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), surface water (Chapter 5), natural and cultural resources (Chapter 6), and groundwater (Chapter 7). Chapter 8 provides information on radiological dose to individuals and flora and fauna. Finally, Chapter 9 describes how BNL ensures 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, and more detailed technical and operational data.

A condensed version of the SER is available in a separate Summary Booklet (see inside front cover for ordering information). 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 BROOKHAVEN NATIONAL LABORATORY OPERATIONS

Brookhaven Science Associates (BSA) operates BNL for the DOE. BSA is 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 1947-1998, BNL was operated by Associated Universities Incorporated. Prior to 1947, the site served as a U.S. Army training camp called Camp Upton, which was active from 1917-1920 for World War I and 1940-1946 for World II.

Approximately 3,000 resident scientists and support staff work at BNL. In addition, more than 4,000 academic and industrial researchers from all over the world visit the site each year to participate in scientific collaborations. BNL's annual budget is approximately $424 million with 88% of its funding coming from DOE. The remainder is from other domestic and international scientific and industrial clients. Just a few of the scientific discoveries at BNL include: discovery of new sub-atomic particles, development of medical treatments for Parkinson's disease and cancer, advances in biotechnology for cleaning up pollution, and innovative materials for computer chips.

The majority of the Laboratory's budget directly supports the local economy through wages and purchases of materials and services. In fiscal year 2000, BNL purchased more than $31 million worth of supplies and services from Long Island businesses. Employee salaries, wages, and fringe benefits accounted for 61%, or $258 million, of the Laboratory's total budget. Additionally, most of the Laboratory's 3,000 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 operating, procurement, payroll, construction, medical benefits, and technology transfer spending spreads throughout Long Island's economy, making the Laboratory vital to Long Island's economic health (Kamer 1995).

1.3 MISSION OF BROOKHAVEN NATIONAL LABORATORY

BNL's broad mission is to produce excellent science and advanced technology in a safe, environmentally responsible manner with the cooperation, support, and appropriate

involvement of the community. Specifically, the elements of the BNL mission are to

- Conceive, design, construct, and operate complex, leading-edge, user-oriented facilities in a safe and environmentally benign manner that is responsive not only to DOE, but also to the needs of the users.
- Carry out basic and applied research in long-term programs at the frontier of science that supports DOE missions and the needs of the Laboratory's user community.
- Develop advanced technologies that address national needs and initiate their transfer to other organizations and to the commercial sector.
- Disseminate technical knowledge to educate new generations of scientists and engineers, to maintain technical currency in the nation's workforce, and to encourage scientific awareness in the general public.

BNL's early research focused on advanced physics, but rapidly expanded into its current suite of research in the fields of medicine, biology, chemistry, physics, materials science, nuclear engineering, and environmental research. The Laboratory's large and unique scientific user facilities make this research possible, providing the tools for BNL scientists and visiting researchers to extend the boundaries of knowledge and technology.

BNL's policy is to integrate environmental stewardship into all facets of the Laboratory's mission and operations. Figure 1-1 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 public health.

1.4 HISTORY OF RESEARCH FACILITIES AT BROOKHAVEN NATIONAL LABORATORY

BNL was founded in 1947 by the Atomic Energy Commission and operated by AUI on the site of the U.S. Army's former Camp Upton. 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, the Brookhaven Graphite Research Reactor (BGRR), began operations in 1950. The BGRR was a research reactor used for peaceful scientific exploration in the

ENVIRONMENTAL STEWARDSHIP POLICY

It is Brookhaven National Laboratory's (BNL's) policy to integrate environmental stewardship into all facets of the Laboratory's missions. We will manage our programs in a manner that protects the ecosystem and public health.

In support of this policy, BNL makes the following commitments:

♦

We are committed to achieving compliance with applicable environmental requirements.

♦

In consideration of the potential impacts of our activities on the environment, we will integrate pollution prevention/waste minimization, resource conservation, and compliance into all of our planning and decision-making. We will adopt cost-effective practices that eliminate, minimize or mitigate environmental impacts.

♦

We will define, prioritize, and aggressively correct and clean up existing environmental problems.

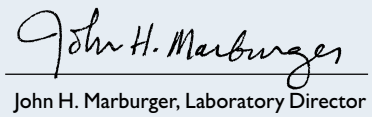
♦

We will work to continually improve our environmental management system and performance. We will establish appropriate environmental objectives and performance indicators to guide these efforts and measure our progress.

♦

We will maintain a positive, proactive, and constructive relationship with our neighbors in the community, regulators, DOE, and our other stakeholders. We will openly communicate with stakeholders on our progress and performance.

In addition to my annual review of BNL's progress on environmental goals and adherence to this policy, I invite all interested parties to provide me with input on our performance relative to this policy, and the policy itself.



John H. Marburger, Laboratory Director

11/19/98

Date

Figure 1-1. Environmental Stewardship Policy.

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 (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 facilities are currently operating. Due to a reduction of research funding, the BMRR conducted its last run on December 28, 2000, and transition and stabilization activities will begin in 2001.

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 more 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 light, which can be detected by specialized instruments, has many uses in both the physical and biological research sciences.

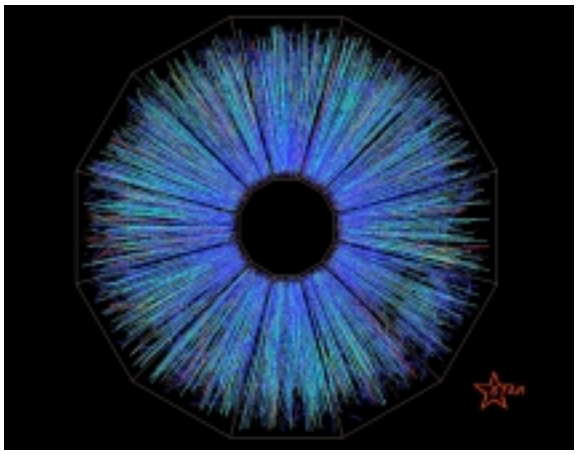


Figure 1-2. End View of a Gold-Ion Collision at the RHIC Facility.

Brookhaven's newest accelerator facility, the Relativistic Heavy Ion Collider (RHIC) began operation in 2000. RHIC is designed to recreate a state of matter that scientists believe existed moments after the universe was formed (Figure 1-2). The RHIC is an example of Brookhaven'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 2000, eight additional facilities at BNL also received ISO 14001 certification and the entire Laboratory is scheduled to become ISO 14001 registered in 2001. BNL will be the first national laboratory to receive this registration.

Unfortunately, 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 National Priorities List of environmentally contaminated sites nationwide identified for priority cleanup. In the past three years, BNL has made significant progress towards improving environmental operations and remediation of past contamination (see Chapter 2 for details). In 2000, BNL received an "Outstanding" performance rating from DOE for its environmental, health and safety performance, the highest ranking for the site in three years.

Figure 1-3. Landsat 7 Satellite Image of Long Island
(Image courtesy of NASA).

1.5 SITE 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 1-3). About a third of the 1.39 million people that reside in Suffolk County live in Brookhaven Township (LIPA 2000). Figure 1-4 shows the distribution of the resident population 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.

Approximately 250-300 people reside long-term in the apartments and cottages onsite, while many of the 4,000 visiting scientists each year stay short term in the onsite guesthouses. Figure 1-5 shows the housing capacity for onsite residents and visitors. In addition to onsite staff and visiting scientists, more than 35,000 visitors participated in educational and public outreach activities conducted onsite during 2000. Finally, more than 75% of BNL's 3,000 employees live within a 15-mile radius of the Laboratory (Figure 1-6).

1.6 FACILITY AND OPERATIONS DESCRIPTION

Most of BNL's principal facilities are located near the center of the 5,265 acre (8.23 square mile) site. The developed area is approximately 1,650 acres, consisting of about

- 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 largely wooded and represents native pine barren ecology. In November 2000 DOE and the U.S. Fish and Wildlife Service set aside 530 acres of the undeveloped land at BNL as the Upton Ecological and Research Reserve (see Figure 1-7). More information about natural resources onsite, the Reserve and the plants and animals it protects can be found in Section 1.9 and in Chapter 6.

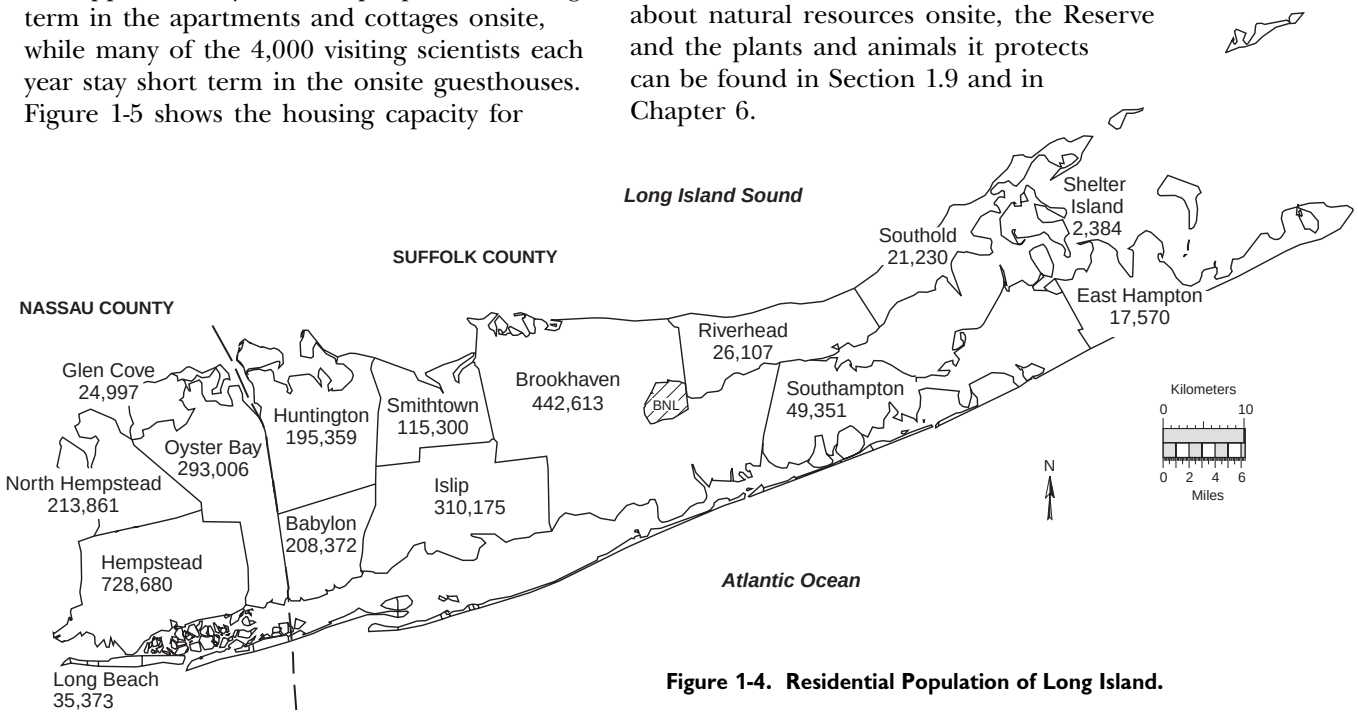
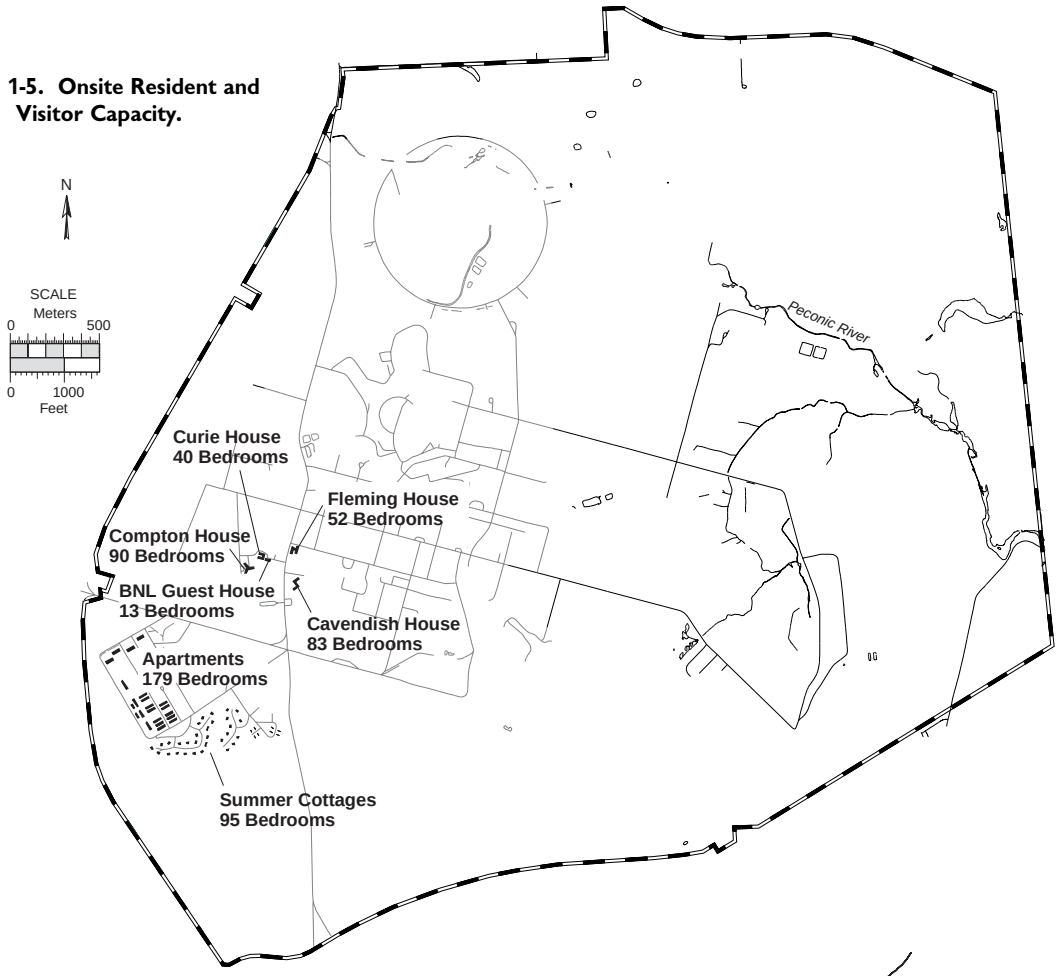


Figure 1-4. Residential Population of Long Island.

Figure 1-5. Onsite Resident and Visitor Capacity.



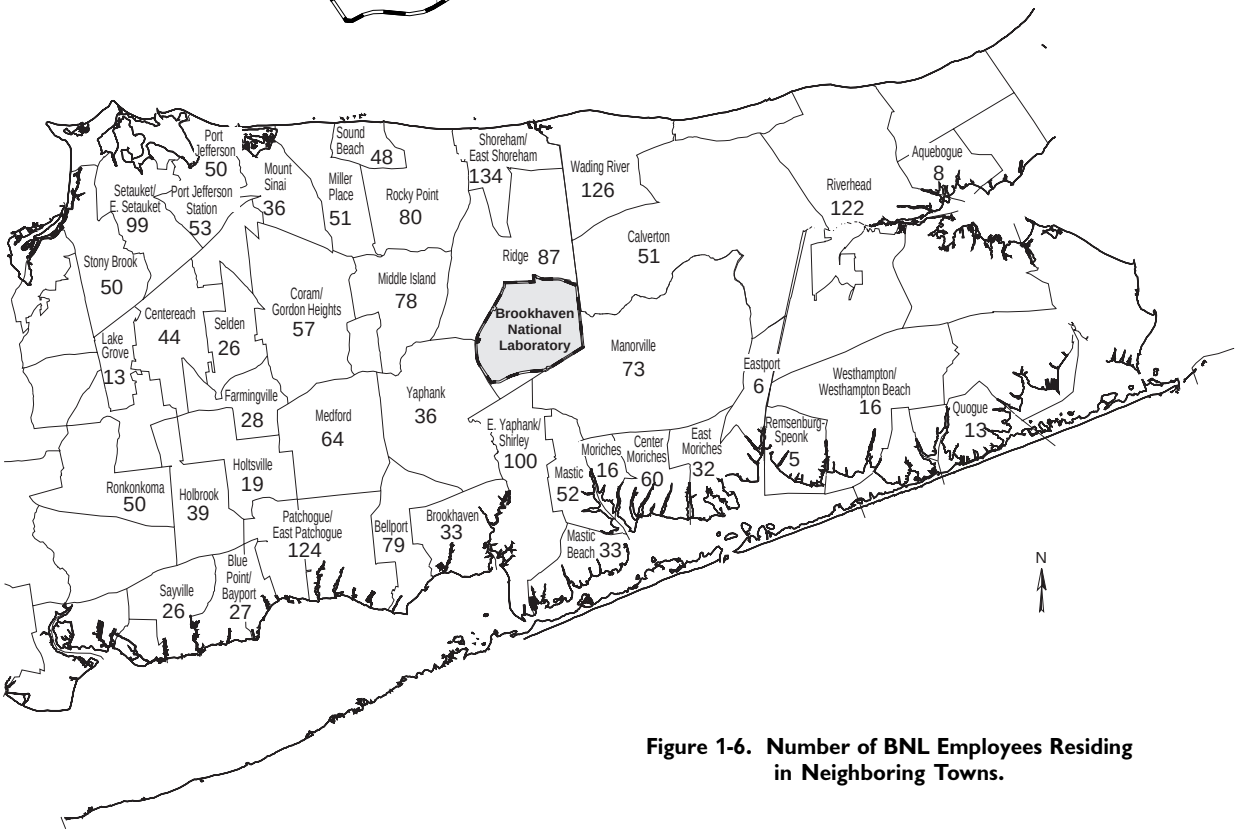


Figure 1-6. Number of BNL Employees Residing in Neighboring Towns.

Figure 1-7. Dedication of the Upton Ecological and Research Reserve. *(From left to right)* BNL Natural Resource Manager, Dr. Timothy Green; U.S. Senator Charles Schumer; and former U.S. DOE Secretary of Energy Bill Richardson help dedicate the reserve.

The major scientific facilities at BNL are shown and briefly described in Figure 1-8. 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 (see Figure 1-9):

- *Water Treatment Plant.* The Water Treatment Plant is a potable water treatment facility with a capacity of 5 million gallons per day (actual 2000 usage averaged 2.8 million gallons per day, see Chapter 2 for more information). Potable water is obtained from six wells located along the western boundary of the developed site and 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 are at or below New York State drinking water standards.
- *Central Chilled Water Plant.* This facility provides chilled water for air conditioning and process refrigeration for the entire site via a network of underground piping. The plant has a large refrigeration capacity with once-through cooling, reducing the need for local refrigeration plants.
- *Central Steam Facility.* The Central Steam Facility is a dual fuel-fired plant that provides high-pressure steam for both facility and process heating for the entire site. Natural gas is the primary fuel and fuel oil is the secondary fuel. Steam is conveyed to the 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.* The Major Petroleum Facility provides reserve fuel for the Central Steam Facility during times of peak operation. This facility has a total capacity of 1.8 million gallons (6.8 million liters) for storing predominately No. 6 fuel oil. The 1997 conversion of the boilers at the Central Steam Facility to natural gas has significantly reduced BNL's reliance on oil as a source of fuel.
- *Sewage Treatment Plant.* The Sewage Treatment Plant receives sanitary and certain process wastewater from BNL facilities for treatment 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 (11 million liters) per day. The 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.* The Waste Management Facility is a state-of-the-art complex for managing the wastes generated from BNL's research and operations activities. This facility, which opened in December 1997, was built with advanced environmental protection systems and features. The Waste Management Facility houses two areas permitted by the New York State Department of Environmental Conservation for storing hazardous wastes, prior to shipment offsite for treatment and disposal at other permitted treatment, storage, and disposal facilities. See Chapter 2 for more information on waste management.
- *Fire Station.* The BNL Fire Department provides fire prevention and response onsite as well as hazardous materials and medical response. They maintain five response vehicles at the Fire Station and typically respond within 8 minutes to any onsite emergency.


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Figure 1-8. Major Brookhaven Scientific Facilities.

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 LINAC, 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 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 BNL 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.

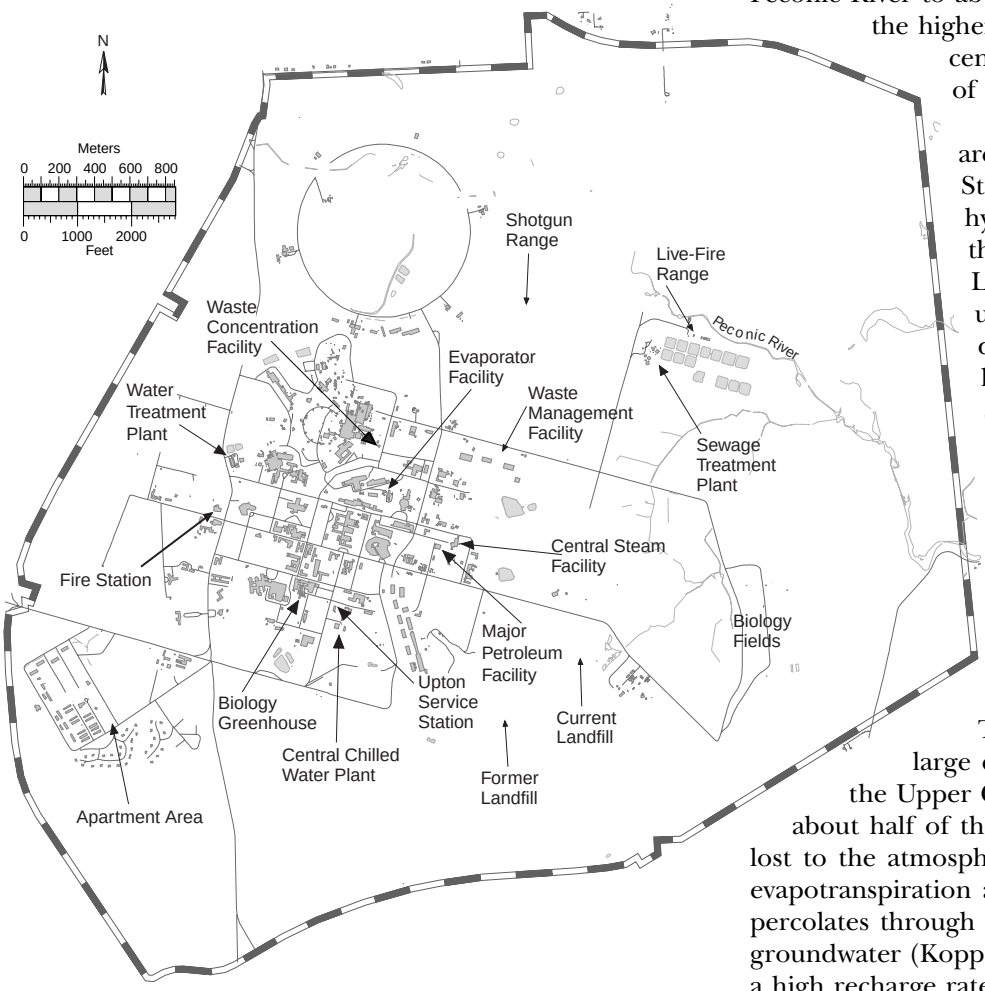


Figure 1-9. Major Brookhaven Support and Services Facilities.

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 the Peconic River. The Peconic River both recharges to, and receives water from, the sole source aquifer system underneath Long Island, depending on the position of the water table relative to the base of the riverbed. 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 site is gently rolling, with elevations varying between 44 and 120 feet (13 and 37 meters) above sea level. Depth to groundwater from the surface of the land ranges from 5 feet (1.5 meters) near the Peconic River to about 80 feet (24 meters) 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 (37 and 76 meters) 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 [56 centimeters] 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 onsite and offsite 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 2.8 million gallons (10.6 million liters) per day of groundwater to meet site potable water needs and heating and cooling requirements. Approximately 74% of the water pumped from BNL supply wells is returned to the aquifer through onsite recharge basins. About 19% is discharged into the Peconic River. Human consumption, evaporation (cooling tower and wind losses), and sewer line losses account for the remaining 7%. An additional 0.6 million gallons (2.3 million liters) per day of groundwater is pumped from remediation wells for treatment and then returned to the aquifer by the use of recharge basins.

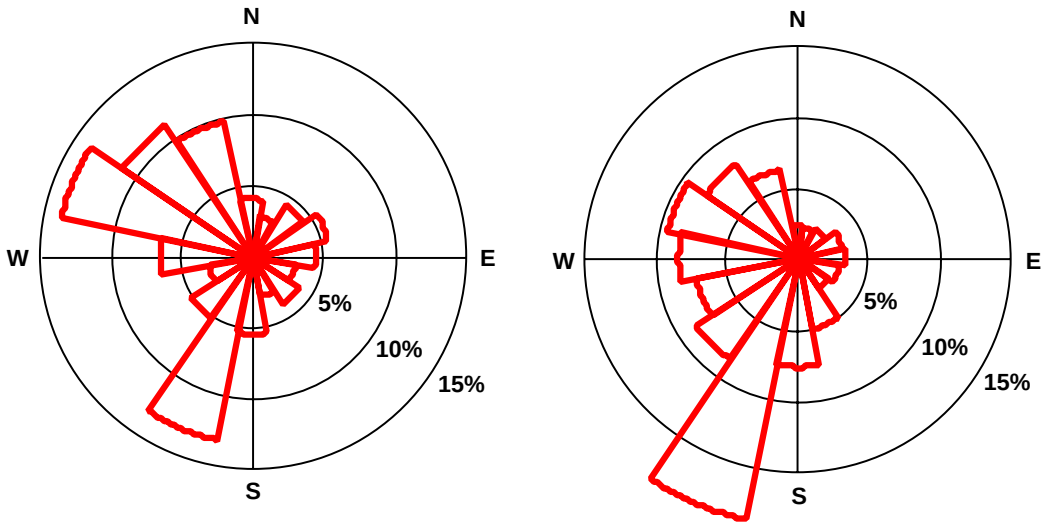
Groundwater flow direction across the BNL site is influenced by natural drainage systems moving eastward along the Peconic River, southeast toward the Forge River and south toward the Carmans River. Pumping from onsite water supply wells also impacts the direction and speed of groundwater flow, especially in the central, developed areas of the site. Two natural groundwater divides have been identified near the BNL site (Scorca *et al.* 1999). One is located approximately one-half mile north of BNL and a second 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 contributing groundwater to the Peconic River watershed.

In most areas at BNL, the horizontal velocity of groundwater is approximately 0.75-1.2 feet per day (0.23-0.37 meters 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.

1.8 CLIMATIC DATA

The Meteorological Group at Brookhaven National Laboratory has collected meteorological data onsite since 1949. The prevailing ground level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equal from these two directions during the spring and fall (Nagle 1975, Nagle 1978). Figure 1-10 shows the 2000 annual wind rose



33-ft Level
Calm (< 1.6 ft/s): 16.4%

300-ft Level
Calm (< 1.6 ft/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 300 feet (90 meters) was from the south-southwest.

Figure 1-10. Annual Wind Rose for 2000.

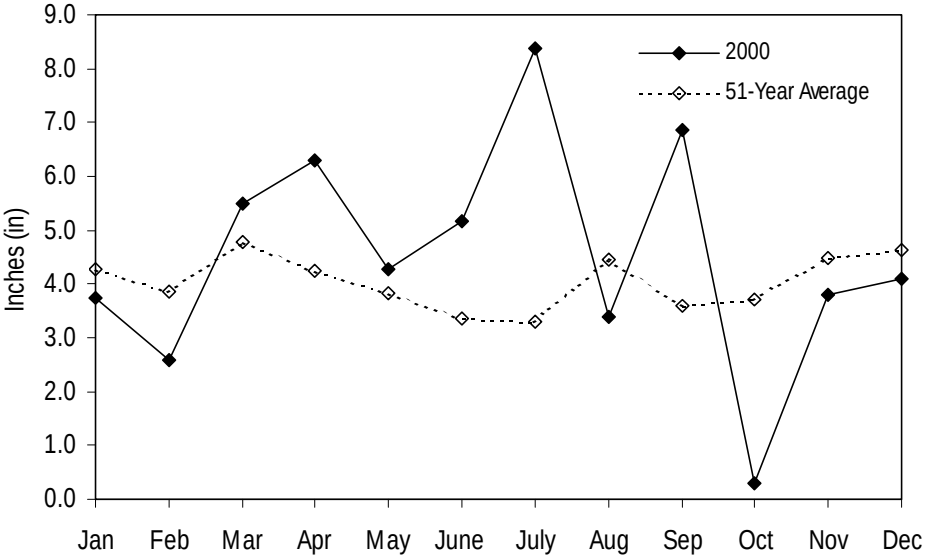


Figure 1-11. 2000 Monthly Precipitation Versus 51-Year Monthly Average.

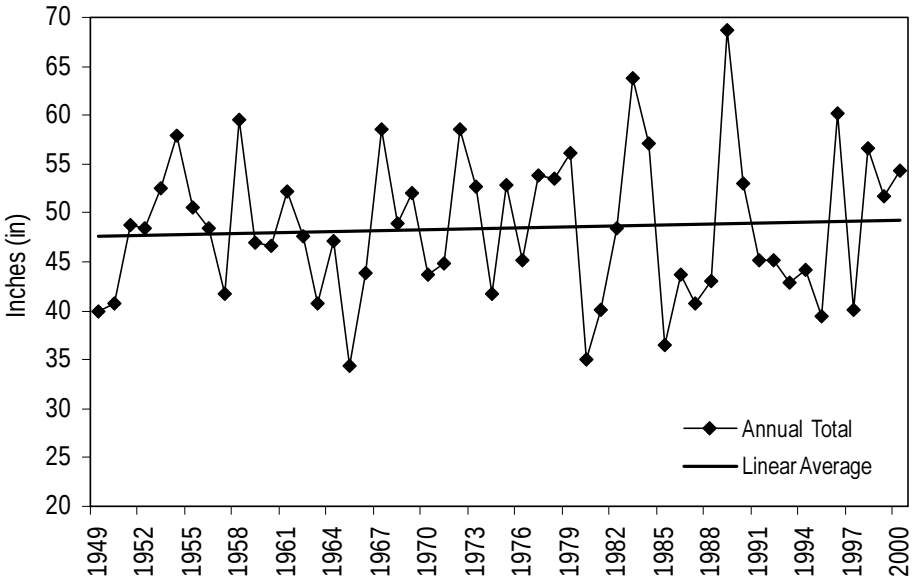


Figure 1-12. Fifty-One Year Annual Precipitation Trend (1949-2000).

for BNL, which depicts the annual frequency distribution of wind speed and direction, measured at an onsite meteorological tower at heights of 33 and 300 feet (10 and 90 meters).

The total precipitation for 2000 was 54.37 inches (138.10 centimeters). Most of the precipitation occurred from March through September, with the late fall and winter months drier than average. With 8.37 inches (21.26 centimeters) of rain, July of 2000 was the second wettest July since BNL started keeping meteorological records in 1949 (the wettest July occurred in 1969). From July 25 through August 19, 2000, only five days were rain-free. In contrast, there were only 0.31 inches (0.79 centimeters) of rain in October. Overall, the year 2000 was wetter than average; the precipitation was 5.89 inches (14.96 centimeters) above the 51-year annual average. Figures 1-11 and 1-12 present the 2000 monthly and the 51-year annual precipitation data, respectively.

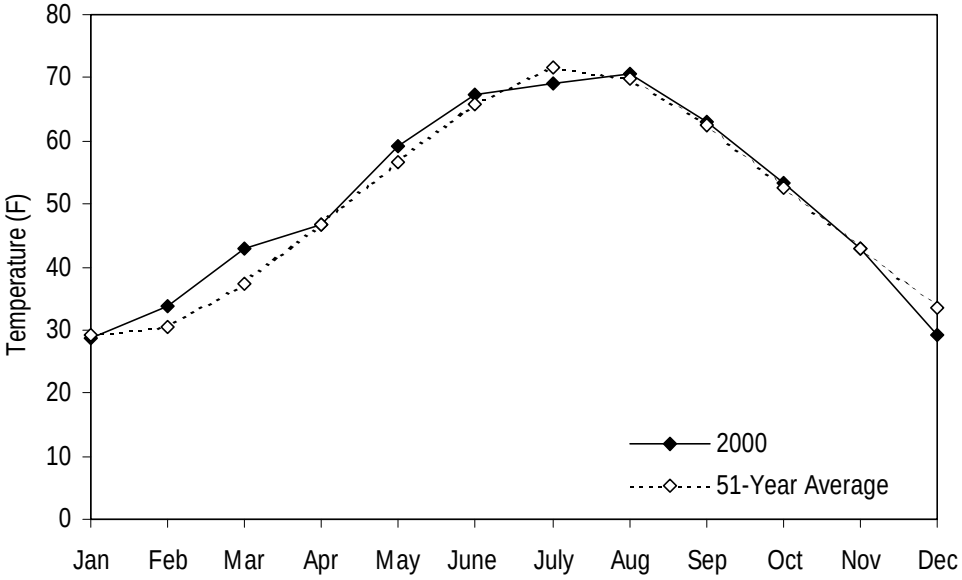


Figure 1-13. 2000 Monthly Mean Temperature Versus 51-Year Monthly Average.

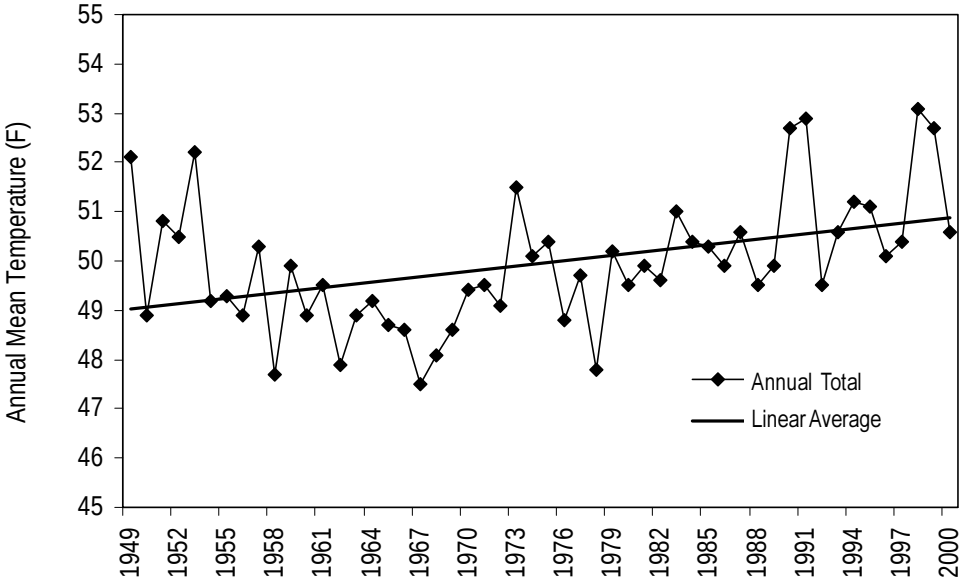


Figure 1-14. Fifty-One Year Annual Mean Temperature Trend (1949-2000).

The monthly mean temperature in 2000 was 50.6°F (10.3°C), ranging from a monthly mean low temperature of 28.7° F (–1.8°C) in January to a monthly mean high temperature of 70.5°F (21.4°C) in August. The year 2000 was slightly warmer than average at 0.6°F (0.3°C) above the 51-year annual average of 50.0°F (10.0°C). In general, using a linear average, temperatures at BNL have increased 1.83°F (1.01°C) over the last 51 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). Five record daily high temperatures were recorded in 2000 on January 2 and 3, March 9 and 24, and October 3. The most notable of these was a record high of 66°F (19°C) on January 3, 2000, beating the previous record of 53°F (12°C) set in 1953. Figures 1-13 and 1-14 show the 2000 temperatures and the historical annual mean temperatures, respectively.

1.9 ECOLOGICAL RESOURCES

BNL is located in the oak/chestnut forest region of the Coastal Plain. BNL property constitutes about 5% 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's property 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 standing water on a seasonal basis (vernal pools), and there are six significant regulated wetlands onsite. Thus, a mosaic of wet and dry areas on the site correlates with variations in topography and depth to the water table. Vegetation onsite is in various stages of succession, which reflects a history of disturbances to the area. For example, during the construction of Camp Upton in 1917, the site was entirely cleared of its native pines and oaks; the site 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.

Over 230 plant species have been identified onsite. The 15 mammal species onsite include species common to mixed hardwood forests and open grassland habitats. The white-tailed deer density is currently estimated at 236 per square mile, compared to the 85 per square mile estimated in 1992 (Thomlinson 1993). 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 a result of BNL's location within 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 10 reptile species have been identified, as well as 9 species of fish.

Ecological studies at the BNL site have confirmed fifteen 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 state threatened species in 1999. It lives solely within the Peconic River system, including backwater areas of the river onsite (Scheibel 1990). In 2000, the New York State-threatened swamp darter (*Etheostoma fusiforme*) was positively identified onsite in one of the larger ponds associated with the Peconic River. One New York State-threatened plant is found onsite: 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. At 530 acres, the Upton Ecological and Research Reserve sets aside 10% of BNL property for conservation and ecological research. The Reserve will permanently preserve a portion of the Central Pine Barrens, a unique ecosystem of forests and wetlands on Long Island. This area provides habitat for approximately 27 endangered, threatened, or species of special concern, including the state endangered eastern tiger salamander and the state-threatened banded sunfish and swamp darter. Other wildlife species of interest that inhabit this area include the wild turkey, red fox, eastern box turtle, and the red-tailed hawk. DOE has committed to providing the U.S. Fish and Wildlife Service with $200,000 a year, over a five-year period, for land management activities and research in the Upton Ecological and Research Reserve. More information about the Reserve and the plants and animals it protects can be found in Chapter 6.

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