Chapter 1

INTRODUCTION

1.1 Brookhaven National Laboratory's Mission

Brookhaven National laboratory is a multi-program national laboratory operated by Brookhaven Science Associates for the U.S. Department of Energy. The Laboratory's broad mission is to produce excellent science in a safe, environmentally benign manner with the cooperation, support and appropriate involvement of our many communities. Specifically, the mission of BNL, which supports the U.S. Department of Energy's strategic missions, is 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 the 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 initiates 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.

In 1997 Brookhaven National Laboratory (BNL) was managed by Associated Universities Inc. (AUI) under DOE Contract No. DE-AC02-76CH00016. AUI was formed in 1946 by a group of nine universities whose purpose was to create and manage a Laboratory in the Northeast to advance scientific research of interest to universities, industry, and government. On January 31, 1947, the contract for BNL was approved by the Manhattan District of the Army Corps of Engineers, and the Laboratory was established on the former Camp Upton Army site.

The Laboratory carries out basic and applied research in the following fields: high-energy, nuclear and solid-state physics; fundamental material and structural properties and the interactions of matter; nuclear medicine, biomedical and environmental sciences; and selected energy technologies. In undertaking research, it is the Laboratory's policy to protect the health and safety of employees and the public, and to minimize the impact of BNL's operations on the environment.

1.2 Site Characteristics

Brookhaven National Laboratory is located near the geographical center of Suffolk County, Long Island, about 97 km east of New York City. About 1.35 million persons reside in Suffolk County (LILCO, 1997), and about 0.43 million in Brookhaven Township, where the Laboratory is situated. Approximately eight thousand people live within a half-km of the Laboratory's boundaries. Figure 1-1 shows the distribution of the resident population within 80 km of the BNL site and Figure 1-2 shows that within 0.5 km. Although much of the land area within a 16 km radius is either forested or cultivated, there has been an increase in residential housing in the rural areas surrounding BNL. There have been no major construction projects since 1978, but detailed plans are proposed for two shopping centers, a corporate park, and several thousand single- and multiple-family dwellings within a 1.5-km area of BNL, predominately on the north, south, and west boundaries. Figure 1-3 shows the rural areas surrounding BNL.

Figure 1-4 shows the Laboratory's site, consisting of 21.3 square kilometers (2,130 hectares [ha]), with most principal facilities located near the center. The developed area is approximately 6.7

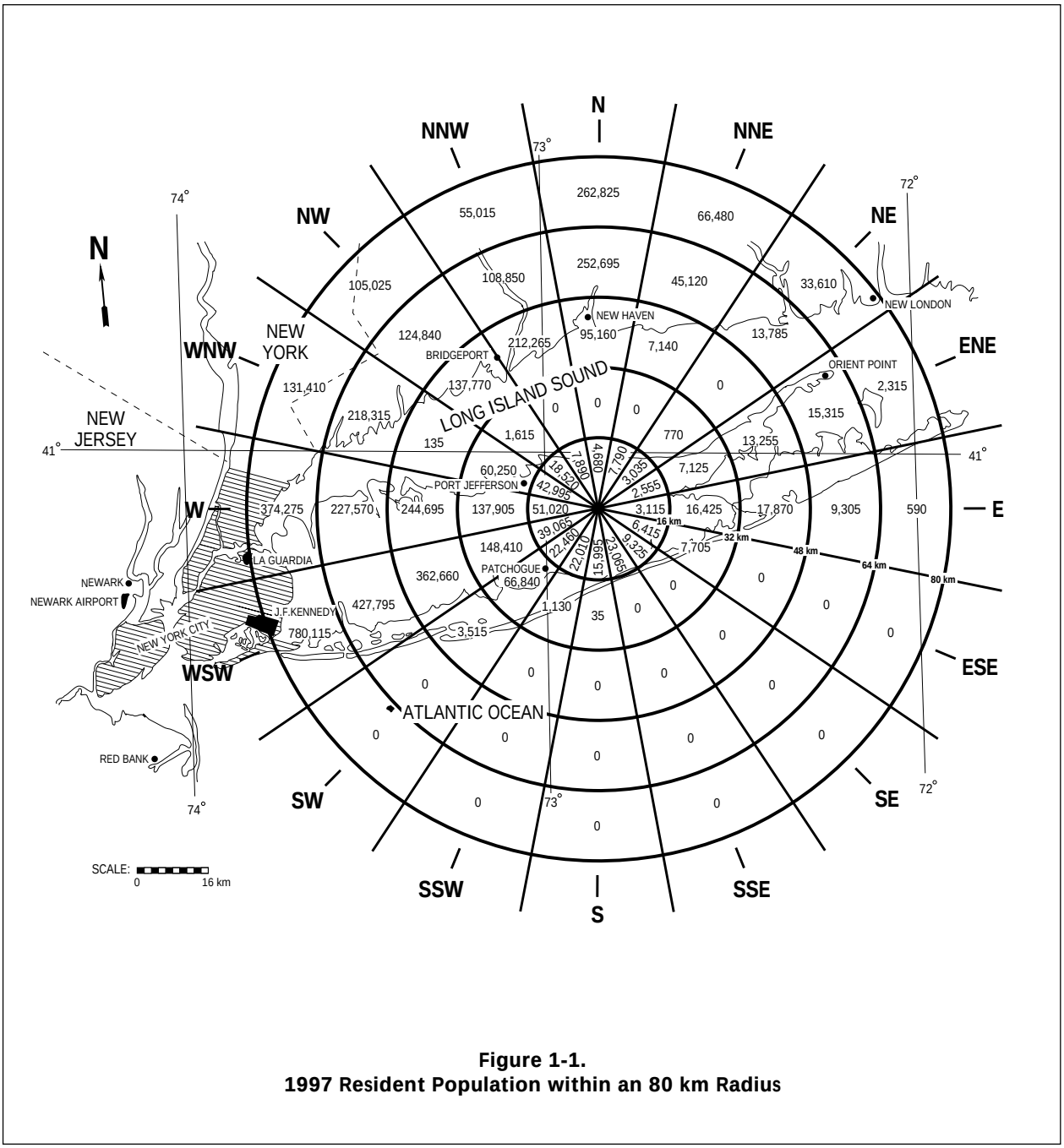

Figure 1-1.
1997 Resident Population within an 80 km Radius

square kilometers (670 ha), of which about 2.02 square kilometers (202 ha) were originally developed by the Army, and about 0.81 square kilometers (81 ha) are occupied by various large, specialized research facilities. Outlying facilities occupy about 2.22 square kilometers (222 ha); these include the Sewage Treatment Plant (STP), research agricultural fields, housing, and fire breaks. The balance of the site is largely wooded.

The Laboratory can be characterized as a well-ventilated site, like most of the eastern seaboard. The prevailing ground level winds 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; 1978). Figure 1-5 shows the 1997 annual wind rose for BNL, measured at a height of 88 m (288 ft.). Figure 1-6 shows the monthly average temperatures.

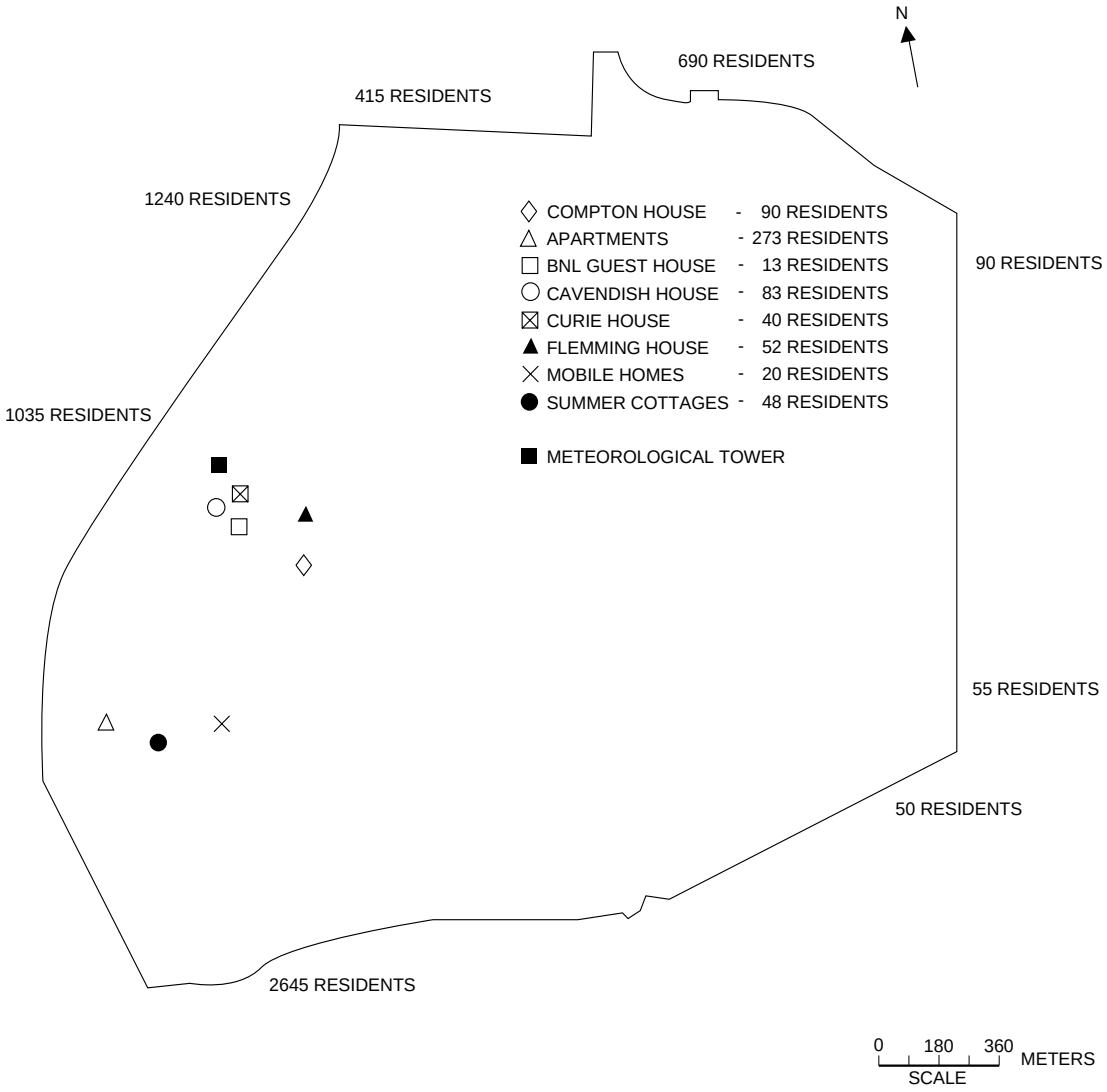

Figure 1-2.
Brookhaven National Laboratory
1997 Local and On-site Population Distribution

The terrain of the site is gently rolling, with elevations varying between 36.6m and 13.3m above sea level. The land lies on the western rim of the shallow Peconic River watershed. The marshy areas in the north and eastern sections of the site are a part of the Peconic River headwaters. The Peconic River both recharges to, and receives water from, the groundwater aquifer depending on the hydrological potential. In times of drought, the river water typically recharges to groundwater (i.e., a losing stream) while with normal to above-normal precipitation, the river receives water from the aquifer (i.e., a gaining stream). Thus, the river on-site is classified as an intermittent river. In 1997, the Peconic River bed on-site was in a discharge mode from January to June and in a recharge mode from July to December. During this latter period, no flow was observed to leave the site.

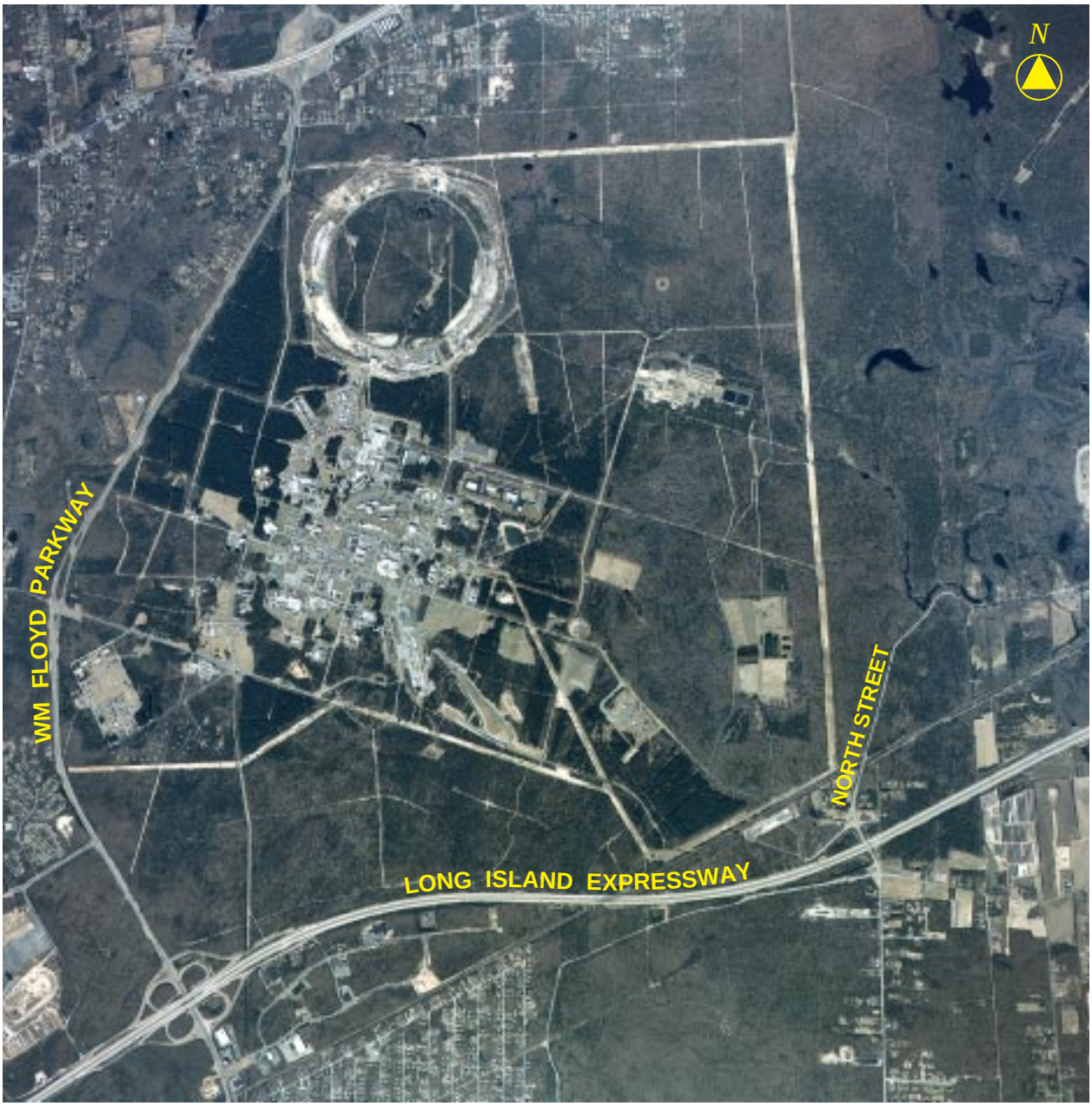

Figure 1-3. Brookhaven National Laboratory Surrounding Communities

The Laboratory uses approximately 10 million liters of groundwater per day (MLD) to meet potable water needs plus heating and cooling requirements. Approximately 74% of the total pumpage is returned to the aquifer through on-site 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 seven percent. An additional 2.13 MLD of groundwater is pumped from remediation wells for treatment, and then returned to the aquifer by the use of recharge basins.

Studies of hydrology and geology in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits (referred as the Upper Glacial Aquifer) are between 31 - 61m thick, and are generally composed of highly permeable glacial sands and gravel (Warren et al., 1968). Water

Figure 1-4. Brookhaven National Laboratory Major Facilities

penetrates these deposits readily and there is little direct runoff into surface streams unless precipitation is intense. The total precipitation for 1997 was 101.7 cm, which is about 20 cm below the 40-year annual average. Figures 1-7 and 1-8, respectively, present the 1997 monthly and historic precipitation data. 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 groundwater (Koppelman, 1978).

Many factors affect groundwater flow around BNL. The main groundwater divide lies approximately 2 - 3 km north of BNL, and runs parallel to the Long Island Sound. The secondary groundwater divide that defines the southern boundary of the area contributing groundwater to the Peconic River lies to the east. South of these divides, the groundwater moves southward to the

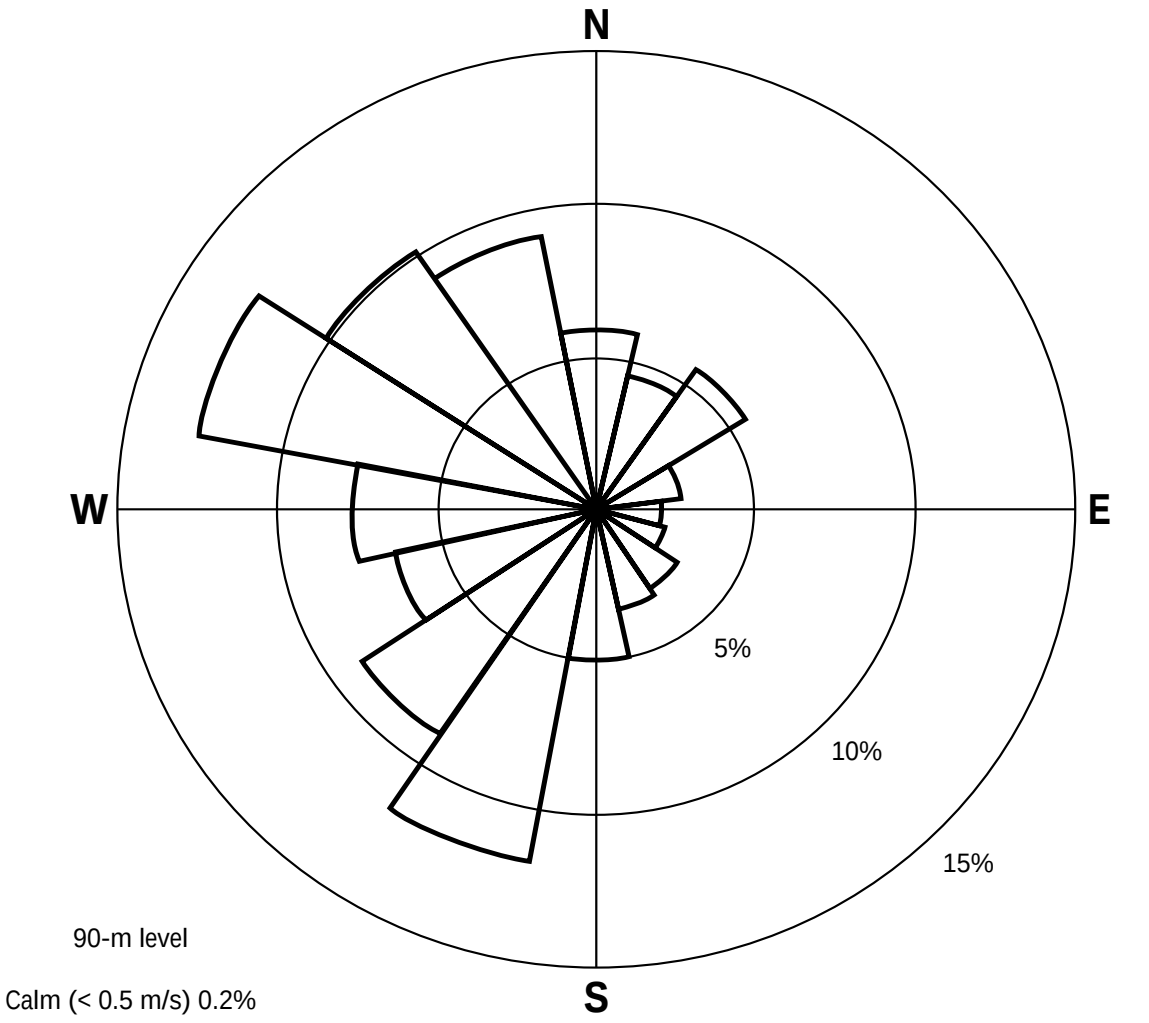

Figure 1-5
Annual Wind Rose for Calendar Year 1997

Great South Bay, Carmans River and Moriches streams. In general, the groundwater from the area between the two branches of the divide moves eastward to the Peconic River. North of the divide, groundwater moves northward to the Long Island Sound. The pressure of a higher water table to the west of the BNL area generally inhibits westward movement. Variability in the direction of flow on the BNL site is a function of the hydraulic potential and is further complicated by the presence of near-surface clay deposits that accumulate perched water at several places within the site, and also by the pumping and recharge of groundwater during BNL's daily operations. In general, groundwater in the northeast and northwest sections of the site flows towards the Peconic River. On the western portion of the site, groundwater flow tends to be towards the south, while along the southern and southeastern sections of the site the flow tends to be towards the

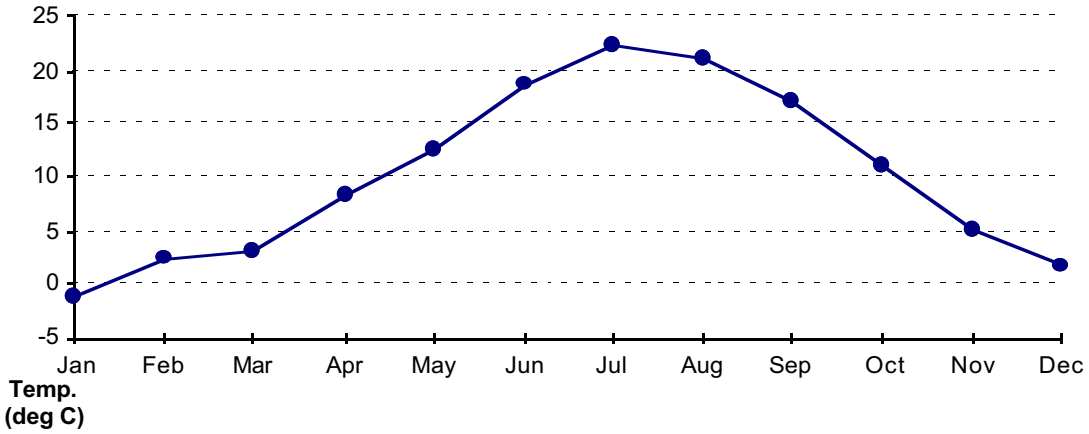

Figure 1-6. Monthly Mean Temperature Trend

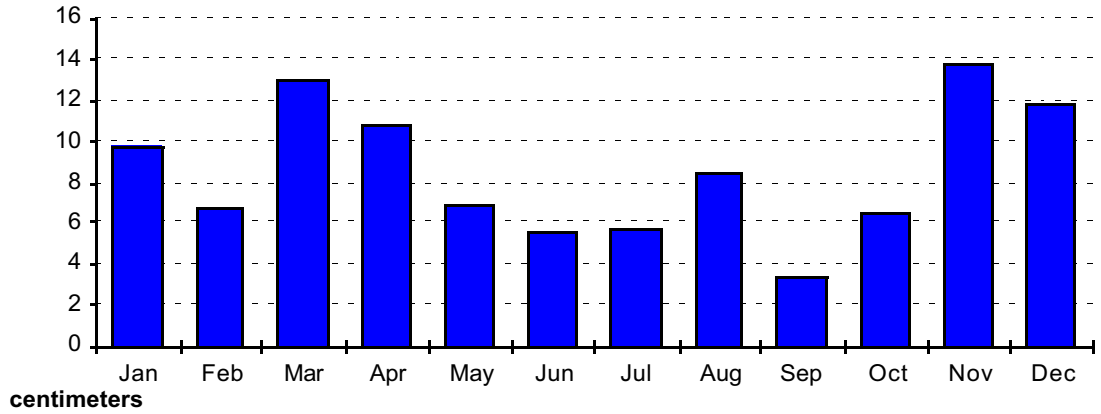

Figure 1-7. Monthly Precipitation

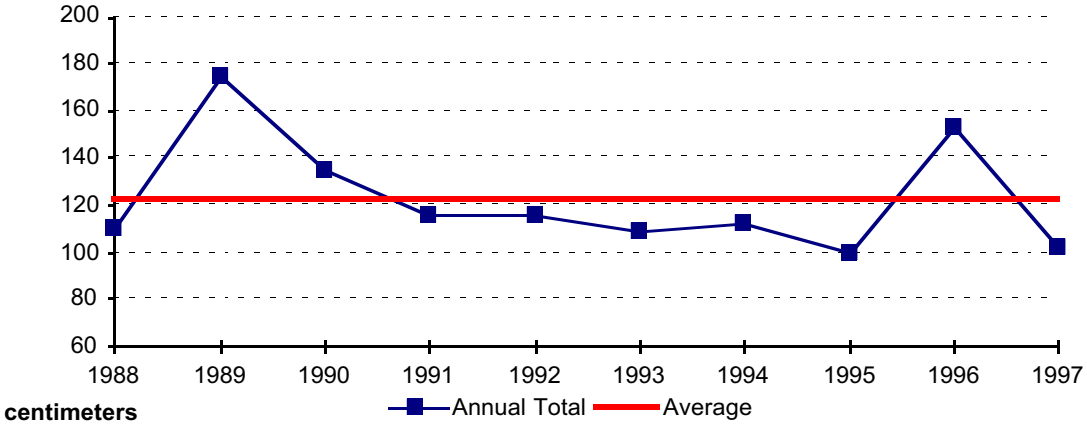

Figure 1-8. 10 Year Precipitation Trend

south to southeast. Figures 1-9 and 1-10 depict the configuration of the groundwater table at the BNL site during March, and August 1997, respectively. The horizontal velocity of groundwater ranges from 22 to 30 cm/d (Warren et al., 1968). BNL's site was identified by the Long Island Regional Planning Board and Suffolk County as being over a deep-flow recharge zone for Long Island (Koppelman, 1978). This finding implies that precipitation and surface water which recharge within this zone have the potential to replenish the lower aquifer systems (Magothy and Lloyd) 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 the BNL site contributes to deep flow recharge was evaluated by Geraghty and Miller (1996b). In coastal areas, these aquifers discharge to the Atlantic Ocean or to the Long Island Sound.

The Laboratory is located in a section of the Oak/Chestnut forest region of the Coastal Plain. Because of the general topography and porous soil, there is little surface runoff or open water. Upland soils tend to be drained excessively, while depressions form small pocket wetlands. Hence, a mosaic of wet and dry areas on the site are correlated with variations in topography and depth to the water table. Without fires or other disturbances, the vegetation normally follows the moisture gradient closely. In actuality, vegetation on-site is in various stages of succession reflecting the history of disturbances to the area, the most important having been land clearing, fire, local flooding, and draining.

Mammals endemic to the site include species common to mixed hardwood forests and open grassland habitats. At least 180 species of birds have been observed at BNL, a result of its location within the Atlantic Flyway, and the scrub/shrub habitats which offer food and rest to migratory songbirds. Open fields bordered by hardwood forests at the recreation complex are excellent hunting areas for hawks. Pocket wetlands with seasonal standing-water provide breeding areas for amphibians. Permanently flooded recharge basins and other watercourses support aquatic reptiles. Recent ecological studies at the BNL site indicated that the NYS-endangered eastern tiger salamander (*Ambystoma tigrinum*) uses BNL's vernal ponds and some recharge basins as breeding areas. The banded sunfish (*Eanneacanthus obesus*) is one NYS species of "special concern", as it occurs solely within the Peconic River system: it has been confirmed as inhabiting the Peconic River on-site (Scheibel, 1990; Corin, 1990). Part of the Peconic River running through BNL's property was designated "scenic" in accordance with the NYS's Wild, Scenic, and Recreational River Systems Act (WSRRSA). The wide variety of wildlife resources at BNL attest to the Laboratory's planning practices which have clustered development to minimize fragmenting habitats, particularly in environmentally sensitive areas such as the Peconic River corridor.

1.3 Existing Facilities

A wide variety of scientific programs are conducted at Brookhaven, including research and development in the following areas:

1. The fundamental structure and properties of matter;
2. The interactions of radiation, particles, and atoms with other atoms and molecules;
3. The physical, chemical, and biological effects of ionizing radiation;
4. The production of special radionuclides and their medical applications;
5. Energy-and nuclear-related technologies; and
6. The assessment of energy sources, transmission, and uses, including their environmental and health effects.

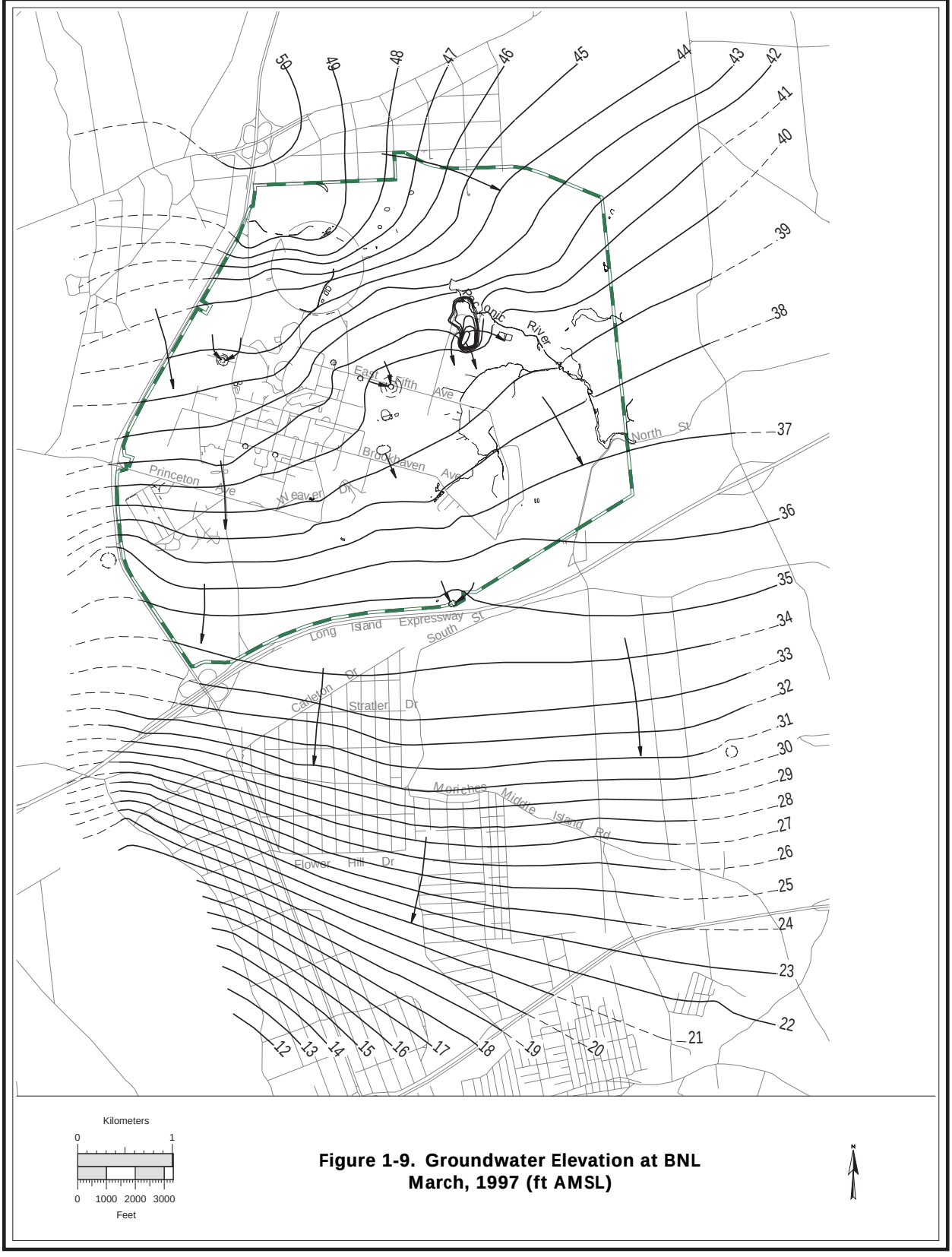

Figure 1-9. Groundwater Elevation at BNL March, 1997 (ft AMSL)

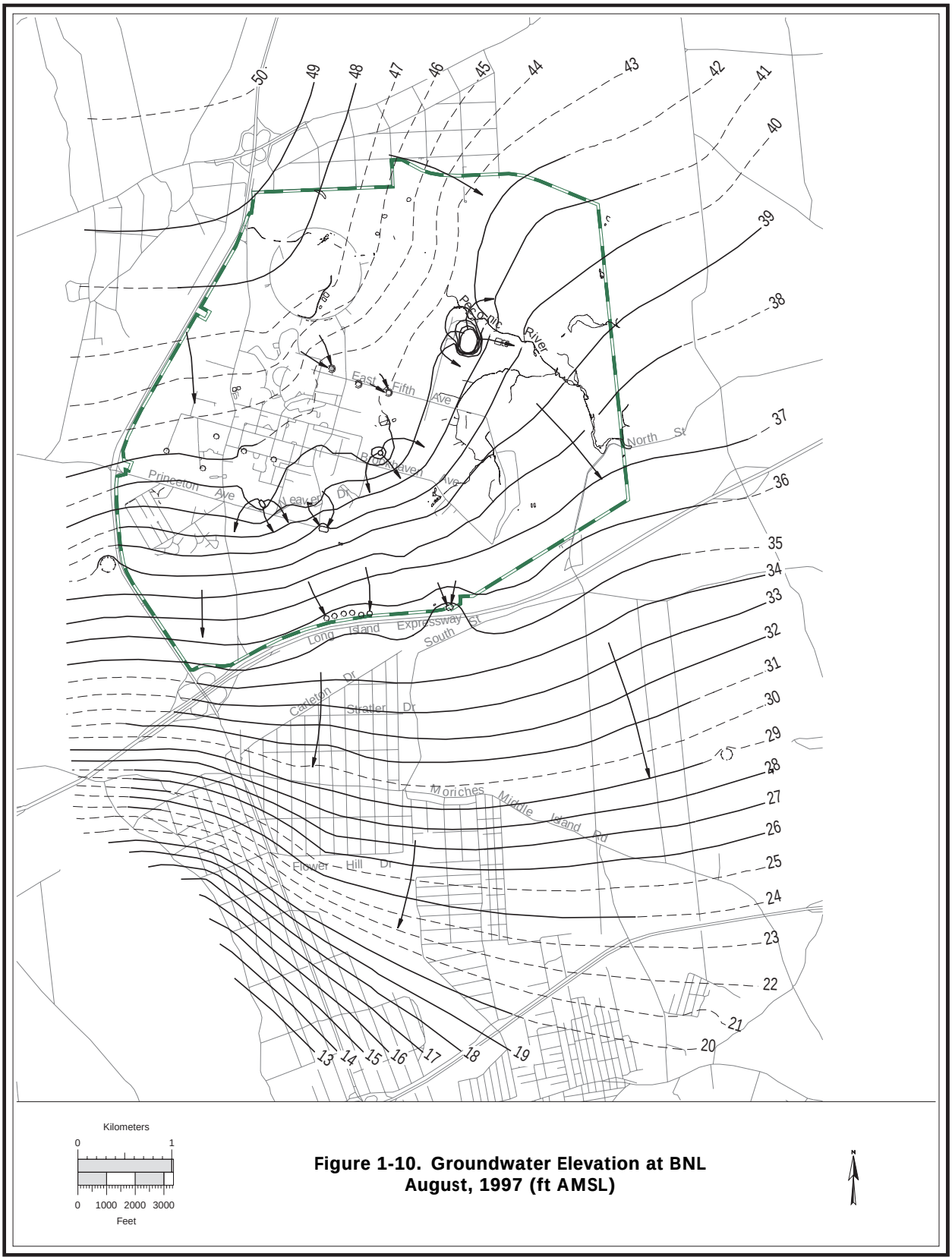

Figure 1-10. Groundwater Elevation at BNL August, 1997 (ft AMSL)

The following are the major scientific facilities operated at the Laboratory:

1. **The National Synchrotron Light Source (NSLS)** utilizes a linear accelerator and booster synchrotron as an injection system for two electron storage rings which provide intense ultraviolet (UV) and x-ray photon sources. There are 83 beam lines for research in Materials Science, Biology, Chemistry, and industrial applications. There are over 2300 users.
2. **The Brookhaven Medical Research Reactor (BMRR)**, an integral part of the Medical Research Center (MRC), is fueled with enriched uranium, moderated and cooled by light water, and is operated intermittently at power levels up to 3 MW (thermal). The BMRR is used for Neutron Capture Cancer Therapy Research.
3. T**he Alternating Gradient Synchrotron (AGS)** is used for research in Particle and Nuclear Physics. It accelerates protons to energies up to 30 GeV, and heavy-ion beams to 15 GeV/amu. It has over 900 users.
4. **The 200 MeV Linear Accelerator** 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 (BLIP) facility.
5. **The Tandem Van de Graaff Facility** can inject heavy ions into the AGS. It contains a microchip radiation testing area and has 250 industrial users from 45 Institutions.
6. **The High Flux Beam Reactor (HFBR)** contains 16 instruments for research in Physics, Biology, Chemistry, and Applied Science. In the past, this facility operated at a routine power level from 40 to 60 MW thermal. Since May 1991, it has operated at 30 MW. In 1997, it did not operate.
7. **The AGS Booster** is a circular accelerator of 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.
8. **The Radiation Therapy Facility,** operated jointly by BNL's Medical Department and State University of New York at Stony Brook, 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 radiotherapy techniques. Approximately, 250 patients are treated annually.
9. **The Accelerator Test Facility** is operated jointly by the National Synchrotron Light Source and the Center for Accelerator Physics. The ATF attracts users from BNL and other institutions for advanced work that has implications for both physics research and future medical uses of accelerators.
10. **The Center for Imaging and Neurosciences** is a joint effort of BNL's Chemistry and Medical Departments. It comprises three imaging facilities that provide a window into the workings of the brain. Two positron emission tomography cameras, a 4-Tesla magnetic resonance imaging machine and a single-photon-emission computed tomography camera are all used to explore addiction, aging, mental disorders and normal brain function.
11. **The Scanning Transmission Electron Microscope (STEM),** operated by BNL's Biology Department, allow scientists to see the intricate details of living things, from bacteria to human tissue.

Additional programs involving irradiations and radionuclides for scientific investigations are carried out at other Laboratory facilities including those at the MRC, the Biology Department, the Chemistry Department, and the Department of Advanced Technology (DAT). Special purpose

radionuclides are developed and processed for general use under the joint auspices of the Department of Applied Science (DAS) and the Medical Department.

In addition to the scientific facilities, there are numerous major facilities, which provide support to the science and technology mission of the Laboratory. These facilities include:

1. **The Sewage Treatment Plant (STP)** (Bldg. 575 and ancillary structures) has a design capacity of 3.0 million gallons per day. The STP receives sanitary and process waste waters from all facilities and treats these wastes before to their discharge to the Peconic River. The STP employs a tertiary treatment sequence and includes primary clarification for removing settleable solids and floatable materials, aerobic oxidation for the removal of biological matter, sand filtration to remove suspended particulate, and UV disinfection for bacterial control. The STP effluent is permitted by the New York State Department of Environmental Conservation.

2. **The Water Treatment Plant (WTP)** (Bldg. 624) is a 5 million-gallon per day potable water treatment facility. The treatment is a lime-softening process for the removal of iron from potable water obtained from the three wells located along the western boundary of the developed site. The WTP also has dual air-stripping towers for controlling volatile organic compounds in the potable-water supply.

3. **The Central Steam Facility (CSF)** (Bldg. 610) provides high-pressure steam, which is used for both facility and process heating. The CSF has a design capacity of 480,000 pounds of steam per hour at 125 pounds per square inch. Steam is conveyed to the users through a series of underground piping. Condensate is collected and returned to the CSF for reuse.

4. **The Major Petroleum Facility (MPF)** provides the petroleum reserves for operating the CSF. In total, 2.3 million gallons of fuel oil, predominantly residual fuel (No. 6) are stored at this facility. The installation of a natural gas line has reduced the Laboratory's reliance on oil as the main source of fuel.

5. **The Central Chilled Water Plant** (Bldg. 600) provides chilled water for ventilation and process cooling. The plant has a refrigeration capacity of 4830 tons (58 million BTU) and reduces the necessity for local refrigeration plants, and once through cooling. A network of underground supply and return piping supplies chilled water.

6. In December 1997 a new state-of-the art **Waste Management Facility** was opened. This complex consists of four buildings in which wastes can be handled with the utmost consideration for the environment. These facilities were constructed with advanced environmental protection systems and features including, but not limited to permanent secondarily contained storage bays for the safe storage of drummed wastes, flammable liquid storage and handling rooms with overpressure relief venting, double walled underground storage tanks and enclosed shielded storage cells. These facilities will improve BNL's management of the chemical and radioactive wastes generated during scientific research and other support operations.