EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

BNL - 52584

Brookhaven National Laboratory

ENVIRONMENTAL MONITORING PLAN

2000

Triennial Update

March 31, 2000

Environmental Services Division

Brookhaven National Laboratory
Operated by
Brookhaven Science Associates
Upton, NY 11973

Under Contract with the United States Department of Energy
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Executive Summary

Brookhaven National Laboratory (BNL) is a multi-program national laboratory operated by Brookhaven Science Associates for the U.S. Department of Energy (DOE). BNL is located on a 5,265 acre site in Suffolk County, Long Island, New York. BNL has a comprehensive environmental monitoring program which is described in this document.

The environmental monitoring program was designed in accordance with DOE Order 5400.1, *General Environmental Protection Program*. This order sets forth the requirements for environmental protection programs at DOE facilities to ensure that operations fully comply with applicable federal, state, and local environmental laws and regulations; executive orders; and DOE policies. The plan describes the monitoring program by media, specifying drivers, monitoring and data quality objectives, identification of sources and contaminants, extent and frequency of monitoring, and analytical procedures and quality assurance.

The various media monitored under BNL's environmental monitoring program include ambient air, emissions from point sources, wastewater discharges, surface water, groundwater, potable water quality, precipitation, soil, sediment, flora and fauna. These media are sampled under one or more types of environmental monitoring: compliance, restoration, or surveillance monitoring. *Compliance monitoring* ensures adherence to regulatory and permit limits, and is comprised of air monitoring, wastewater monitoring, and groundwater monitoring. *Restoration monitoring* measures the impact of past operations and assesses the effectiveness of remedial measures. *Surveillance monitoring* evaluates the impacts, if any, of current or historical operations on the various environmental media. Control samples are also collected so that results from areas potentially impacted by BNL operations can be compared to background results. The data derived from the systematic monitoring of the various environmental media enable BNL to make informed decisions concerning the protection of human health and the environment, and to be responsive to community concerns.

Air surveillance monitoring at BNL involves the analysis of particulate matter collected on filters, as well as vapor chemically trapped in a collection medium. Concentrations of various airborne radionuclides (including particulates and tritiated water vapor) are measured on the BNL site and at offsite locations on eastern Long Island. Specific diffuse, or non-point sources, arising due to environmental restoration activities, are also monitored as needed. The data derived from this program are used to assess public dose.

Continuous monitoring of radiological discharges, along with the estimation of radiological dose to the public resulting from operations with the potential to deliver a radiation dose to a member of the public of greater than 0.1 millirem per year (mrem/yr), is conducted. Facilities with emissions that fall below this value require only periodic, confirmatory monitoring.

Samples of wastewater effluent from BNL operations are collected at the point of discharge. Monitoring is conducted in accordance with permit requirements, and includes both water quality parameters and parameters specifically related to operational processes contributing wastewater to the Sewage Treatment Plant. Samples are also analyzed for pH, dissolved oxygen, conductivity, temperature, radioactivity, inorganics, and wet chemistry parameters.

The Peconic River is sampled at five offsite locations between the southeast site boundary and Riverhead, New York; at four locations onsite; and at one station offsite and upstream of BNL. The Carmans River is sampled to determine background or ambient conditions. Samples are collected and later analyzed for radiological and non-radiological parameters.

The BNL site is included on the Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) National Priorities List. The DOE, U.S. Environmental Protection Agency, and the New York State Department of Environmental Conservation have integrated DOE's response obligations into a comprehensive Federal Facilities Agreement. In compliance with this agreement, BNL's comprehensive groundwater protection and management program evaluates groundwater contamination from historical operations and determines whether measures taken to protect or restore groundwater quality are effective. Wells also monitor research and support facilities where there is a potential for environmental impact to determine whether operational and engineered controls designed to protect groundwater are effective.

BNL maintains six groundwater production wells for the distribution of potable water to the BNL community. The supply wells and distribution system are monitored for chemical and radiological parameters. The objective of the potable water compliance monitoring program is to ensure that the concentrations of regulated contaminants present in the domestic water system are less than the maximum contaminant levels specified by regulation.

Sampling and analysis of vegetation and fauna is a valuable source of data for estimating bioaccumulation and the projection of dose via the ingestion pathway. Precipitation, soil, and sediment are analyzed for contaminants released to the atmosphere and surface water.

BNL measures environmental background radiation through a network of onsite and offsite dosimeter units. These units measure gamma radiation originating from cosmic and terrestrial sources as well as any contribution from BNL operations. These data are reported as Effective Dose Equivalent (EDE) in mrem. This value includes the measured dose received from naturally-occurring, direct exposure sources as well as any potential BNL sources.

A program is in place to ensure that all environmental monitoring data meet appropriate quality assurance requirements. Some environmental samples collected by BNL are analyzed by the onsite Analytical Services Laboratory. BNL also procures and maintains contracts with offsite laboratories. All analytical laboratories are New York State certified for specific parameters, and are subject to audits.

Brookhaven National Laboratory
Environmental Monitoring Plan
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1 INTRODUCTION

1.1 Environmental Monitoring Plan Purpose

The Environmental Monitoring Plan (EMP) describes Brookhaven National Laboratory's (BNL) environmental monitoring program and is prepared in accordance with U.S. Department of Energy (DOE) Order 5400.1, *General Environmental Protection Program*. This order sets forth the requirements for environmental protection programs at DOE facilities to ensure that operations fully comply with applicable federal, state, and local environmental laws and regulations, executive orders, and DOE policies.

1.2 Environmental Monitoring Plan Organization

The 2000 BNL Environmental Monitoring Plan is structured to provide people familiar with environmental requirements and monitoring at DOE facilities with an understanding of how BNL fulfills its monitoring obligations. The EMP describes and explains BNL's environmental monitoring networks, sampling methods, locations, frequencies, and measured parameters, as well as methods and procedures for data collection, analysis, maintenance, reporting, and archiving. It also addresses quality assurance and control and verification of monitoring data and the specifics of sampling and data collection.

The organizational framework of BNL's environmental monitoring program is described in this chapter. Chapter 2 describes the setting of environmental monitoring at BNL and the surrounding environs. Chapter 3 describes major facility sources and characterizes their principal effluents and/or emissions. Chapters 4 through 11 address subjects that encompass all environmental media (air emissions, surface water monitoring, groundwater monitoring, precipitation monitoring, flora, fauna and soil/sediment monitoring, and direct radiation). Each chapter specific to a medium contains a discussion of the rationale and design criteria, the extent and frequency of monitoring, sampling methodology, and quality assurance.

Chapter 12 describes the BNL Analytical Services Laboratory's (ASL) Quality Assurance Program (QAP). It provides a description of analytical capabilities and standard methods, internal quality control practices, and laboratory performance relative to proficiency evaluation tests. Appendix A provides a glossary of terms and acronyms used throughout the plan. Appendix B presents a table showing the combined list of measured parameters by media. Appendix C contains a description of the analytical methods used for onsite analyses.

1.3 Environmental Monitoring Program Purpose

BNL has a comprehensive environmental management system that includes an extensive environmental monitoring program. The purpose of environmental monitoring is to:

- Assess compliance with applicable regulatory requirements and permit limits,
- Evaluate whether environmental protection programs (e.g., engineering or administrative controls) are effective,
- Quantify what impact BNL activities may have on the environment as a result of planned or unplanned releases,
- Identify potential pathways for exposure of the public and the environment, and

- Provide comprehensive, high quality data on levels of radioactive materials and/or hazardous substances in the environment to enable BNL to make informed decisions concerning protection of human health and the environment, and also to be responsive to community concerns and outreach programs.

1.4 Environmental Monitoring Program Scope

BNL monitors ambient air, emissions from point sources, wastewater discharges, surface water quality, groundwater quality, precipitation, soil, flora and fauna. The BNL environmental monitoring program is comprised of three primary types of monitoring:

- *Compliance monitoring* to ensure adherence to regulatory and permit limits,
- *Restoration monitoring* to measure the impact of past operations and assess the effectiveness of remedial measures, and
- *Surveillance monitoring* to evaluate what impact, if any, current operations have on environmental media and public health.

1.4.1 Compliance Monitoring

Compliance monitoring is performed in accordance with environmental requirements (permits, regulations, etc.). These requirements may be separated into three categories: air monitoring, wastewater monitoring, and groundwater monitoring.

1.4.1.1 Air Monitoring

Monitoring of air emissions is conducted at reactors, accelerators, and other radiological emission sources, as well as the Central Steam Facility (CSF). Real-time, continuous emission monitoring or continuous sample collection equipment is installed and maintained at these facilities, as required by permit conditions. Analytical data are routinely reported to the permitting agency.

1.4.1.2 Wastewater Monitoring

Wastewater discharges are subject to Clean Water Act (CWA) permit monitoring requirements. Monitoring is performed at the point of the wastewater discharge and is used to ensure that the effluent complies with release limits. Twelve point source discharges are monitored under the BNL CWA program: three from the Environmental Restoration (ER) program and nine under the New York State Pollutant Discharge Elimination System (SPDES) permit program. Samples are collected daily, weekly, monthly, or quarterly, in accordance with permit requirements; and are monitored for organics, inorganics, and radiological parameters. Monthly reports filed with the permitting agency provide analytical results and an assessment of compliance for the reporting period.

1.4.1.3 Groundwater Monitoring

Some groundwater monitoring is also performed in accordance with permit requirements. Specifically, monitoring of groundwater is required under the Major Petroleum Facility (MPF) License and the Resource Conservation and Recovery Act (RCRA) permit for the waste management facilities. Extensive groundwater monitoring is also conducted under the ER program as required under the various Record of

Decisions (RODs) for many of the Operable Units (OUs) or Areas of Concerns (AOCs). Additionally, to ensure that BNL maintains a viable potable water supply, drinking water supply wells are monitored as required by the New York State Department of Health (NYSDOH) regulations.

1.4.2 Restoration Monitoring

Monitoring performed under the ER program is conducted to determine if past operations released or deposited contaminants in the environment or otherwise resulted in degradation of environmental media. This program typically includes collection of soil and groundwater samples to determine the lateral and vertical extent of the contaminated area. These samples are analyzed for organics, inorganics, and radiological contaminants and the analytical results are compared with recognized guidance or background concentrations. Areas where impacts have been confirmed are fully characterized and, if necessary, remediated to mitigate impacts. Follow up monitoring of groundwater is conducted in accordance with a ROD to determine the efficacy of restoration programs (such as groundwater treatment).

1.4.3 Surveillance Monitoring

The focus of the environmental surveillance program is to assess potential environmental impacts resulting from routine facility operations beyond what is required by regulations or permits. This program includes collection of ambient air, surface water, groundwater, soil, flora, fauna, and precipitation samples. Samples are analyzed for radiological, organic, and inorganic contaminants. Additionally review of data collected with thermoluminescent dosimeters (TLDs) (devices to measure radioactive exposure) placed on and offsite is conducted under the program.

Surveillance monitoring also includes collection of background samples (also sometimes called "reference" or "control" samples) in locations unaffected by BNL operations. Background results are used as a standard of comparison.

1.5 Environmental Monitoring Activities

BNL's environmental monitoring program is reviewed, and revised as necessary, on an annual basis to reflect changes in permit requirements, changes in facility-specific monitoring activities, the need to increase or decrease monitoring based on a review of previous analytical results, and/or in response to stakeholder concerns. As required under DOE Order 5400.1 [1988], the EMP outlines annual sampling goals by specific media and frequency. Appendix B provides a matrix of the media sampled and the parameters that are measured. The following provides a brief overview of these activities.

1.5.1 Radiological Monitoring

Radiological monitoring consists of the following:

- Assessment of airborne emission impact through National Emission Standards for Hazardous Air Pollutants (NESHAP) reviews of facilities that are known to utilize radioactive materials in the course of experimental research,
- Continuous monitoring of facilities such as reactors, medical isotope production areas, and accelerators that use large quantities of or generate radioactive materials,
- Liquid effluent monitoring for radiological materials discharged from facilities before release to the environment for compliance with DOE Orders,

- Environmental surveillance of the soil, vegetation, and fauna (including aquatic biota),
- Monitoring of potable water for compliance with the Safe Drinking Water Act (SDWA),
- Determination of external exposure component of dose through the use of TLDs, and
- Groundwater monitoring for radiological constituents to evaluate the impact of BNL operations on the U.S. Environmental Protection Agency (EPA) designated sole source aquifer which underlies the site.

1.5.2 Nonradiological Monitoring

- Monitoring of effluents for parameters listed in the SPDES permit.
- Monitoring of fuel oils used by the Central Steam Facility (CSF) for potential polychlorinated biphenyl (PCB) contamination, as needed.
- Monitoring of emissions from the CSF.
- Monitoring of the potable water for parameters regulated by the SDWA and the NYSDOH.
- Environmental surveillance of soil, surface water, and groundwater for nonradiological parameters to assess the impact of BNL operations on the environment.

1.6 Reference

DOE Order 5400.1. 1988. *General Environmental Protection Program.* U.S. Department of Energy, Washington, D.C.

2 LABORATORY SETTING

2.1 Introduction

Brookhaven National Laboratory (BNL) is a multi-program national laboratory operated by Brookhaven Science Associates (BSA) for the U.S. Department of Energy (DOE). The Laboratory carries out basic and applied research in the physical, biological, and environmental sciences, as well as in selected energy technologies. In order to evaluate what impact BNL's past and present operations may have on the environment, it is important to understand local site characteristics in terms of human population, geology, hydrology, climatic data, and ecological resources.

2.2 BNL Mission

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, which support the DOE strategic missions, are to:

- Conceive, design, construct, and operate complex, leading-edge, user-oriented facilities in a safe and environmentally responsible manner that is responsive to the DOE and the needs of the international community of users,
- Carry out basic and applied research in long-term programs at the frontier of science in support of DOE missions,
- Develop advanced technologies that address national needs and to transfer them to other organizations and to the commercial sector, and
- 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.

2.3 Site Location and Local Population

BNL is located near the geographical center of Suffolk County, Long Island, about 60 miles east of New York City (Figure 2-1). About a third of the 1.36 million people that reside in Suffolk County live in Brookhaven Township where BNL is situated [LIPA 1998]. Figure 2-2 shows the distribution of the resident population on Long Island. Approximately eight thousand people live within 0.3 miles of BNL's boundaries as shown in Figure 2-3. Although much of the land area within a 10 mile radius of BNL is either forested or cultivated, there has been an increase in residential housing in recent years, a trend that is expected to continue.

2.4 Facility Description

BNL's site consists of 5,265 acres, with most principal facilities located near the center. The developed area is approximately 1,656 acres, of which about 500 acres were originally developed by the Army, and about 200 acres are occupied by various large, specialized research facilities. Outlying facilities occupy about 549 acres; these include the Sewage Treatment Plant (STP), research agricultural fields, housing, and fire breaks. The balance of the site is largely wooded. The major facilities are described below and pictured in Figure 2-4.

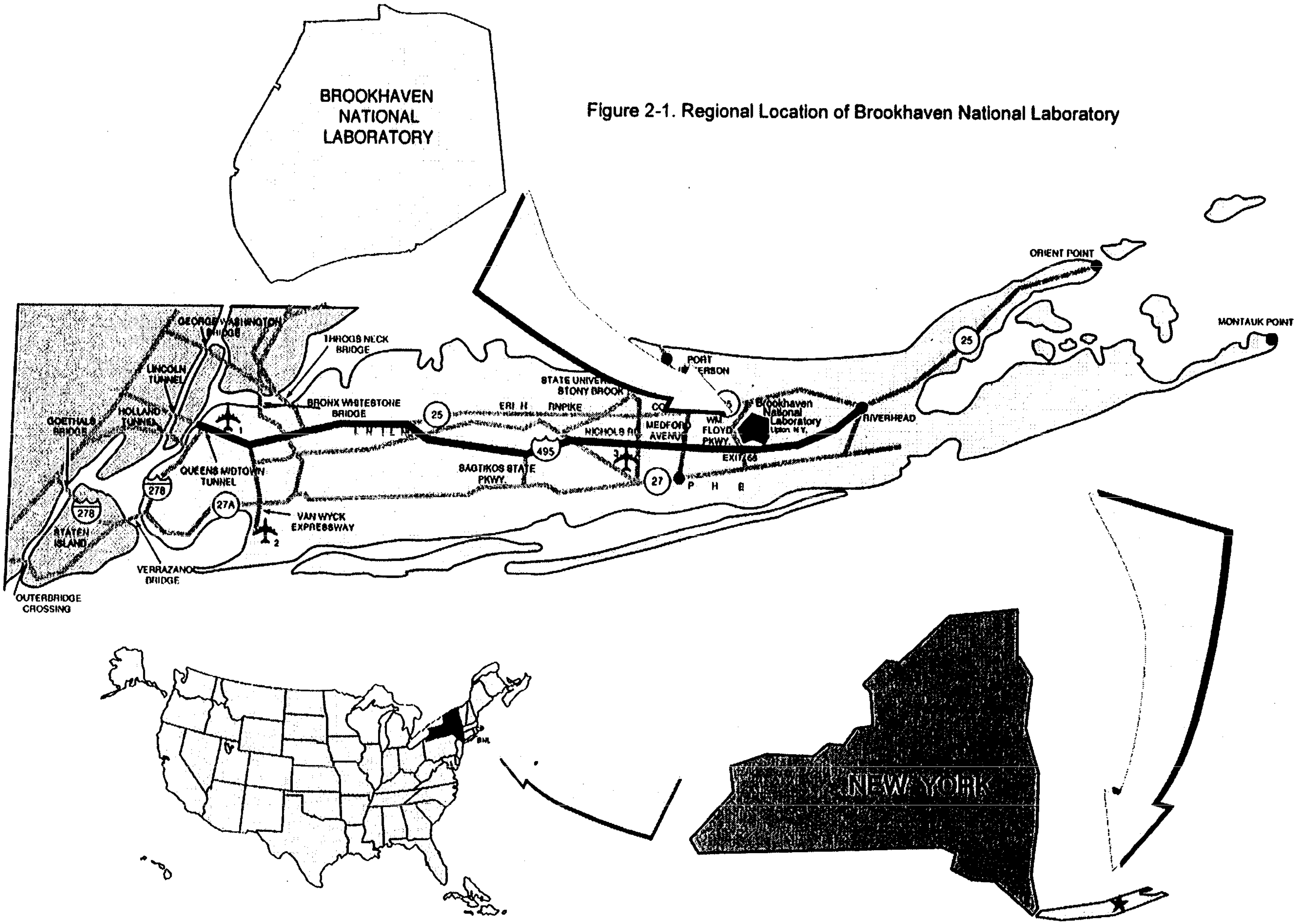


Figure 2-1. Regional Location of Brookhaven National Laboratory

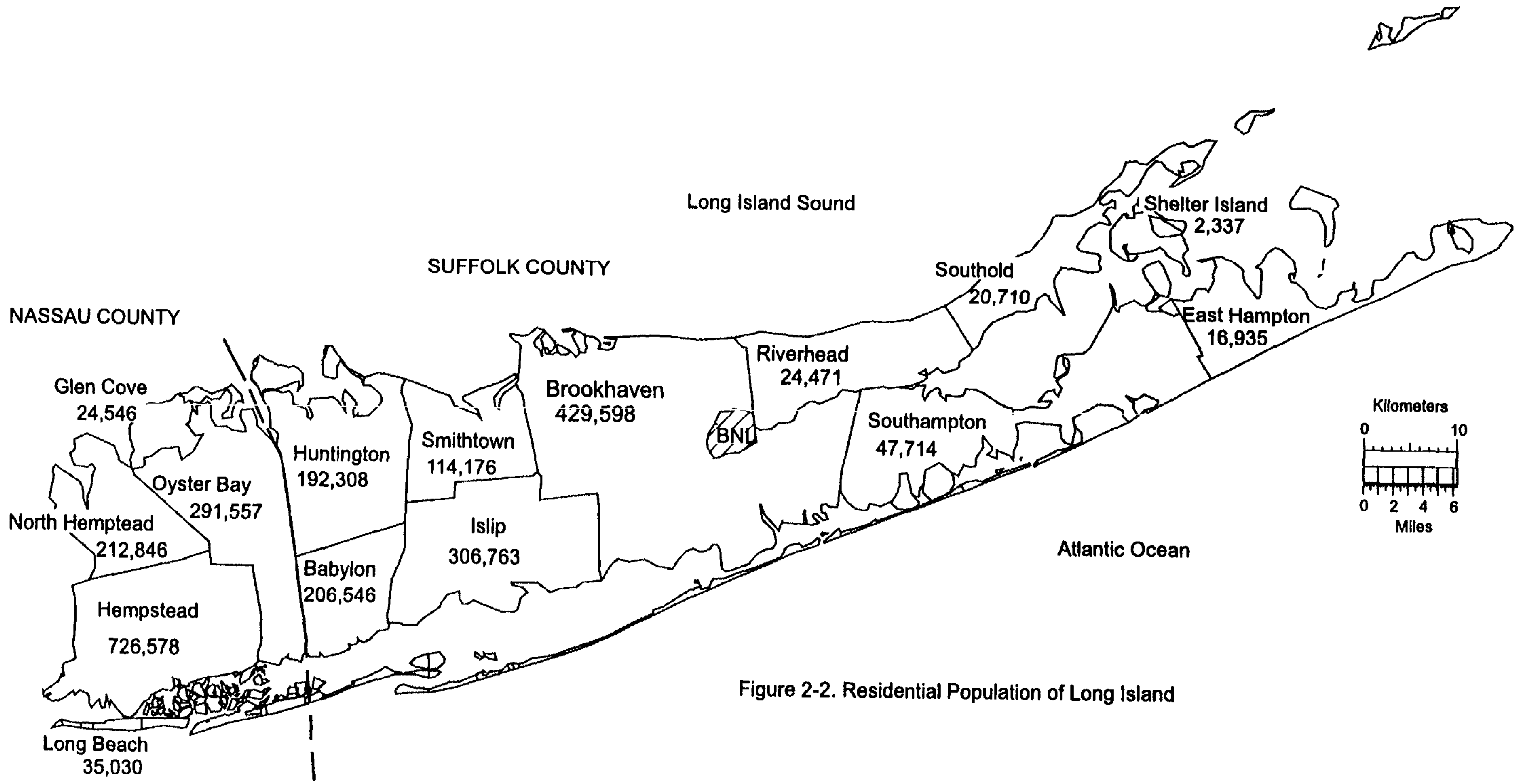


Figure 2-2. Residential Population of Long Island

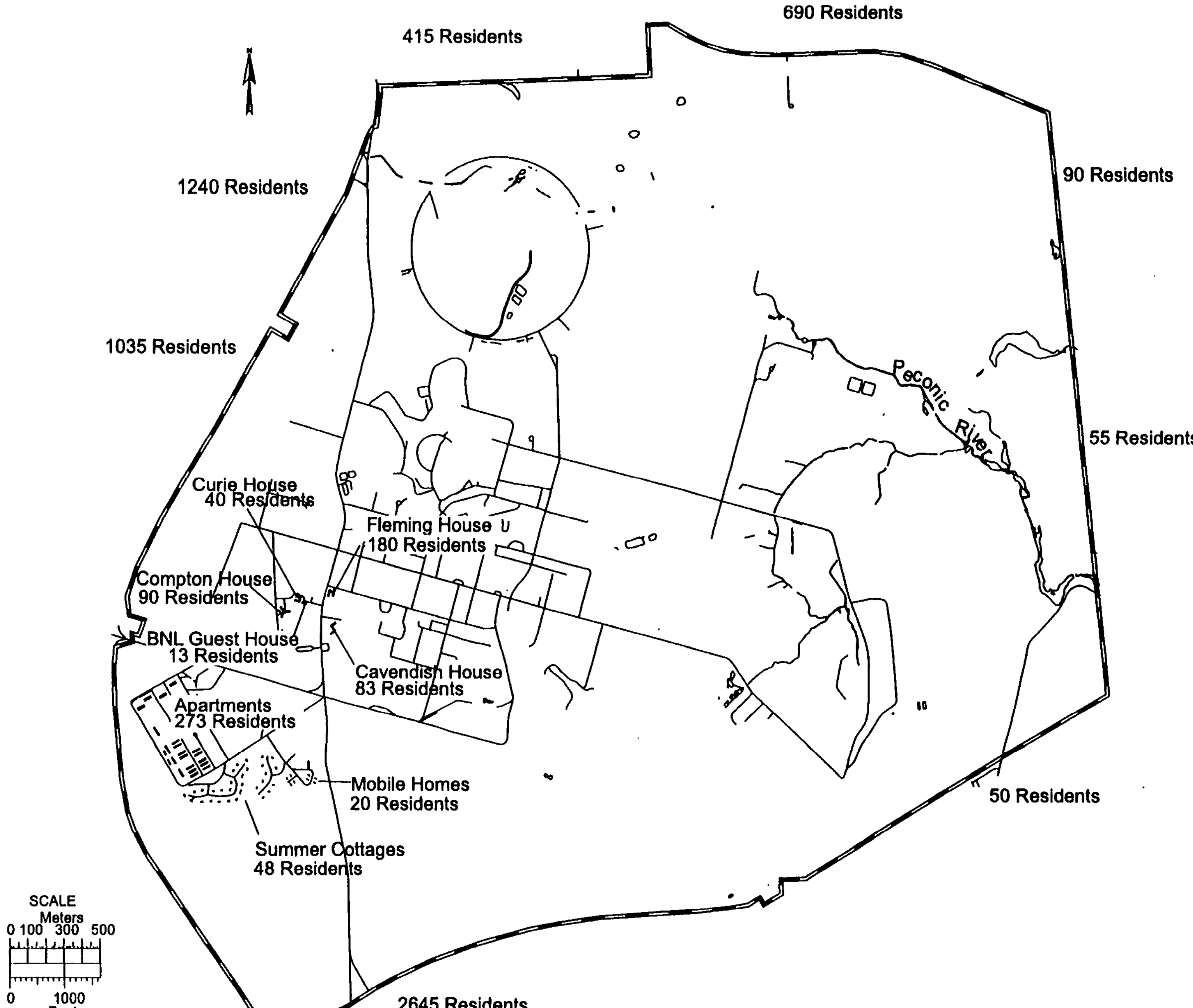


Figure 2-3. Local and Onsite Residential Population

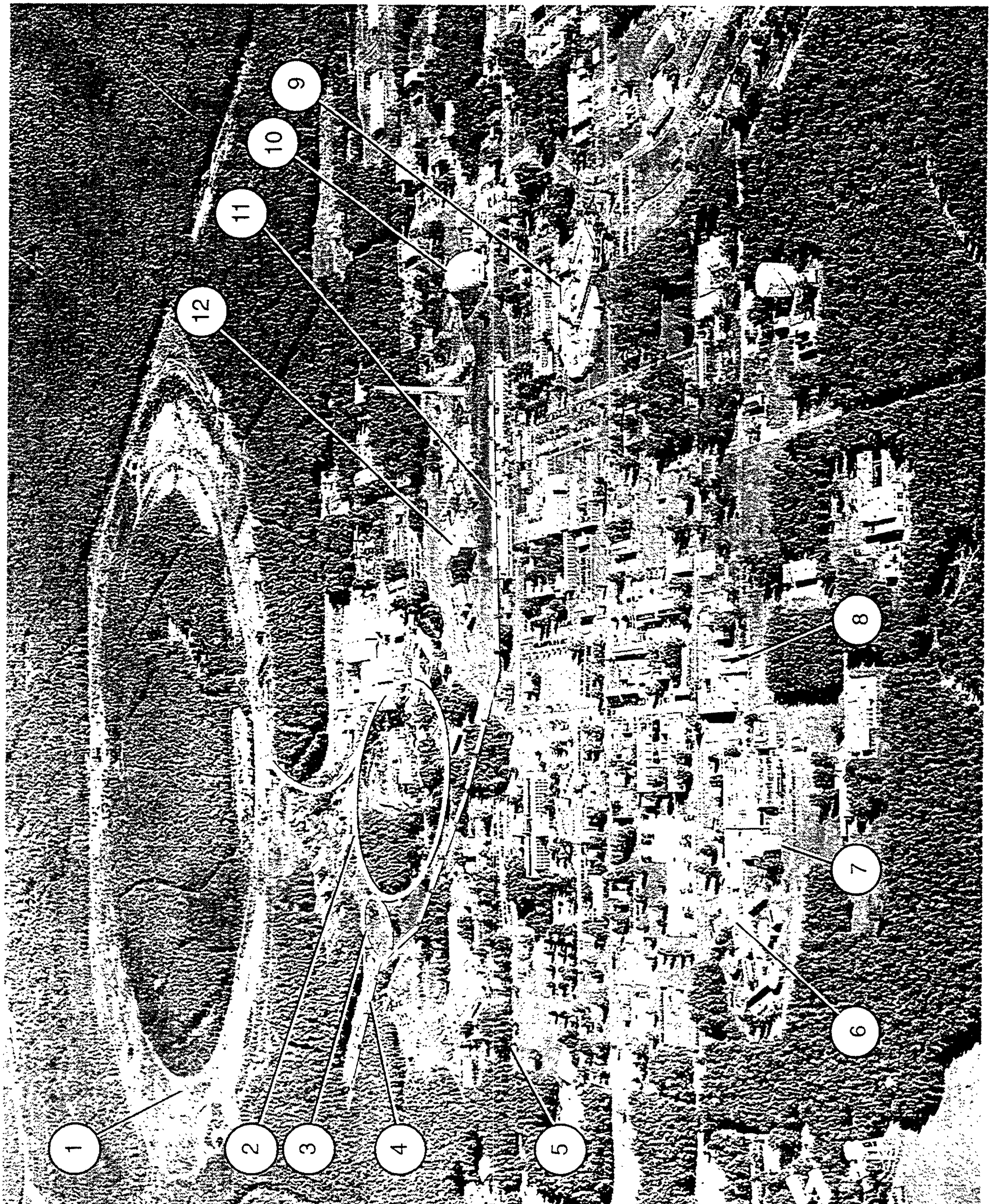


Figure 2-4. Brookhaven National Laboratory Site-Wide Photo

1. **Relativistic Heavy Ion Collider (RHIC)** – The RHIC is one of the world's largest and most powerful accelerators. RHIC's main physics mission is to study subatomic particles.

2. **Alternating Gradient Synchrotron (AGS)** – The AGS is used for high energy physics research and accelerates protons to energies up to 30 gigaVolt (GeV) and heavy-ion beams to 15 GeV. A 200 megaVolt (MeV) Linear Accelerator (LINAC), 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 (BLIP) facility.

3. **AGS Booster** – The AGS Booster is a circular accelerator 200 meters in circumference that receives either a proton beam from the LINAC, or heavy ions from the Tandem Van de Graaff. The 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 produces beams of polarized protons for the AGS and, when it becomes operational, for the Relativistic Heavy Ion Collider (RHIC). 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 at 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)** – Also a part of the MRC, 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 radiotherapy techniques. Approximately 200 patients are treated at the RTF each month.

7. **Brookhaven Medical Research Reactor (BMRR)** – The Brookhaven Medical Research Reactor (BMRR) was the world's first nuclear reactor built exclusively for medical research applications. The BMRR is an integral part of the Medical Research Center (MRC).

8. **Scanning Transmission Electron Microscope (STEM)** – This facility actually includes two microscopes, STEM 1 and STEM 3, used for biological research. Both powerful devices allow scientists to see the intricate details of living things, from bacteria to human tissue. The STEM is used by more than 50 scientists each year.

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 for x-ray diffraction studies.

10. **High Flux Beam Reactor (HFBR)** – The High Flux Beam Reactor (HFBR) was one of the premier neutron physics research facilities in the world over the last three decades. Neutron beams produced at the HFBR were used to investigate the molecular structure of materials which aid in pharmaceutical design and materials development, as well as expanding the current knowledge base of physics, chemistry and biology. Due to a leak in the fuel storage pool which was discovered in

1997, the HFBR was shut down and is now planned to be permanently decommissioned. The HFBR is pictured in Figure 2-5.

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. The Heavy Ion Transfer Line 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 (atomic mass units). These ions are then extracted and sent to the AGS experimental area for physics research.

12. **Brookhaven Graphite Research Reactor (BGRR)** – No longer in operation, the BGRR was used to research cancer therapy methods, such as boron neutron capture therapy.

In addition to the scientific facilities, there are numerous other major facilities, which provide support to BNL's science and technology mission. Among these are:

- **Sewage Treatment Plant (STP)** – The STP, shown in Figure 2-6, has a design capacity of 3.0 million gallons per day (MGD) and receives sanitary and certain process wastewaters from BNL facilities for treatment prior to discharge into the Peconic River.

- **Water Treatment Plant (WTP)** – The WTP is a potable water treatment facility with a capacity of 5.0 MGD. During the treatment process, potable water obtained from three wells located along the western boundary of the developed site is treated with a lime-softening process to remove naturally occurring iron. The WTP is also equipped with dual air-stripping towers to ensure that volatile organic compounds (VOCs) are at or below New York State drinking water standards.

- **Central Steam Facility (CSF)** – The CSF provides high-pressure steam used for both facility and process heating. Steam is conveyed to the user facilities through a network of underground piping. Condensate is collected and returned to the CSF for reuse as a water and energy conservation measure.

- **Major Petroleum Facility (MPF)** – The MPF provides the petroleum reserve needed for operating the CSF. This facility has a total capacity of 2.3 million gallons for storing predominately fuel oil No. 6. The recent installation of a natural gas line has reduced BNL's reliance on oil as the primary source of fuel.

- **Central Chilled Water Plant (CCWP)** – This facility provides chilled water for ventilation and process cooling via a network of underground piping. The plant has a large refrigeration capacity, which reduces the necessity for local refrigeration plants, and once-through cooling.

- **Waste Management Facility (WMF)** – The WMF is a state-of-the-art complex of four buildings for managing the wastes generated from BNL's research and operation activities. This facility, which opened in December 1997, was built with advanced environmental protection systems and features. The WMF houses two areas permitted by the New York State Department of Environmental Conservation (NYSDEC) for storing and treating hazardous wastes prior to shipment offsite for treatment and disposal at other permitted Treatment, Storage, and Disposal Facilities (TSDFs).

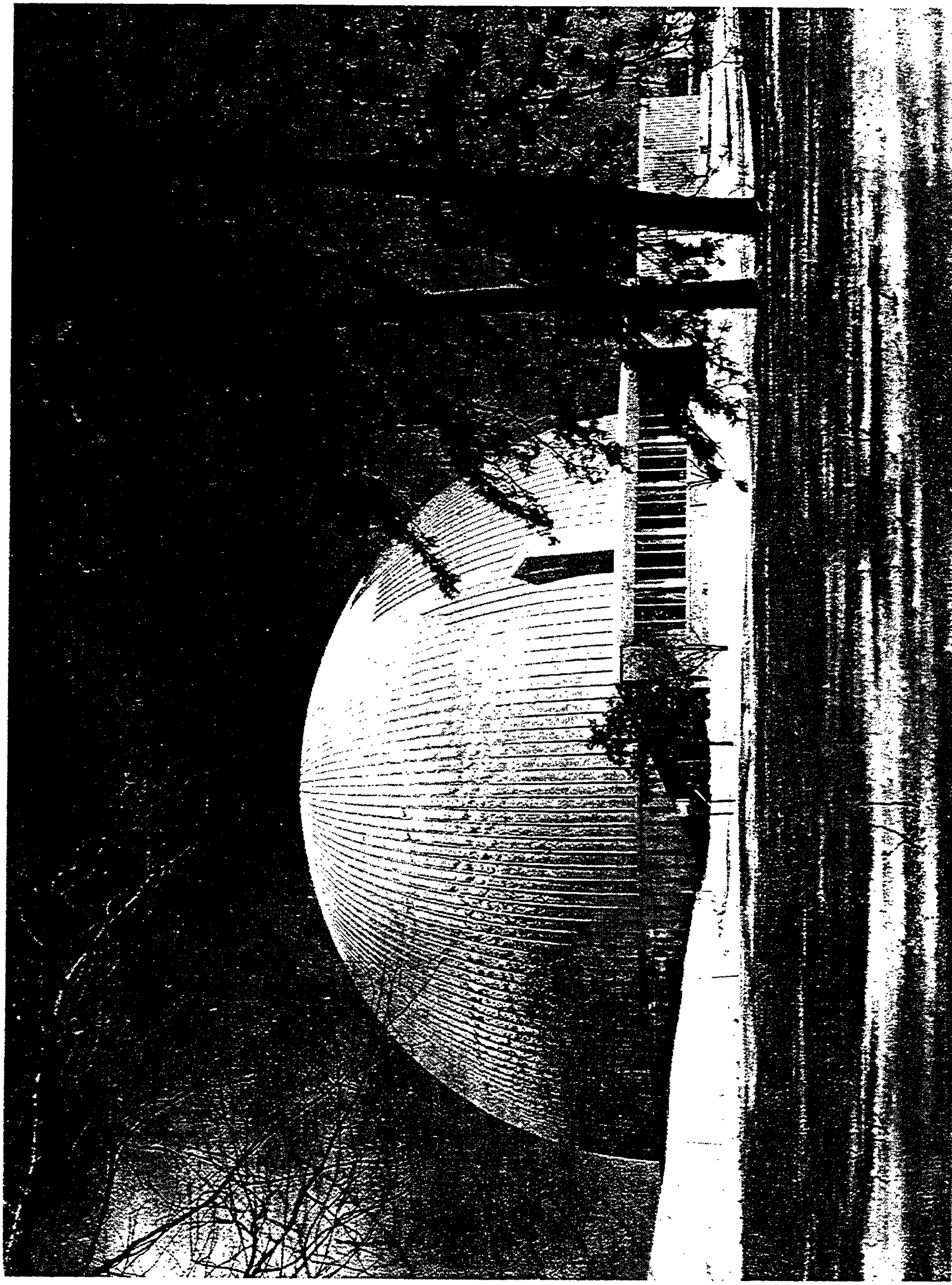


Figure 2-5. High Flux Beam Reactor (HFBR)

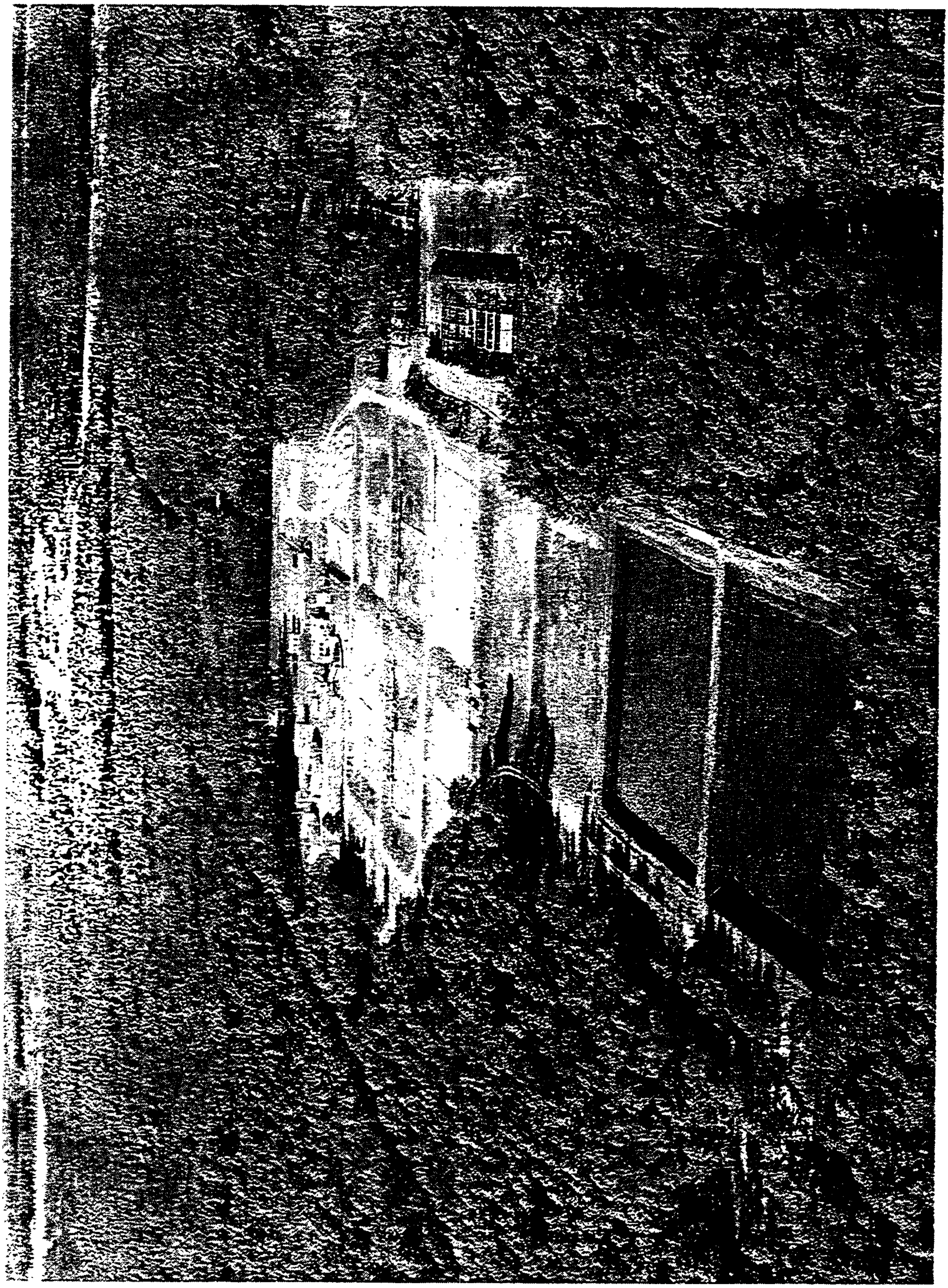


Figure 2-6. Sewage Treatment Plant (STP)

2.5 Hydrogeology and Water Resources

The hydrogeology of the BNL site was initially studied by the U.S. Geological Survey in the late 1940's and early 1950's under a cooperative agreement with the Atomic Energy Commission. Since these initial studies, groundwater flow patterns and groundwater quality have been impacted by a significant increase in the number of BNL research facilities and subsequent demands for water. Since the early 1990's, BNL has been conducting extensive subsurface investigations to better define the hydrogeological setting of the BNL site and surrounding areas. The BNL hydrogeologic characterization programs have included soil borings, geophysical logging, the installation of monitoring wells and piezometers, water level measurements, aquifer pumping tests, and groundwater modeling. A detailed description of the hydrogeology in the vicinity of BNL is presented in Chapter 8.

Studies of Long Island hydrology and geology in the vicinity of BNL indicate that the uppermost Pleistocene deposits (referred as the Upper Glacial aquifer) are between 130 and 200 feet thick, and are generally composed of highly permeable glacial sands and gravel [Warren *et al.* 1968]. Water penetrates these deposits readily, and there is little direct runoff into surface streams unless precipitation is intense. 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 [Koppleman 1978].

The terrain of the site is gently rolling, with elevations varying between 44 and 120 feet above sea level. The land 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, while with normal to above-normal precipitation, the river receives water from the aquifer.

BNL uses approximately 2.6 MGD of groundwater from the Upper Glacial aquifer to meet potable water needs in addition to heating and cooling requirements. Approximately 74 percent of the total water is returned to the aquifer through onsite 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 seven percent. An additional 0.56 MGD of groundwater is pumped from remediation wells for treatment and then returned to the aquifer by the use of recharge basins. See Figure 2-7 for a graphical representation of ground water usage at BNL.

2.6 Climatic Data

BNL can be characterized as a breezy, 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; Nagle 1978]. A Wind Rose is a graphical depiction of the annual frequency distribution of wind speed and direction. Figure 2-8 shows the 1998 annual Wind Rose for BNL, measured at a height of 288 feet.

The total precipitation for 1998 was 56.61 inches, which is about eight inches above the 50-year annual average. Most of the precipitation was received from January through June. Precipitation for the months of July to December 1998 was below normal, leading to drier conditions on site at the end of 1998. Figures 2-9 and 2-10, respectively, present the 1998 monthly and historic precipitation data. The monthly mean temperature in 1998 was 11.7 °C (53.1 °F), ranging from a monthly mean low temperature of -2.3 °C (27.8 °F) to a monthly mean high temperature of 28.3 °C (83 °F). Figure 2-11 shows the 1998 and historical monthly mean temperatures.

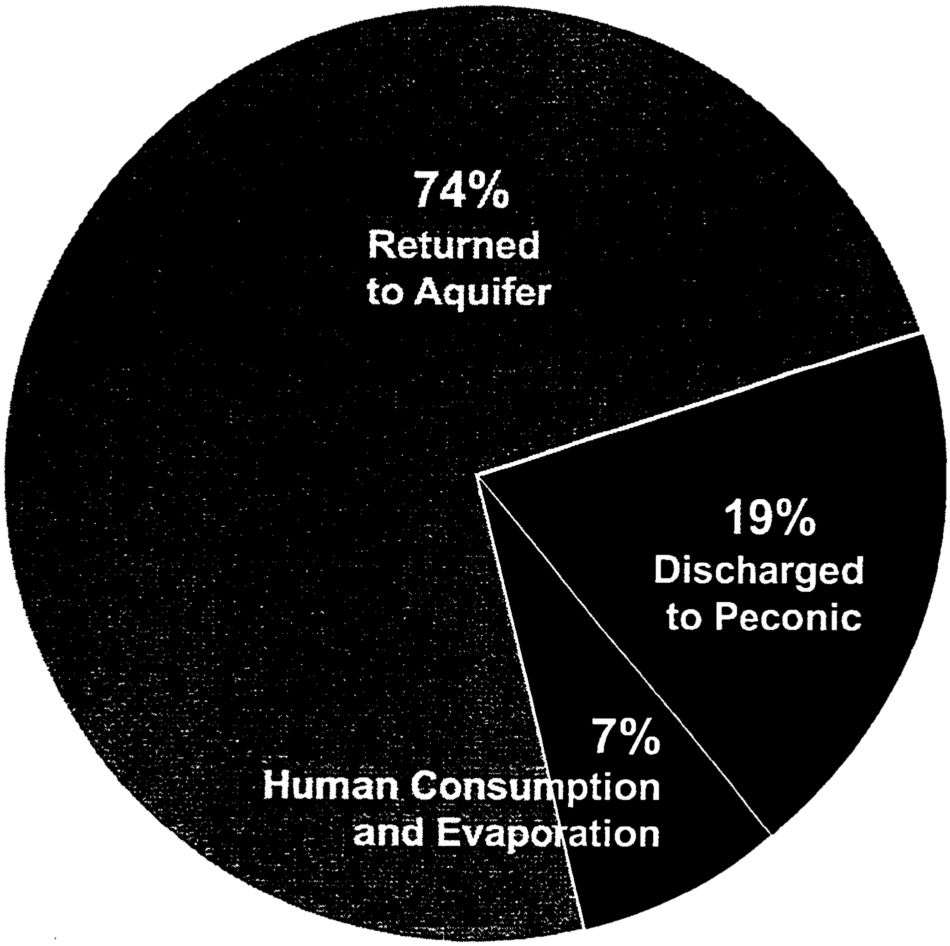
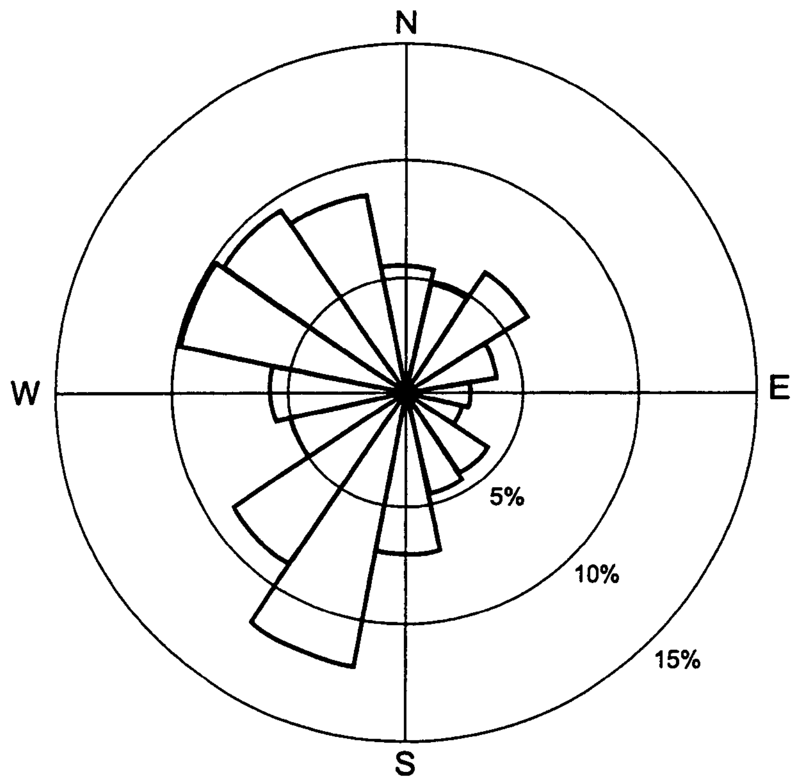


Figure 2-7. Use of Groundwater at BNL



Notes:
1. The arrows formed by the wedges indicate wind direction. This diagram indicates that the predominant wind direction in 1998 was towards the north-northeast.
2. Each concentric circle represents a 5 percent frequency, so wind blew towards the NNE 12% of the time in 1998.
3. Wind was calm 2.3% of the time in 1998
4. Wind directions were measured at a hieght of 88 meters.

Figure 2-8. Annual Wind Rose for 1998

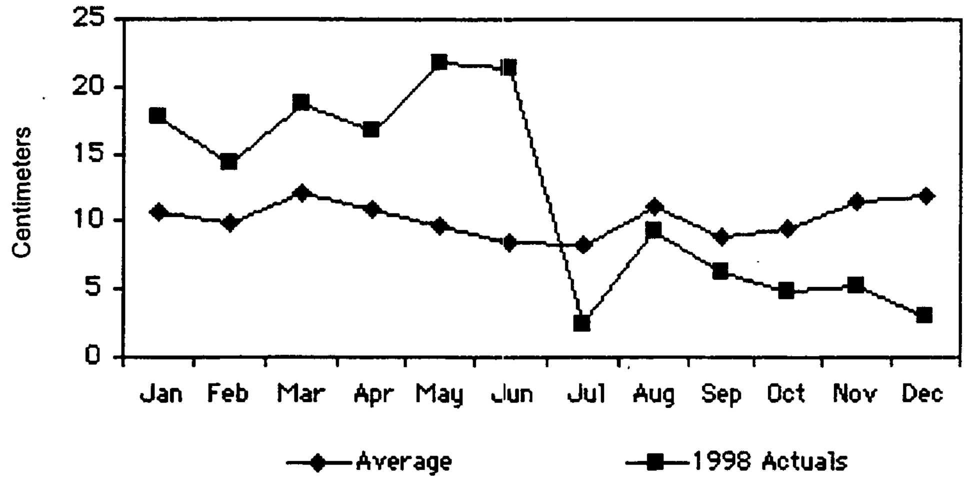


Figure 2-9. Monthly Precipitation Trends

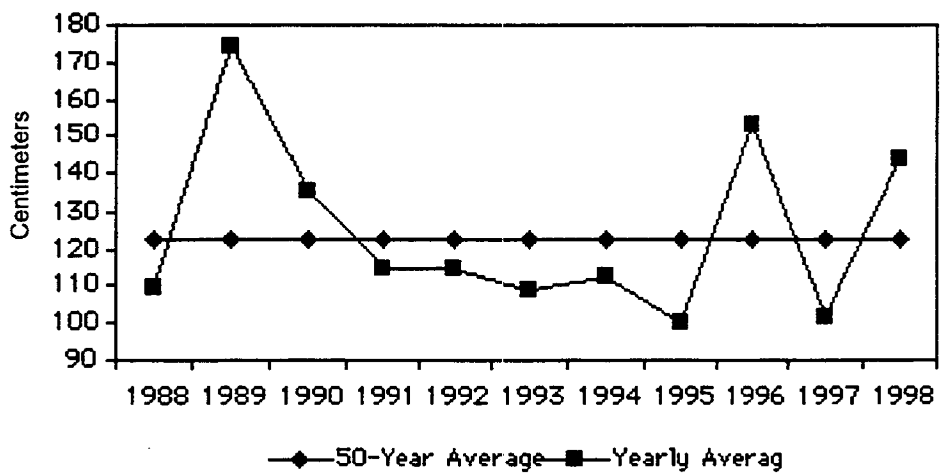


Figure 2-10.Ten-Year Precipitation Trend

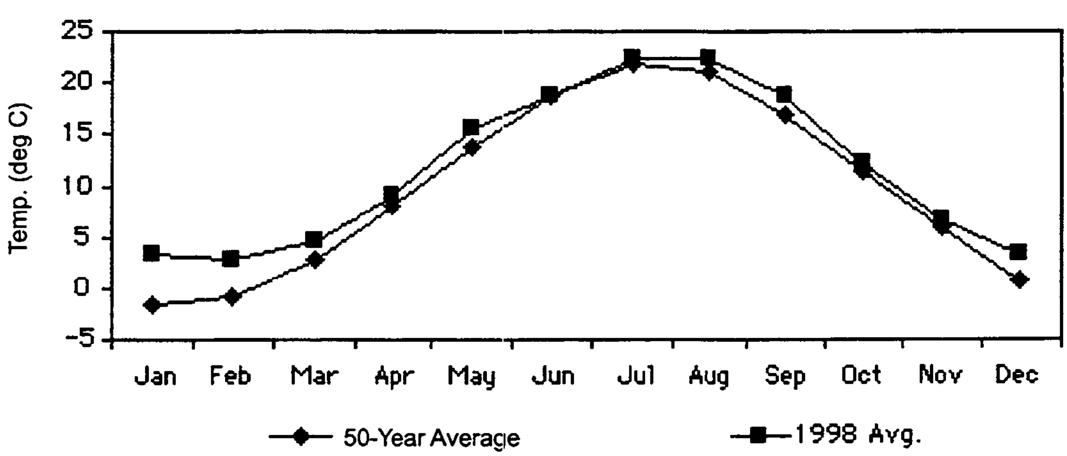


Figure 2-11. Monthly Mean Temperature Trend

2.7 Ecological Resources

BNL's natural resources have been extensively mapped to identify any environmentally sensitive areas, and to inventory biological species. The BNL site is located in a section of the Oak/Chestnut forest region of the Coastal Plain and constitutes five percent of the 100,000 acre Pine Barrens on Long Island. Because of the general topography and porous soil, there is little surface runoff or open water. Upland soils tend to be very well drained, while depressions form small pocket wetlands with standing water on a seasonal basis. There are also six major regulated wetlands onsite. Hence, a mosaic of wet and dry areas on the site is 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 onsite 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. Over 230 plant species have been identified onsite.

The fifteen mammal species endemic to the site include species common to mixed hardwood forests and open grassland habitats. The white-tailed deer density is at least 100 per square mile according to a BNL deer population study issued in 1993 [Thomlinson 1993]. At least 85 species of birds have been observed at BNL, a result of its 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. Nine amphibian and ten reptile species have been identified. Permanently flooded retention basins and other watercourses support amphibians and aquatic reptiles. Recent ecological studies at the BNL site have confirmed 14 breeding sites for the New York State-endangered eastern tiger salamander (*Ambystoma tigrinum*) in BNL's vernal ponds and some recharge basins. Nine species of fish have also been identified. The banded sunfish (*Eanneacanthus obesus*) is one New York State (NYS) threatened species, as it occurs solely within the Peconic River system. It has been confirmed as inhabiting the Peconic River onsite [Scheibel 1990; Corin 1990]. Part of the Peconic River running through BNL's property was designated "scenic" by the New York State Wild, Scenic, and Recreational River Systems Act (WSRRSA).

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3 EMISSION/EFFLUENT SOURCES AND PATHWAYS

3.1 Introduction

One of the main objectives of Brookhaven National Laboratory's (BNL) environmental monitoring program is to predict exposures that could be received by humans from radioactive and chemical substances via various potential exposure pathways. To meet this objective, not only must the character of the emitted pollutant be known (e.g., identity, amount, rate of release, chemical form, etc.), but there also must be an understanding of how the pollutants are subsequently absorbed, retained, and passed along by the various compartments of the many possible exposure pathways. This chapter describes the sources of radioactive and chemical emissions and effluents from BNL facilities and provides a general description of the primary exposure pathways to members of the public.

3.2 Pathways

Chemicals and radionuclides released into the environment can move through the biosphere by a number of routes that could eventually lead to exposure of humans. These routes can be direct, as in the inhalation of contaminated air or ingestion of contaminated drinking water; or indirect and complex, involving many levels of the food chain and different transport mechanisms.

Exposure is defined as the interaction of an organism with a physical or chemical agent of interest. An exposure pathway is identified based on:

- An examination of the types, location, and sources (contaminated soil, raw effluent, etc.) of contaminants,
- Principal release mechanisms,
- Probable environmental fate and transport (including persistence, partitioning, and intermediate transfer) of contaminants of interest, and
- Location and activities of the potentially exposed populations.

Mechanisms that influence the fate and transport of a chemical through the environment and influence the amount of exposure a person might receive at various receptor locations are listed below. While processes that move radionuclides through the atmosphere and hydrosphere tend to reduce radionuclide concentrations, many pathway components or processes that move radionuclides through the food chains to humans can cause bioaccumulation of pollutants. Once a radionuclide or chemical is released into the environment it may be:

- *Transported* (e.g., migrate downstream in solution or on suspended sediment, travel through the atmosphere, or be carried offsite in contaminated wildlife),
- *Physically or chemically transformed* (e.g., deposition, precipitation, volatilization, photolysis, oxidation, reduction, hydrolysis, or radionuclide decay),
- *Biologically transformed* (e.g., biodegradation), and/or
- *Accumulated in the receiving media* (e.g., sorbed strongly in the soil column, stored in organism tissues).

The primary pathways for movement of radioactive materials and chemicals from the site to the public are the atmosphere and surface water. Figure 3-1 illustrates the potential routes and exposure pathways to humans.

The significance of each pathway is determined by comparing measurements and calculations that estimate the amount of radioactive material or chemical transported along each pathway with the concentrations or potential doses to environmental and public health protection standards or guides. Pathways are also evaluated based on prior studies and observations of radionuclide and chemical movement through the environment and food chains. Calculations based on effluent and emission data show the expected concentrations off the BNL site to be low for all BNL-produced radionuclides and most chemicals. Frequently, concentrations are below the level that can be accurately detected by monitoring technology. To ensure that radiological and chemical analyses of samples are sufficiently sensitive, minimum detectable concentrations of key radionuclides and chemicals have been established at levels well below applicable health standards. Environmental and food chain pathways are monitored near facilities releasing effluents or emissions and also at potential offsite receptor locations.

3.3 Sources

3.3.1 Airborne Emissions – Radioactive

Several BNL facilities conduct research activities involving the use of radioisotopes or create radioactive material as part of their normal operations. Facilities with emissions that have the potential to deliver a radiation dose to a member of the public of greater than 0.1 millirem per year (mrem/yr) must be continuously monitored in accordance with National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements [40 CFR 61, Subpart H]. The facilities that fall below NESHAP levels require only periodic, confirmatory monitoring. Figure 3-2 indicates the location of each of the monitored facilities on the BNL site.

The BNL facilities with the most significant radiological airborne emissions are the Brookhaven Medical Research Reactor (BMRR), the High Flux Beam Reactor (HFBR), and the Brookhaven LINAC Isotope Producer (BLIP). Of these, the BMRR typically contributes the largest fraction (85 percent or more) of the total annual Effective Dose Equivalent (EDE) to the Maximally Exposed Individual (MEI) residing at the BNL site boundary. The primary radionuclide releases from the BMRR, HFBR, and BLIP are argon-41, tritium, and oxygen-15, respectively. Table 3-1 presents the airborne radionuclide releases from monitored facilities in calendar year (CY) 1998.

Other BNL facilities which produce airborne radioactive emissions include the Evaporator Facility, the Building 801 Target Processing Laboratory, and the Linear Accelerator (LINAC). However, the emissions from these facilities are relatively small by comparison and result in estimated doses which are substantially less than 0.1 mrem/yr at the site boundary. The other common potential source of airborne radionuclide emissions are laboratory hoods in which work with dispersible radionuclides is performed. The quantities of activity in use in these hoods is quite small, usually on the order of millicuries to microcuries. Compliance of these sources with the NESHAP regulations are demonstrated annually through the use of an inventory system, as allowed under Appendix D of the rule. Environmental monitoring also provides independent verification that abnormal emissions from these sources have not occurred.

New facilities or planned activities that will generate environmental releases of airborne radionuclides are reviewed for NESHAP compliance and potential environmental impact. This review serves to document the details of the operation generating the release, the source terms involved, effluent control equipment

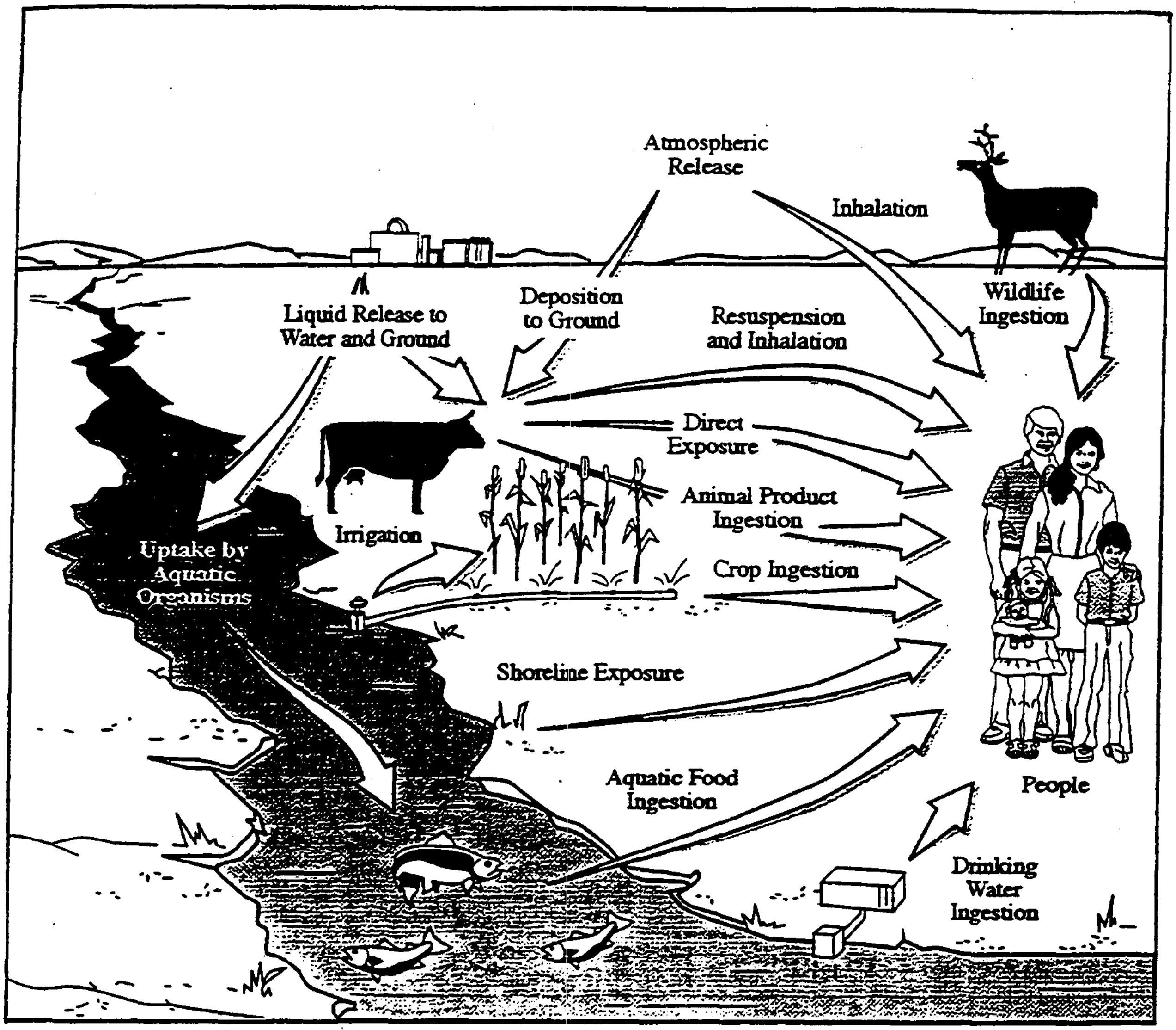

Figure 3-1. Primary Exposure Pathways to Humans

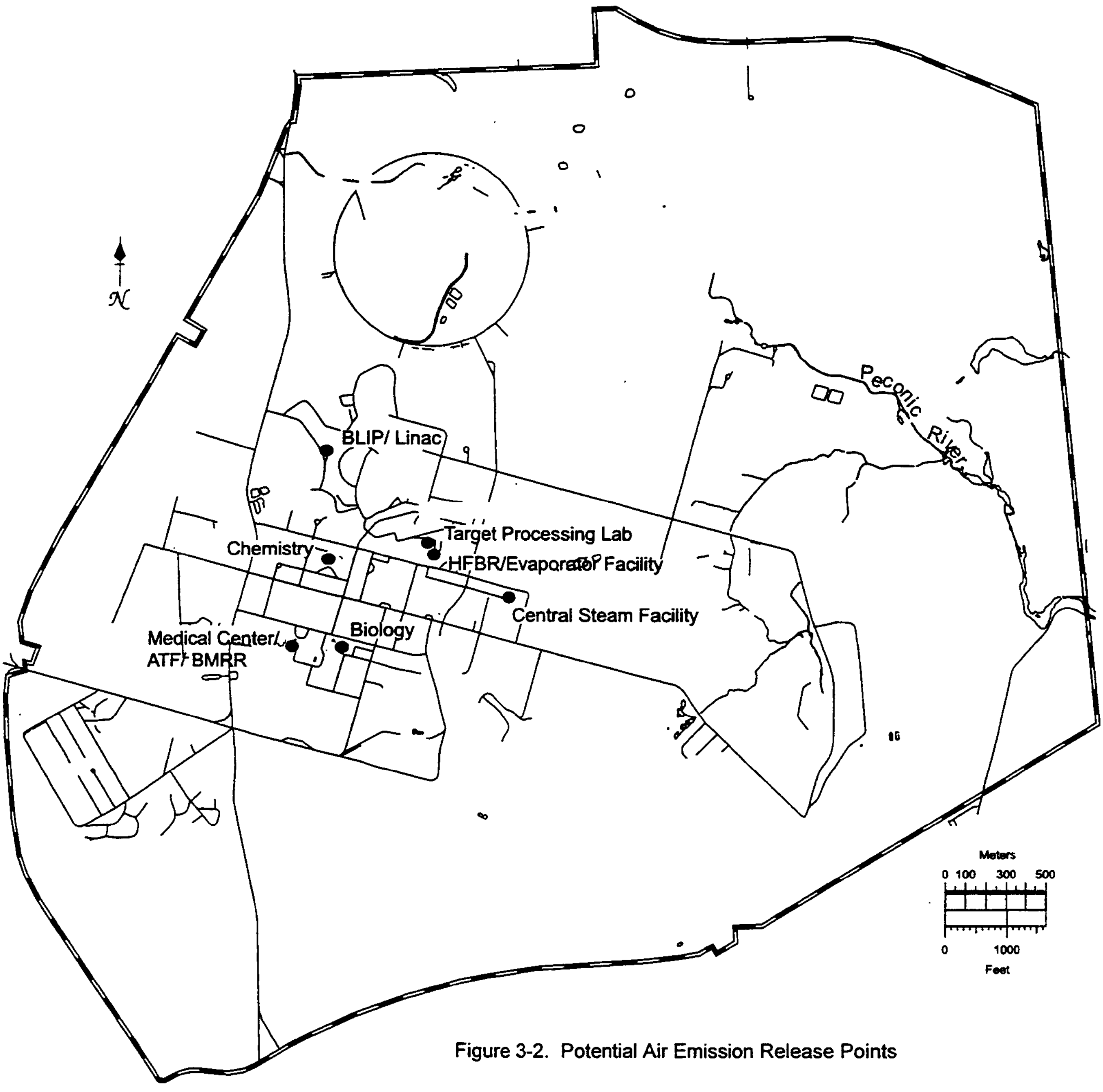

Figure 3-2. Potential Air Emission Release Points

Table 3-1. Monitored Air Emission Point Releases

Facility	Nuclide[1]	Half-life[2]	Ci-Released[3]
BMRR	Ar-41	1.8 h	2.36E+03
Bldg. 801	As-74	18 d	9.38E-06
	Br-77	57 h	7.81E-05
	Cs-137	30 y	7.33E-07
	F-18	110 m	1.74E-01
	Ga-68	68 m	1.33E-01
	Ge-69	36 h	1.37E-04
	Rb-86	18.6 d	2.36E-05
	Se-75	120 d	6.74E-07
HFBR	Be-7	53 d	1.21E-07
	Cs-137	30 y	1.25E-07
	V-48	16 d	3.48E-08
	H-3	12.3 y	3.73E+01
BLIP	O-15	2 m	5.77E+01
	H-3	12.3 y	7.46E-03
	Be-7	53 d	9.97E-06
	Ge-69	36 h	1.33E-04
	Rb-86	18.6 d	1.55E-05
Evaporator Facility	Co-56	79 d	1.94E-05
	Co-57	271 d	6.71E-05
	Co-58	71 d	4.07E-05
	Co-60	5.2 y	1.44E-06
	Cs-137	30 y	2.68E-06
	Ga-66	9.4 h	7.31E-05
	Mn-54	312 d	2.48E-06
	Rb-83	86 d	7.46E-05
	Zn-65	244 d	8.02E-05

Notes:
1. While other nuclides are released from the BMRR, none contribute more than 10% of the total public dose due to BMRR air emissions. See text for discussion.
2. Half-life abbreviations:
   m = minutes
   h = hours
   d = days
   y = years
3. 1 Ci = 3.7¥10[10] Bq.

to be used, and the calculated dose impact from the release. This evaluation is also used to assess the need for modifications to the environmental monitoring program. The following sections briefly describe the primary sources of radioactive air emissions from BNL.

3.3.1.1 Brookhaven Medical Research Reactor (BMRR)

The BMRR is fueled with enriched uranium, moderated and cooled by light water, and is operated intermittently at power levels up to 3 megawatts (MW) (thermal). To cool the neutron reflector surrounding the core of the BMRR reactor vessel, air from the interior of the containment building is used. When air is drawn through the reflector, it is exposed to a neutron field that causes the argon component of the air to become radioactive. This radioactive form is argon-41. It is a chemically inert gas with a short half-life of 1.8 hours ($t_{1/2}$ = 1.8 hours). After passage through the reflector, the air is routed through a roughing filter and a high efficiency particulate air (HEPA) filter to remove any particulate matter, and finally, a charcoal filter for the removal of radioiodines produced by the fissioning of fuel. Following the filter bank, the air is exhausted to a 150-foot stack adjacent to the reactor containment building.

3.3.1.2 High Flux Beam Reactor (HFBR)

The HFBR is a small research reactor capable of operating at power levels ranging from 30 to 60 MW. Heavy water is used to cool the reactor fuel and moderate neutrons used in the fission process. (Heavy water, or D_2O, is water that is composed of a nonradioactive isotope of hydrogen known as deuterium.) Heavy water flowing in the reactor core is exposed to a dense neutron field which activates the deuterium atoms in the water to produce tritium, which is the heaviest and only radioactive isotope of hydrogen ($t_{1/2}$ = 12.3 years). The rate at which the tritium concentration builds in the primary cooling water is dependent upon the reactor power level and the amount of time elapsed since the last reactor shutdown or coolant change out. This, in turn, determines the amount of tritium that may eventually be released as an airborne emission. The primary mechanism by which tritium is transferred from the interior coolant system to the building atmosphere is depressurization of the reactor vessel and evaporative losses during maintenance and refueling operations. Diffusion at valve seals and other fittings also occurs. Tritiated water vapor (abbreviated "HTO") is thus released from reactor systems to building air where it is routed to the facility's 320-foot stack.

The HFBR was placed in a standby mode in January 1997, following the discovery of an underground plume of tritium emanating from the spent fuel storage pool. This pool was drained in 1998 to prevent additional leakage as well as to facilitate repairs. Although the HFBR has not operated since, the reactor vessel remains filled with D_2O containing significant amounts of tritium. This tritium is still a source of radioactivity that may be released to the atmosphere via the mechanisms described above. In November 1999, the U.S. Department of Energy (DOE) announced their decision that the HFBR would not restart, but instead would be decontaminated and decommissioned.

3.3.1.3 Brookhaven LINAC Isotope Producer (BLIP)

Protons from the LINAC are sent via an underground beam tunnel to the BLIP where they strike various target metals. These metals, which become activated by the proton beam, are then transferred to the Building 801 Target Processing Laboratory (see section 3.3.1.5) for later use in radiopharmaceutical production. The targets are cooled by a continuously recirculating water system. During irradiation, several radioisotopes are produced in the cooling water; the most significant of which is gaseous oxygen-15, a radionuclide with a very short half-life ($t_{1/2}$ = 123 seconds). This isotope is released as an airborne emission. Other radionuclides such as tritium and germanium-69 are released in much smaller quantities.

3.3.1.4 Evaporator Facility

Liquid waste generated onsite that contains residual radioactive material is processed at the Building 811 Waste Concentration Facility (WCF). At the WCF, suspended solids and a high percentage of radionuclides are removed from the liquid using a reverse osmosis process. However, because of its chemical properties, tritium is not removed during this process. The tritiated water which remains following waste concentration is delivered to the Evaporator Facility where it is converted to steam and released as an airborne emission. The emission is directed to the same stack used by the HFBR for building air exhaust. Since the waste concentration process does not remove all other radionuclides with complete efficiency, radionuclides other than tritium are released at much lower activity levels (see Table 3-1).

3.3.1.5 Building 801 Target Processing Laboratory

Target metals that have been irradiated at the BLIP facility are transported to the Building 801 Target Processing Laboratory, where the useful isotopes are chemically extracted. Airborne radionuclides released during the extraction process are drawn through multi-stage HEPA and charcoal filters and then vented to the HFBR stack (see Table 3-1 for isotopes and quantities). Radionuclide quantities released from this facility annually are small, typically in the microcurie to millicurie range. Isotopes released to the atmosphere from Building 801 operations are not significant contributors to the site perimeter dose via the airborne pathway (less than one percent).

3.3.1.6 Linear Accelerator (LINAC)

The LINAC produces beams of polarized protons of energies up to 200 MeV for use at both the Alternating Gradient Synchrotron (AGS) and BLIP facilities. Due to the composition of the beam and the energies involved, production of airborne radionuclides through air activation and/or spallation interactions is possible. The most significant production point of airborne radionuclides inside the tunnel occurs where the beam crosses an air gap as it enters the BLIP vacuum system. These radioactive products are available for atmospheric release via the tunnel ventilation exhaust stack, located adjacent to the BLIP building. Radionuclides detected during sampling in 1998 include carbon-11 ($t_{1/2}$ = 20 minutes), nitrogen-13 ($t_{1/2}$ = 10 minutes), sulfur-38 ($t_{1/2}$ = 3 hours), chlorine-38 ($t_{1/2}$ = 37 minutes), and chlorine-39 ($t_{1/2}$ = 55 minutes). The total annual release of each isotope is no more than a few microcuries.

3.3.1.7 Alternating Gradient Synchrotron (AGS) Cooling Tower #2

Magnets used to steer the AGS particle beam experience significant heating and are cooled via a recirculating, non-contact water loop. Under certain conditions such as high energy proton operations, low concentrations of radioactive elements may be produced in the cooling water when it circulates in the vicinity of the beam line. Radioisotopes that exist as gases may be liberated from the water when exposed to air during circulation in the outdoor cooling tower. These gaseous isotopes can constitute an airborne emission. The radionuclides that are likely to be released via this mechanism include oxygen-14 ($t_{1/2}$ = 1.2 minutes), oxygen-15 ($t_{1/2}$ = 2.1 minutes), nitrogen-13, and carbon-11. Tritium is also present and may be emitted from the tower as water vapor in microcurie (megabecquerel) quantities per year. Modeling using CAP88-PC indicates that the typical annual dose to the MEI from this source is approximately 0.00002 mrem. Note that this cooling tower is only an airborne radionuclide emission source during those times when the AGS C-line is in use. Cooling Tower #2 does not service any other beam lines.

3.3.1.8 Additional Minor Sources

There are several research organizations within BNL conducting work that involves very small quantities of radioactive materials (in the microcurie to millicurie [or megabecquerel] range). This material is typically used within fume hoods designated for use with radioactive materials. Operations such as transferring material between containers, pipetting, and chemical compound labeling are typical of the work conducted with these sources. Due to the use of filters, the nature of the work conducted, and the small quantities involved, these operations have a very low potential for atmospheric release of any environmentally-significant quantity of radioactive material. Facilities characterized as minor sources include Buildings 463 (Biology), 555 (Chemistry), 318 (Dept. of Applied Science), 490 (Medical Research Center), 490A (Dept. of Applied Science), 703W (Dept. of Advanced Technology), and 830 (Environmental and Waste Management Group).

3.3.2 Airborne Emissions – Nonradioactive

Several state and federal regulations covering nonradioactive releases require facilities to conduct periodic or continuous emissions monitoring in order to demonstrate compliance with emission limits. BNL has several emission sources subject to state and/or federal regulatory requirements that do not require emissions monitoring. The Central Steam Facility (CSF) is the only BNL facility that is required to perform nonradioactive emissions monitoring. The CSF supplies steam for heating and cooling to all major facilities through the underground steam distribution and condensate grid. The location of the CSF is shown in Figure 3-2. The combustion units at the CSF emit nitrogen oxides, sulfur oxides, carbon oxides, and particulate matter.

3.3.3 Liquid Effluents

BNL's State Pollutant Discharge Elimination System (SPDES) permit provides the basis for regulating wastewater effluents at BNL. The SPDES permit establishes release concentration limits and dictates monitoring requirements.

The BNL SPDES permit was issued in 1995. This permit stipulates monitoring requirements and lists effluent limits for the following outfalls:

- Outfall 001 is the discharge of treated effluent from the BNL Sewage Treatment Plant (STP) to the Peconic River.
- Outfalls 002 – 006, 008 and 010 are recharge basins used for the discharge of cooling tower blowdown, once-through cooling water, and stormwater.
- Outfall 007 is backwash water from the Water Treatment Plant (WTP) filter building.

Note: Outfall 009 consists of numerous subsurface and surface wastewater disposal systems that receive predominantly sanitary waste, and steam and air compressor discharges. The SPDES permit does not require effluent monitoring of Outfall 009.

3.3.3.1 BNL Sewage Treatment Plant (STP) Outfall 001

Sanitary and process wastewaters generated by Laboratory operations are conveyed to the BNL STP for subsequent treatment prior to discharge to the Peconic River. In 1997, the STP underwent significant construction modifications and was upgraded from a primary plant (i.e., separation of settleable solids and floatables) to a tertiary treatment system (i.e., biological reduction of organic matter and reduction of nitrogen). This treatment process became fully functional in 1998.

The STP, shown in Figure 2-6, has a design capacity of 3.0 million gallons per day and receives sanitary and certain process wastewaters from BNL facilities for treatment prior to discharge into the Peconic River.

3.3.3.2 BNL Recharge Basins and Stormwater Outfalls 002 through 008 and 010

Figure 3-3 depicts the locations of BNL's recharge basins and stormwater outfalls.

- Recharge Basins HN (Outfall 002) and HT (Outfall 006) receive once-through cooling water discharges generated at the AGS as well as cooling tower blowdown and stormwater runoff.

- Recharge Basin HS (Outfall 005) receives predominantly stormwater runoff and minimal cooling tower blowdown from the National Synchrotron Light Source (NSLS).

- Basin HX (Outfall 007) receives WTP filter backwash water.

- Basin HP (Outfall 004) receives once-through cooling water from the BMRR.

- Recharge Basin HO (Outfall 003) receives cooling water and cooling tower discharges from the AGS and HFBR, and stormwater runoff. The HFBR secondary cooling system water recirculates through mechanical cooling towers and is treated with inorganic polyphosphate and tolytriazole to control corrosion and deposition of solids. The blowdown from this system, combined with once-through cooling water used at the Cold Neutron Facility and the Cyclotrons, is also discharged to the HO Basin.

- In addition, several other recharge areas are used exclusively for discharging stormwater runoff. These include Basin HW (Outfall 008) and the CSF stormwater outlet (Outfall 010).

3.3.3.3 Assessments of Process-Specific Wastewater

Wastewater that may potentially contain constituents above SPDES permit limits or groundwater discharge standards is held and characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate limit, and the wastewater released only if the discharge would not jeopardize the quality of the effluent.

Examples of process specific wastewater requiring routine characterization are discharges resulting from the photographic developing operations in Building 197B (Graphic Arts), the printed circuit board fabrication operations conducted in Building 535B (Instrumentation Division), the metal cleaning operations in Building 498 (Central Cleaning Facility), cooling tower discharges from Building 902 (Superconducting Magnet Division), and miscellaneous satellite boiler blowdown. These operations are potential sources of contaminants such as inorganic elements (i.e., metals), cyanide, and volatile and semivolatile organic compounds.

Process wastewaters that are not routinely monitored under the SPDES permit are held for characterization before release to the sewer. Wastewaters routinely evaluated are ion-exchange column regeneration wastes, primary closed-loop cooling water systems, and other industrial wastewaters. To determine the appropriate disposal method, samples are analyzed for contaminants specific to the process.

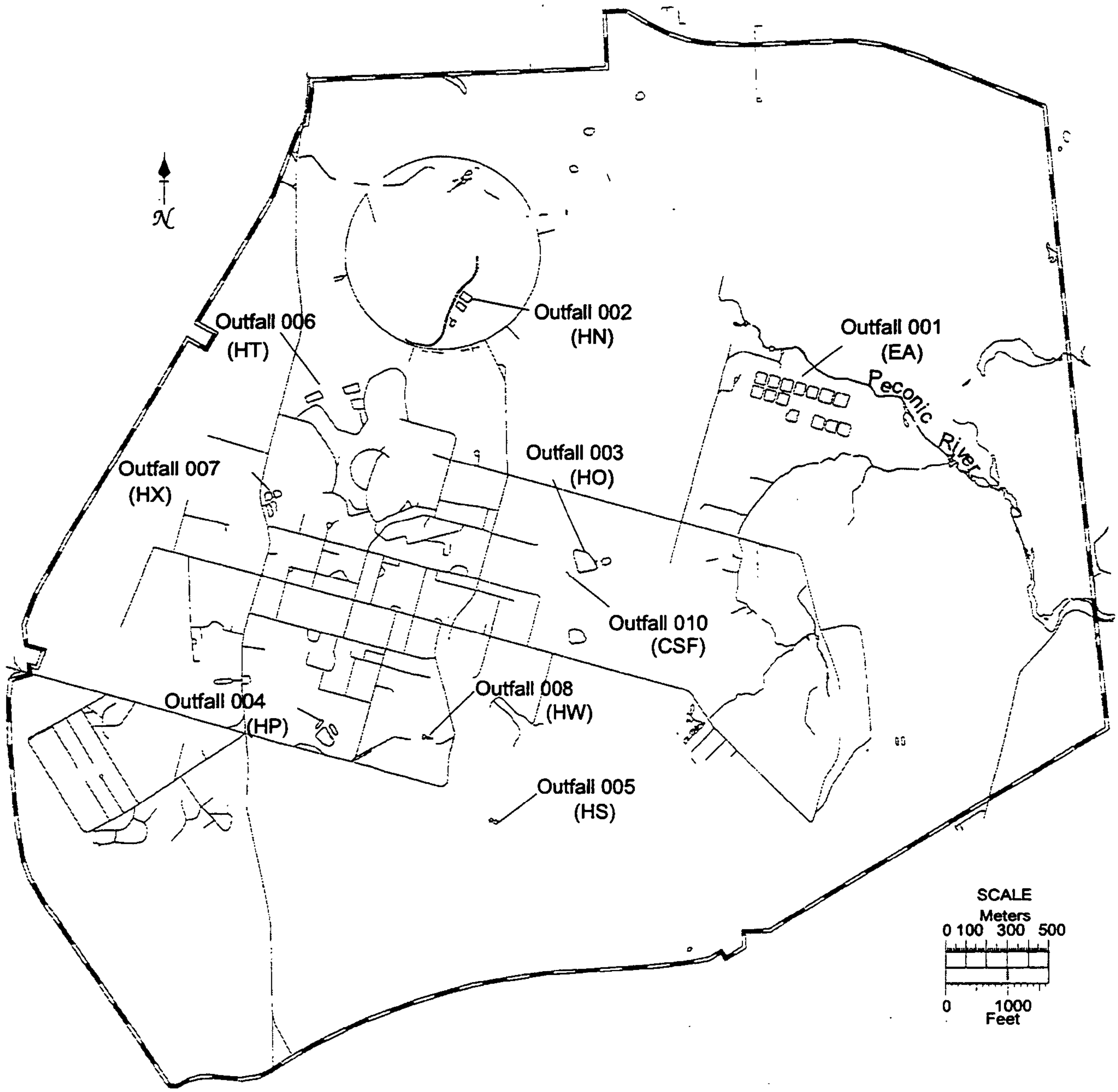

Figure 3-3. BNL Outfall Map with H Locations

In all instances, any waste that contains hazardous levels of contaminants or elevated radiological contamination is sent to the waste management program for disposal.

3.4 Environmental Restoration (ER) Program Monitoring

In 1980, the U.S. Congress enacted the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, also known as Superfund) to ensure that sites with historical contamination were cleaned up and to hold the responsible party liable for the cleanup. CERCLA established the National Priorities List (also known as the NPL). The NPL is a list of sites nationwide where cleanup of past contamination is required. In November 1989, BNL was included as one of a number of sites on the NPL located on Long Island. Much of the contamination at BNL is due to past accidental spills and practices for handling chemical and radiological material storage and disposal.

Since its establishment in 1991, BNL's ER program has been characterizing and removing sources of contamination (e.g., underground tanks and pools) or treating the groundwater and soil contamination resulting from past BNL practices. ER groundwater cleanup efforts have included monitoring of existing groundwater wells, overseeing the installation of new, permanent groundwater monitoring wells, installing groundwater treatment systems, and extension of public water service. Soil cleanup efforts have identified contaminated soils through sampling and resulted in various programs involving soil removal and treatment. Several landfills have been capped, and 55 waste pits have been excavated.

ER used historical facility records and sampling to determine where contamination might be present on the site today. These areas were geographically grouped into Operable Units (OU) (See *Areas of Concern at BNL, Upton, New York. A Reference Handbook.* June 1998).

Many remediation techniques can result in temporary increases in contaminant effluents or emissions and require monitoring to assure the potential impacts are minimized. The BNL environmental monitoring program supports ER activities by selecting monitoring locations and sampling media designed to assist in evaluating the impact of restoration activities on the environment and public health.

3.5 References

40 CFR 61, Subpart H. 1999. U.S. Environmental Protection Agency. "National Emissions Standards for Hazardous Air Pollutants, Subpart H, National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities." *U.S. Code of Federal Regulations.*

Areas of Concern at BNL, Upton, New York. A Reference Handbook. Brookhaven National Laboratory, Upton, New York. June 1998.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended, Public Law 96-510, 94 Stat. 2767, 42 USC 9601 et seq.

State Pollutant Discharge Elimination System (SPDES) Permit No. NY005835. Issued by the New York State Department of Environmental Conservation, 1995.
1995.

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4 AIR EMISSIONS MONITORING

4.1 Introduction

A monitoring method for evaluating environmental impacts from Brookhaven National Laboratory's (BNL) air emissions is the measurement of pollutants at their point of emission. BNL performs continuous air emission sampling of atmospheric discharge points at several facilities in compliance with U.S. Department of Energy (DOE) requirements, federal and state laws and regulations, and industry standards. The BNL air emissions monitoring program complements the environmental air surveillance monitoring effort (see Chapter 5, "Air Surveillance Monitoring"). Together, these monitoring activities can confirm or discount specific source locations as contributors to any release that environmental surveillance monitoring might detect.

4.2 Rationale and Design Criteria

4.2.1 Drivers

DOE Orders 5400.1 [1988], *General Environmental Protection Program*, and 5400.5 [1990], *Radiation Protection of the Public and the Environment*, define standards for controlling exposures to the public from operations at DOE facilities. The "National Emissions Standards for Hazardous Air Pollutants" (NESHAP) [40 CFR 61, Subpart H], a regulation promulgated under the Clean Air Act (CAA), requires the continuous monitoring of radiological discharges and the estimation of radiological dose to the public resulting from operations at DOE facilities. Guidance on air emission sampling is provided in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* [DOE/EH-0173T 1991], "Standards of Performance for New Stationary Sources" [40 CFR 60], and NESHAP-cited American National Standards Institute (ANSI) standards [ANSI N13.1 1999].

4.2.2 Monitoring Objectives

The primary purpose of BNL's air emissions monitoring program is to measure radiological emissions at the point of release. In doing so, BNL can demonstrate compliance with regulatory requirements and ensure protection of the public and the environment. In addition, sampling provides confirmation of the effectiveness of facility emission control systems.

4.2.3 Potential Sources and Contaminants

Sources and pathways are described in Chapter 3, "Emission/Effluent Sources and Pathways."

4.3 Extent and Frequency of Monitoring

4.3.1 Radioactive Emissions

Federal air quality laws and DOE regulations governing the release of airborne radioactive material include NESHAP and DOE Orders 5400.1 and 5400.5. Under NESHAP, facilities whose emissions have the potential to deliver a radiation dose to a member of the public of greater than 0.1 mrem/yr must be continuously monitored. Facilities with emissions that fall below this value require only periodic, confirmatory monitoring. Figure 3-3 indicates the location of monitored facilities within the BNL site.

The most significant contributors to radioactive air emissions from the BNL site are the Brookhaven Medical Research Reactor (BMRR), the High Flux Beam Reactor (HFBR), and the Brookhaven LINAC Isotope Producer (BLIP). Releases of gaseous argon-41 from the Medical Research Reactor typically account for over 95 percent of total radioactivity released annually. The following sections describe the emissions monitoring activities for each of BNL's monitored facilities.

4.3.1.1 Brookhaven Medical Research Reactor (BMRR)

A real-time monitor is in place to track argon-41 air emissions, while passive filter media are used to collect and quantify radioiodines and particulates. Because non-argon radionuclide concentrations in the air emissions are of a much lower concentration and total activity, they contribute less than 10 percent of the total potential public dose resulting from the BMRR's air emissions. In accordance with NESHAP requirements, these nuclides are sampled only on a periodic basis to confirm that their concentrations remain consistent with expected levels. The BMRR generates the largest quantity of airborne radioactive effluent released from the BNL site with argon-41 consistently contributing the greatest fraction of all radionuclide activity released.

The argon-41 emission rate has been calculated by direct measurement of the stack effluent using gamma spectroscopy analysis, and more recently confirmed by the in-line monitoring system. The emission rate is approximately 2 curies (Ci) of argon-41 released for every Megawatt-hour (MW-hr) of reactor operation (2Ci/MW-hr). Approximately 2,000 Ci of argon-41 are released annually from this facility, resulting in offsite doses of about 0.1 mrem to the maximally exposed individual (MEI).

Because the BMRR has the capacity to release airborne radionuclides in quantities sufficient to cause greater than 0.1 mrem annually, it must have continuous monitoring equipment in place. The effluent monitoring system is comprised of the following components: a plastic beta scintillator for noble gas quantification, particulate and iodine sampling media (particulate filter and charcoal cartridge), and an ANSI N13.1-compliant rake-probe flow monitor system.

Small amounts of fission and activation gases are produced in the primary tank of the reactor, which is also vented to the stack. The release of radioactive particulates and radioiodines is limited to negligible quantities by the inclusion of high efficiency particulate air (HEPA) and charcoal filters in the effluent stream.

4.3.1.2 High Flux Beam Reactor (HFBR)

Current HFBR effluent monitoring consists of weekly sample collections from continuously operating sampling devices for tritiated water vapor (HTO) (via silica gel), particulate (via 0.3 microns filter paper), and radioiodine (via triethylene diamine [TEDA] charcoal).

Upgrades to the stack monitoring facility took place in 1993 with the installation of the Sampler, Particulate, Iodine, and Noble Gas monitoring system (Eberline Model SPING-3AS) in the facility effluent stream. The design is appropriate for the facility effluent and is in accordance with the design criteria of DOE/EH-0173T. This upgrade was necessary to bring the HFBR into compliance with the accident monitoring components of current DOE regulations and those of the foreseeable future.

Starting at the SPING sample inlet, sample gas is routed through a three-chambered sampling assembly where it passes through filter paper, on which any particulates are deposited, then through a charcoal cartridge which traps iodines, and then into a gas chamber for low- and medium-activity range noble gas measurement. It then passes into a high-activity range noble gas chamber, then through a solid-state flow sensor. The particulate filter is monitored by a beta scintillation detector on one side and a solid state alpha detector on the other. The iodine cartridge is monitored by a 2" x 2" NaI(Tl) gamma scintillation detector. The gas chamber is monitored by a beta scintillation detector for low-range noble gas measurement, and energy-compensated Geiger-Muller detectors for the medium and high range measurements. In conjunction with the SPING unit, a Kurz Series 4200 Isokinetic Sampling System utilizing mass flow metering is in place to provide continuous, automatic effluent flow measurement.

4.3.1.3 Brookhaven LINAC Isotope Producer (BLIP)

The air emissions from the BLIP pass through a HEPA filtration system. Air emissions are monitored by fixed, continuously operating sampling devices: silica gel to sample tritiated water vapor, a particulate matter filter (0.3 microns) for analysis of gamma-emitting radionuclides, and a TEDA-loaded charcoal cartridge for radioiodine detection. Emissions of radioactive gases, such as oxygen-15, are estimated by the number of machine micro-ampere-hours and a measured activity conversion factor (mCi/micro-ampere-hrs).

4.3.1.4 Evaporator Facility

The evaporator emissions are not actively monitored and are directed to the same stack used by the HFBR for building air exhaust. These emissions are conservatively estimated based on facility inventory records using U.S. Environmental Protection Agency (EPA) approved methodology. All liquids sent to the Evaporator Facility are sampled and analyzed prior to delivery to determine actual radionuclide concentrations.

4.3.1.5 Building 801 Target Processing Laboratory

The Building 801 Hot Laboratory includes five semi-hot cells, three chemical processing hot cells, and three high-level hot cells for the handling and processing of radioactive materials. Each is provided with individual exhaust air filters as well as a backup filter preceding discharge to a common duct leading to the HFBR stack. Airborne radioactive effluents are generated as a result of hood work involving the processing of BLIP targets for the recovery of radioisotopes used by medical health practitioners. The Hot Laboratory effluent pathway is monitored by a particulate filter system for gross beta activity measurements and by a charcoal cartridge for radioiodines.

4.3.1.6 Additional Minor Sources

Additional minor sources are described in Chapter 3, Section 3.3.1.8.

4.3.2 Nonradioactive Emissions

The Central Steam Facility (CSF) supplies steam for heating and cooling to all major facilities through the underground steam distribution and condensate grid. The combustion units at the CSF are designated as Boiler numbers 1A, 5, 6, and 7. Boiler 1A, which was installed in 1962, has a heat input of 16.4 MW (56.7 MMBtu/hr). Boiler 5 was installed in 1965 and has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers 6 and 7, were installed in 1984 and 1996, respectively. Both of these boilers have heat inputs of 42.6 MW (147 MMBtu/hr).

Because of their design heat inputs and dates of installation, Boilers 6 and 7 are subject to Title 6, Subpart 227-2 of the New York Code of Rules and Regulations [6 NYCRR Subpart 227-2], and the "Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units" [40 CFR 60, Subpart Db]. As such, these boilers are equipped with continuous emissions monitors (CEM) for nitrogen oxides (NO_x). Boiler 7 emissions are also continuously monitored for opacity in accordance with Subpart Db requirements. All four boilers are monitored for oxygen and carbon dioxide. Emissions from these boilers are reported on a quarterly basis to the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation (NYSDEC).

In the spring of 1997, the Long Island Lighting Company completed work to extend a natural gas main into the CSF. To accommodate the combustion of natural gas, new gas rings were added to the burners of Boiler 5, and natural gas trains were installed to connect the gas main to Boilers 5 and 7. Plans to upgrade Boiler 6, which included the replacement of the existing steam atomized oil burners with two Peabody-Hamworthy duel-fuel low NO_x burners and the addition of a natural gas train connection to the gas main, were completed in early 1998. After shakedown testing of the new duel-fuel burners was completed in August, the CSF started burning natural gas in Boiler 6 for steam production.

Due to the increased use of natural gas in the facility, annual particulate, NO_x, and sulfur dioxide (SO_2) emissions at the CSF in 1998 declined by 11.0 tons, 8.5 tons, and 66.2 tons, respectively, from totals recorded in 1997. On an equivalent heat input basis, particulate emissions at the CSF dropped by 10.6 tons, NO_x emissions dropped by 6.2 tons, and SO_2 emissions fell by 64.2 tons.

4.4 Quality Assurance

BNL's quality assurance program is addressed in Chapter 12.

4.5 References

6 NYCRR Subpart 227-2. New York State Department of Environmental Conservation. "Reasonably Available Control Technology (RACT) for Oxides of Nitrogen (NO_x)." *New York Codes, Rules, ands Regulations.*

40 CFR 60. 1999. U.S. Environmental Protection Agency. "Standards of Performance for New Stationary Sources." *U.S. Code of Federal Regulations.*

40 CFR 60, Subpart Db. 1999. U.S. Environmental Protection Agency. "Standards of Performance for New Stationary Sources, Subpart Db, Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units." *U.S. Code of Federal Regulations.*

40 CFR 61, Subpart H. 1999. U.S. Environmental Protection Agency. "National Emissions Standards for Hazardous Air Pollutants, Subpart H, National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities." *U.S. Code of Federal Regulations.*

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DOE Order 5400.5. 1990. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Washington, D.C.

DOE/EH-0173T. 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.* U.S. Department of Energy, Washington, D.C.

5 AIR SURVEILLANCE MONITORING

5.1 Introduction

Air can be a primary exposure pathway for human and ecological impact. To reduce, control, and eliminate air pollutants from its operations, Brookhaven National Laboratory (BNL) employs various engineering and administrative controls. In compliance with environmental requirements, BNL conducts both air surveillance and facility air emission monitoring to assess the adequacy of these controls and to determine the impact, if any, of its air pollutants on the environment. Facility emission monitoring and air surveillance monitoring are complementary in assessing potential human health and environmental impacts.

Air surveillance monitoring involves the analysis of particulate matter collected on filters, as well as vapor chemically trapped in a collection medium. Concentrations of various airborne radionuclides (including particulates and tritiated water vapor) are measured on the BNL site and at offsite locations on eastern Long Island. Specific diffuse, or non-point sources, arising due to environmental restoration activities, are also monitored as needed.

5.2 Rationale and Design Criteria

5.2.1 Drivers

BNL's air surveillance monitoring is governed by the Clean Air Act (CAA). The fundamental objective of the CAA is to protect human health and the environment from air pollution, and enables the U.S. Environmental Protection Agency (EPA) to define and establish standards for criteria for air pollutants that are of major concern to the environment. These pollutants and the National Primary and Secondary Ambient Air Quality Standards (NAAQS) are defined in 40 CFR 50. In 1990, Section 112 of the CAA, the National Emission Standards for Hazardous Air Pollutants (NESHAP) [40 CFR 61], was amended by Title III. Title III lists 189 hazardous air pollutants (HAPs; of which "radionuclides" are counted as one), calls for emission reductions of air toxics, and imposes new standards on both new and existing sources. While standards have not yet been set for many HAPs, a dose limit has been established for radionuclides.

The U.S. EPA has established a radiation dose standard for all radiological air emissions of 10 mrem/yr (millirem per year) effective dose equivalent (EDE) for members of the public [40 CFR 61, Subpart H]. This dose standard is based on emissions that can contribute to human radiation doses via all pathways once released to the air. Facility air emission monitoring and air surveillance monitoring can provide the actual source terms for modeling to ensure that the NESHAP standard is not exceeded.

U.S. Department of Energy (DOE) Order 5400.5 [1990], *Radiation Protection of the Public and the Environment*, establishes a primary radiation protection standard for members of the public at 100 mrem/yr EDE for prolonged exposure from all sources, including air emissions. For air, Derived Concentration Guides (DCGs) listed in the Order specify the concentrations of radionuclides that can be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public. DOE Order 5400.5 also states that DOE facilities should have the capabilities, consistent with the types of operations conducted, to monitor routine and nonroutine releases and to assess doses to members of the public.

DOE Order 5400.1, *General Environmental Protection Program* [1988], defines standards for controlling exposures to the public from operations at DOE facilities. Guidance on air surveillance monitoring is also provided in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* [DOE/EH-0173T 1991].

5.2.2 Monitoring Objectives

According to DOE Order 5400.1, environmental surveillance shall be conducted to monitor the effects, if any, of DOE activities on environmental and natural resources both onsite and offsite. This order states that an air monitoring environmental surveillance program at a DOE facility should have the following objectives:

- Establish background concentration levels of pertinent chemical species,
- Determine the highest concentrations of the pertinent pollutant species expected to occur in the vicinity of DOE operations,
- Determine representative pollutant concentrations at areas where public health and other concerns should be considered, and
- Evaluate the effects of emissions on ambient levels of pertinent contaminants.

In addition, DOE/EH-0173T states it is a DOE objective that all its operations properly and accurately measure radionuclides in their emissions and in ambient environmental media. This guidance document also specifies that the surveillance program should characterize the radiological conditions of the offsite environment, estimate public doses, confirm predictions of public dose based on effluent monitoring data and modeling, and provide compliance data for all applicable environmental regulations. It also states that surveillance may be necessary for legal reasons, public concerns, and state and local commitments; and that "provisions should be made for the detection and quantification of unplanned releases of radionuclides to the environment."

The objectives of BNL's air surveillance activities are as follows:

- Obtain air concentration measurements at locations of actual and potential public residence to verify that doses to the public through the air pathway from DOE operations remain low relative to standards,
- Provide early detection of potential increases in public exposures and contamination of the environment through measurements of actual and potential emissions to the air from facilities and areas with surface contamination and buried wastes,
- Obtain pre-operational baseline data and environmental surveillance data for areas near waste units scheduled for treatment and/or restoration to assess the integrated effects of individual site actions and over time,
- Obtain measurements at the site perimeter and in nearby communities to provide public assurance that the degree of contamination from DOE operations is known,
- Sample air onsite and offsite continuously to assess the environmental effects and doses from unusual releases, and
- Provide data to evaluate and improve pathway models used to predict and assess public dose compliance and environmental contamination.

5.2.3 Potential Sources and Contaminants

Potential sources and contaminants are described in Chapter 3, "Emission/Effluent Sources and Pathways."

5.2.4 Collection Methods and Procedures

Environmental air surveillance samples are collected in accordance with standard operating procedures EM-SOP-500, *Air Sampling at Permanent Monitoring Stations* [BNL 1999a], and EM-SOP-501, *Tritium Air Sampling at Portable Stations* [BNL 1999b]. The particulate matter sampling media consists of a 5-centimeter (cm)-diameter glass fiber air filter followed by a 51.5-cm^3 canister of triethylene diamine (TEDA)-impregnated charcoal for collecting radiohalogens. Samples are collected weekly and counted for gross alpha and gross beta radiation using an anticoincidence proportional counter. Analyses for gamma-emitting nuclides are performed monthly on composites of weekly filter papers and on charcoal filter bed samples that have a sample period of one month. Tritium water vapor suspended in the air is sampled weekly by drawing a stream of air through silica gel cartridges. After collection, the entrapped liquid is extracted from the desiccant and analyzed for tritium using liquid scintillation techniques. In all cases, flow rates, media volumes, and exposure periods are such that the media are not likely to be saturated during the sampling period and high collection efficiencies are achieved in accordance with the manufacturer's recommendations.

5.3 Extent and Frequency of Monitoring

Downwind of each operating area with significant inventories of nuclear materials, an air sampler is located based on considerations of predominant wind directions at the site and the location of population centers at and surrounding BNL (considering access, power availability, and costs).

Figure 5-1 depicts the array of monitoring stations in place around the BNL site designed to collect air samples to determine radiological air quality. At each of the six stations located within dedicated blockhouses, glass fiber filter paper is used to capture airborne particulate matter, charcoal cartridges are used to collect potential radioiodines, and silica gel tubes are used to collect water vapor for tritium analysis (with the exception of Station S5 which does not contain a tritium sampler).

In addition to the blockhouses, 21 pole-mounted, battery-powered silica gel samplers are distributed throughout the site, primarily along the site boundary and near sources of tritium emissions, to measure ambient tritium concentrations. Tritiated water vapor (HTO) is collected by using a pump that draws air through a column of silica gel, a water-absorbent medium which retains moisture. The absorbed water is recovered in the BNL Analytical Services Laboratory (ASL) and analyzed using liquid scintillation counting techniques.

Filter paper is collected weekly and analyzed for gross alpha and beta activity using a gas-flow proportional counter. Silica gel samples are also collected weekly and processed for liquid scintillation analysis. Charcoal cartridges are collected monthly and analyzed by gamma spectroscopy.

In addition to these samples, the New York State Department of Health (NYSDOH) receives duplicate filter samples which are collected at Station P7, located at the southeast boundary. These samples are also collected on a weekly basis and are analyzed by an independent NYSDOH Laboratory. Analytical results are comparable to those collected by BNL and are reported annually in a document titled *Environmental Radiation Levels in New York State*.

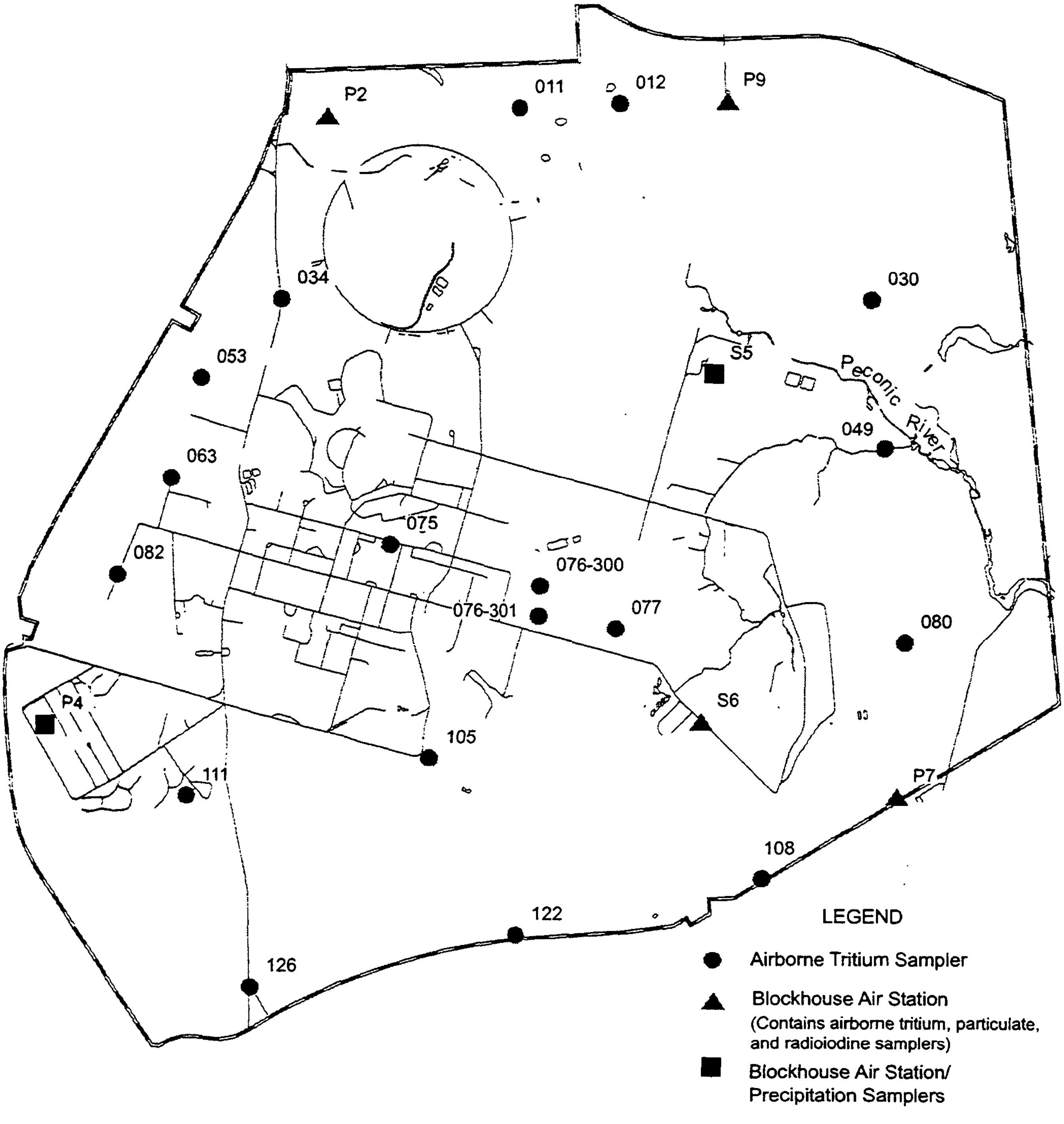

Figure 5-1. Air Monitoring Stations

As part of a state-wide monitoring program, the NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions. The NYSDOH reports that typical airborne gross beta activity at that location varies between 0.005 and 0.025 pCi/m^3 ([picocuries per cubic meter], or 0.2 to 0.9 mBq/m^3 [millibequerel per cubic meter]) [NYSDOH 1993]. Sample results measured at BNL fall well within this range, demonstrating that onsite radiological air quality is consistent with that observed at New York locations not located near radiological facilities.

In 1997, an interim pump-and-recharge system was constructed to control the leading edge of the plume of tritium associated with the leakage of the spent fuel storage pool at the High Flux Beam Reactor (HFBR). Three extraction wells are used to pump groundwater containing both tritium and volatile organic compounds (VOCs) from approximately 150 feet below ground surface to carbon filtration units and ultimately to the Removal Action (RA) V recharge basin located 3,000 feet to the north of the plume edge. Airborne HTO monitoring in the vicinity of the RA V recharge basin continued in 1998. Two monitors are installed immediately adjacent to the basin at the northeast and southeast corners, the downwind directions of the predominant winds on site (see Figure 2-8, Annual Wind Rose for 1998). An additional monitoring station was placed near the National Weather Service building, approximately 0.2 miles to the east of the basin.

5.4 Analytical Procedures and Quality Assurance

5.4.1 Data Quality Objectives

Analytical methods are selected to meet the minimum detection levels equivalent to a dose of 1 mrem under conditions of continuous exposure for one year. An additional goal is to achieve the lowest detection levels available using standard state-of-the-art analytical methods.

5.4.2 Data Management

Environmental monitoring samples are collected according to documented procedures. Each environmental sample is identified with a unique number and accompanied by a Chain-of-Custody form. The sampling data are entered into the environmental monitoring database, and the sample collection forms are filed for future reference. The analytical data generated in the environmental monitoring program is maintained in the database and can be retrieved and evaluated in an interactive fashion.

5.4.3 Data Analysis

Air surveillance data are analyzed with the intent of satisfying the following goals:

- Estimation of concentrations at each sampling point,
- Comparison of current concentrations to previous concentrations in order to identify changes or inconsistencies,
- Comparison of concentrations to established DCGs or permit limits, and
- Comparison of concentrations at a single location, or a group of locations, to control or background locations; and evaluation of the reliability of the comparisons.

BNL's data analysis practices are consistent with the guidance provided in the *Handbook of Radioactivity Measurements Procedures* [NCRP 1985] and DOE/EH-0173T.

5.5 References

40 CFR 50. 1999. U.S. Environmental Protection Agency. "National Primary and Secondary Ambient Air Quality Standards." *U.S. Code of Federal Regulations.*

40 CFR 61. 1999. U.S. Environmental Protection Agency. "National Emission Standards for Hazardous Air Pollutants." *U.S. Code of Federal Regulations.*

40 CFR 61, Subpart H. 1999. U.S. Environmental Protection Agency. "National Emissions Standards for Hazardous Air Pollutants, Subpart H, National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities." *U.S. Code of Federal Regulations.*

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6 LIQUID EFFLUENT MONITORING

6.1 Introduction

Wastewater effluents are routinely generated as a result of Brookhaven National Laboratory's (BNL) operations and research activities. These effluents consist of sanitary discharges (i.e., kitchen and bathroom wastes), stormwater runoff, research laboratory wastewater, and process wastewater. Eventually, each effluent is discharged to the environment either as a direct discharge to groundwater or as an indirect discharge to the Peconic River via the Sewage Treatment Plant (STP). Wastewater discharges to the environment have the potential to impact surface water bodies, aquatic and terrestrial organisms, groundwater, and eventually public health either via direct ingestion of groundwater, secondary contact through recreational activities, or via ingestion of aquatic or terrestrial organisms. To ensure that these discharges comply with regulatory requirements and pose minimal environmental impact, they are monitored on a periodic basis. This chapter provides a full description of this monitoring program and also discusses the rationale for siting sample collection locations and specification of analytical parameters.

In addition to monitoring liquid effluents at the point of release to the environment, several processes that generate and discharge wastewater routinely to the sewage treatment plant are monitored at the source to ensure that the discharge does not compromise the quality of the STP effluent. These sources include photographic developing operations, metal cleaning, and plating facilities. The characteristics of these and other effluent sources, operational parameters, etc. are also discussed in this chapter to clarify the basis for the program design.

6.2 Rationale and Design Criteria

6.2.1 Drivers

The Federal Water Pollution Control Act establishes a national permitting program, specifies minimum treatment levels for sewage treatment plants, establishes pretreatment standards for indirect discharges of industrial wastes, and develops quality based water criteria. Wastewater discharges from BNL operations are subject to the Act. BNL maintains a State Pollutant Discharge Elimination System (SPDES) permit. This permit is issued by the New York State Department of Environmental Conservation (NYSDEC), which has been authorized to implement Clean Water Act (CWA) provisions under Part 750 of Title 6 of the New York State Codes, Rules, and Regulations [6 NYCRR Part 750]. The SPDES permit authorizes releases to the environment through thirteen designated outfalls and specifies monitoring requirements for each, including frequency of monitoring and specification of analytical requirements. Effluent limitations specified for each analytical parameter are based upon the receiving water classification and the corresponding water quality standards. Water quality standards have been pre-established for each water classification and are codified under 6 NYCRR Parts 700-705. A map depicting the locations of each of the monitoring stations is provided as Figure 3-3.

In addition to the federal and state water quality regulations, U.S. Department of Energy (DOE) Order 5400.1 [1988] requires that DOE sites not only comply with federal and state statutes and regulations, but also establish effluent monitoring and environmental surveillance programs. These programs ensure that DOE operations are conducted in a manner that minimizes impacts to the environment and public health, and anticipates and addresses potential environmental problems before causing adverse conditions.

The NYSDEC does not regulate radioactive effluents.

6.2.2 Monitoring Objectives

To ensure that wastewater effluents discharged to the environment pose minimal impact to surface waters and groundwater, as well as to the recipients of these water sources, a sampling and analysis program has been developed that evaluates concentrations of natural and BNL-contributed contaminants, and compares them to background levels and established water quality standards. This program has been designed to ensure:

- Compliance with regulatory permit monitoring requirements,
- Collection and analysis of samples is performed according to U.S. Environmental Protection Agency (EPA), state, or other regulatory agency standards or guidelines,
- Samples are representative of routine discharges and monitoring locations are appropriate,
- Analytical parameters are appropriate to the process generating the waste,
- Treatment systems remain efficient and effective, and
- The sampling and analysis program is well documented.

The effluent monitoring program relies on both real-time analysis of wastewater streams and collection and analysis of flow-proportional composite and grab samples.

Wastewater effluents discharged from BNL operations have the potential to affect fresh surface waters and groundwater resources. Groundwater on Long Island is the predominant source of potable water and has been designated as a Sole Source Aquifer under the Safe Drinking Water Act (SDWA). Consequently, wastewater discharge criteria and ambient water quality standards are based upon human health effects, assuming a drinking water pathway.

Surface waters on the BNL site are designated as "Class C Fresh Surface Water" by the NYSDEC [6NYCRR Parts 700-705]. Best usage of Class C surface waters are fish survival and propagation, and primary and secondary contact recreation (i.e., fishing and swimming). Wastewater discharge criteria are therefore based upon the effects of the contaminants contained in the effluent on the survival and reproduction of aquatic organisms. In many instances the water quality standards for protection of aquatic life are more stringent than human health standards; consequently discharges to Class C surface waters are more restrictive than discharges to groundwater. Due to the stringent nature of these limits, alternative limits for the BNL STP discharge have been approved by the NYSDEC under the condition that a toxicity evaluation program is established. This program uses fresh water organisms to assess the toxicity of the STP effluents to ensure that organisms residing in the Peconic River remain viable.

6.2.3 Data Quality Objectives

Wastewater effluents generated by, and ultimately discharged from, BNL operations interact with the environment. Direct discharges to the ground percolate to groundwater aquifers and have potential impacts to public health. Surface water discharges interact with aquatic and terrestrial organisms. To ensure these discharges have minimal impact on these receptors, the discharges are sampled and analyzed for chemical and radiological contaminants associated with BNL operations. The concentrations of these contaminants are then compared to pre-established effluent limits, ambient water quality standards, and/or background concentrations to assess impacts.

Data quality objectives for the liquid effluent monitoring program are derived largely by permit condition or regulatory guidance. The SPDES permit contains specific monitoring requirements including analytical method reference and effluent limitations. Identification of analytical parameters is based upon known BNL operations and processes, chemical inventories, and historical analysis of wastewater effluents. Effluent limitations directly influence the methodology detection limits and are directly related to pre-established water quality standards. Similarly, the effluent limits and ambient water quality standards are also the basis for the monitoring implemented under the environmental surveillance program. In the case of radiological parameters, the drinking water standard has been utilized as the comparative standard regardless of the potential pathway analysis of the effluent.

6.2.4 Identification of Sources and Contaminants

There are two major categories of liquid effluent managed at BNL. These are (1) direct discharges of stormwater runoff, cooling tower blowdown, and non-contact cooling water to recharge basins; and (2) indirect discharges of sanitary, process, and non-contact cooling wastewater to the Peconic River via the BNL STP. Wastewater streams that comprise each of these discharges are discussed in detail below. Subsurface disposal of liquid effluents via underground injection wells is conducted for remotely located sanitary systems (Relativistic Heavy Ion Collider [RHIC] and apartments) and for stormwater runoff. No industrial processes discharge to these systems. As these systems become obsolete, the subsurface drainage system is assessed for residual contamination and closed in accordance with an EPA-approved closure plan.

6.2.4.1 Sewage Treatment Plant (STP)

The STP receives the majority of the wastewater generated by site operations and treats these wastes prior to discharging them to the Peconic River. Approximately 600,000 gallons of wastewater per day are processed by the STP. The treatment process includes separation of heavy inert matter (sand, grit, and other inorganic matter), removal of floatables (e.g., oils), and aerobic treatment of the wastewater using a suspended-growth, activated-sludge process. The treated waste is then settled, filtered, and treated by ultraviolet disinfection prior to discharge to the Peconic River. Wastewater streams received at the Sewage Treatment Plant include: sanitary wastes (kitchen and bathroom wastes), process wastes (industrial cleaning operations, photographic developing rinse water, cooling tower blowdown, air conditioning and air compressor condensate, glassware cleaning wastewater, plating and metal cleaning rinse water, boiler blowdown, etc.), and non-contact cooling water used in experimental and mechanical systems. Radionuclides and chemical constituents are present in these wastewaters as a result of research facility operations, non-regulated releases associated with medical patients, and routine maintenance operations. Typical pollutants identified in the STP influent stream include acids and alkalis, phosphates, nitrogenous compounds, phenolics, biological wastes, volatile organic compounds (VOCs), inorganics (i.e., metals), tritium, and other naturally occurring and manmade radionuclides.

In addition to those contaminants released from routine operations, contaminants are also present in sludge residing in the building piping systems and in the main sewage collection piping that was deposited by former BNL operations. These contaminants slowly leach into the main wastewater stream and become a component of the STP discharge. Analysis of this sludge shows it to contain mercury and other inorganics, and cesium-137 and other radionuclides.

6.2.4.2 Recharge Basins

Wastewater effluents discharged to recharge basins and the ground surface percolate through the permeable surface soils and eventually recharge to groundwater. As groundwater on Long Island is the predominant source of potable water, direct discharges to it must be protective of public health.

Liquid effluents originating as non-contact cooling water, cooling tower blowdown, and stormwater runoff from the developed part of the site are discharged to the ground in eleven locations. These consist of six recharge basins and five areas of low ground elevation. Potential contaminants identified in these discharges include oils and grease from parking lot runoff, residual cooling tower treatment reagents (including algaecides, sequestrants, and other scale deposition control agents), and low level concentrations of radionuclides from direct cooling of experimental facilities and sediment runoff.

The Environmental Restoration (ER) program also relies upon recharge basins for the discharge of groundwater treated to remove environmental contaminants. The operation and monitoring of these systems are not discussed in this plan, but are addressed in the operations and maintenance plans for the Removal Action (RA) V High Flux Beam Reactor (HFBR) tritium plume remediation [BNL 1998] and the Operable Unit (OU) III southern boundary treatment systems [BNL 1997].

6.3 Extent and Frequency of Monitoring

6.3.1 Criteria for Selecting Sample Collection Locations

In accordance with SPDES permit requirements, liquid effluent samples are typically collected at the point of discharge to the environment. Consequently, monitoring stations have been located at each permitted outfall to facilitate sample collection. To ensure that these locations are truly representative, the stations are located downstream of all wastewater-contributing sources. These monitoring stations have been equipped with flow measurement and remote sampling devices.

The SPDES permit also specifies monitoring requirements for certain processes contributing wastewater to the STP. These processes include wastewater generated by photo-developing, metal cleaning, and printed circuit board fabrication operations. Again as prescribed by permit condition, these processes are sampled at the point of discharge from the process and prior to mixing with other wastewaters.

To achieve the DOE objective of anticipating releases, several real-time monitoring stations have been established at and upstream of the STP. These stations monitor pH, conductivity, and gross beta emissions in real-time, and continuously report to the STP operations laboratory located in Building 575.

6.3.2 Sampling Frequency

6.3.2.1 Compliance Monitoring

The sample collection frequency for the compliance monitoring program is dictated by regulatory permit conditions. Sample frequency varies from daily to quarterly and is analyte and location dependent. Table 6-1 (see p. 6-7), "Summary of Liquid Effluent Compliance Monitoring Program," provides the outfall designation, required and actual monitoring frequency, analytical parameters, and the reason behind monitoring for each.

6.3.2.2 Required versus Actual Compliance Monitoring

The BNL compliance monitoring program exceeds the minimum monitoring requirements specified by permit for several reasons. Since many parameters have both a daily average and daily maximum value, collection of a single sample is not truly representative of day-to-day variations in effluent concentrations. In addition to providing a more representative data set, by increasing the frequency of sampling a true average can be calculated and reported.

6.3.2.3 Surveillance Monitoring

Under the environmental surveillance program, wastewater effluent samples are collected and analyzed for pH, dissolved oxygen, conductivity, temperature, radioactivity, inorganics, and wet chemistry parameters. These analyses are performed to complement the compliance program by providing additional data and by filling analytical gaps not covered under permit requirements (e.g., radioactivity). Table 6-2 (see p. 6-13), "Summary of BNL Environmental Surveillance Program for Liquid Effluents," summarizes the environmental surveillance monitoring program.

6.4 Analytical Methodologies and Laboratory Procedures

Two types of laboratories are utilized for the analysis of liquid effluent samples. Samples collected and analyzed for compliance purposes are typically performed by contracted laboratories. Analysis of samples used for environmental surveillance purposes are performed by onsite laboratories. All contracted laboratories are fully certified by the New York State Department of Health (NYSDOH) for the analysis of wastewater samples.

In accordance with permit conditions and state regulations, analysis of liquid effluents used to document regulatory compliance is performed according to the standard methods of analysis as codified in 40 CFR 136 and/or EPA standard methods. Methodologies are matrix and parameter dependent. Procedures for the analysis of samples are maintained and documented by the analytical laboratory. The contracted laboratories participate in EPA-sponsored proficiency testing programs. The contracted laboratories are also audited periodically by BNL to verify competence in analytical methodology and implementation of a comprehensive quality assurance program.

The onsite Analytical Services Laboratory (ASL) performs analysis of environmental surveillance samples. When practicable, analysis is performed using EPA standard methods of analysis. Any deviation from these methods is documented in the analytical procedures maintained by the ASL. Appendix C, Instrumentation and Analytical Methods, contains a description of the analytical methods used for onsite analyses. The ASL also participates in both DOE- and EPA-sponsored proficiency evaluation programs. The results of these evaluations are published annually in BNL's *Site Environmental Report.*

6.5 References

6 NYCRR Parts 700-705. 1999. New York State Department of Environmental Conservation. "Classifications and Standards of Quality and Purity." *New York Codes, Rules, ands Regulations.*

6 NYCRR Part 750. 1975. New York State Department of Environmental Conservation. "State Pollutant Discharge Elimination System." *New York Codes, Rules, ands Regulations.*

40 CFR 136. 1999. U.S. Environmental Protection Agency. "Test procedures for the analysis of pollutants under the Clean Water Act." *U.S. Code of Federal Regulations.*

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Table 6-1

Summary of Liquid Effluent Compliance Monitoring Program

Parameter	Sample Type	Required Frequency	Actual Frequency	Rationale
Outfall 001 (EA) – STP Discharge				
pH	Grab	Daily	Continuous	Secondary treatment standard criteria
Temperature	Grab	Daily	Daily	Aquatic organisms are temperature sensitive.
Biological Oxygen Demand (BOD), 5-day (avg./max.)	Composite	Monthly	2x/month	Excess organic matter can stress oxygen levels in receiving water bodies. Inefficient treatment of sanitary waste can lead to elevated levels of BOD.
Total Suspended Solids (TSS) (avg./max.)	Composite	Monthly	2x/month	Excess organic matter can stress oxygen levels in receiving water bodies. Inefficient treatment of sanitary waste can lead to elevated levels of suspended solids.
Nitrogen, total	Composite	Monthly	2x/month	Elevated nitrogen levels lead to excessive plant growth and depletion of oxygen during periods of respiration. Nitrogen is a byproduct of sanitary waste treatment.
Nitrogen, Ammonia	Composite	Monthly	2x/month	Ammonia is toxic to fish survival. Ammonia is a byproduct of sanitary waste treatment
Phosphorus, total	Composite	Monthly	2x/month	Elevated phosphate levels lead to excessive plant growth and depletion of oxygen during periods of respiration. Phosphates are found in many detergents typically found in household and industrial cleaners.
Cyanide	Grab	2x/month	2x/month	Cyanide is found in many industrial chemicals, including some photo-developers and metal plating solutions. Low concentrations of cyanide can lead to acute effects to aquatic organisms.
Copper	Composite	Monthly	2x/month	Metals are present in typical sanitary waste. Metals are also discharged from industrial cleaning and metal working processes. Some metals are toxic to aquatic organisms in very low concentration.
Iron	Composite	Monthly	2x/month	Metals are present in typical sanitary waste. Metals are also discharged from industrial cleaning and metal working processes. Some metals are toxic to aquatic organisms in very low concentration.

Table 6-1 *(continued)*
Summary of Liquid Effluent Compliance Monitoring Program

Parameter	Sample Type	Required Frequency	Actual Frequency	Rationale
Outfall 001 (EA) – STP Discharge *(continued)*				
Lead	Composite	Monthly	2x/month	Metals are present in typical sanitary waste. Metals are also discharged from industrial cleaning and metal working processes. Some metals are toxic to aquatic organisms in very low concentration.
Nickel	Composite	Monthly	2x/month	Metals are present in typical sanitary waste. Metals are also discharged from industrial cleaning and metal working processes. Some metals are toxic to aquatic organisms in very low concentration.
Silver	Composite	Monthly	2x/month	Metals are present in typical sanitary waste. Metals are also discharged from industrial cleaning and metal working processes. Some metals are toxic to aquatic organisms in very low concentration.
Zinc	Composite	Monthly	2x/month	Metals are present in typical sanitary waste. Metals are also discharged from industrial cleaning and metal working processes. Some metals are toxic to aquatic organisms in very low concentration.
Mercury	Composite	Monthly	2x/month	Metals are present in typical sanitary waste. Metals are also discharged from industrial cleaning and metal working processes. Some metals are toxic to aquatic organisms in very low concentration.
Toluene	Grab	2x/month	2x/month	Organic chemicals are used ubiquitously in industry for their cleaning and solvent properties. Due to the carcinogenicity of some of these compounds, discharge standards are very stringent. Many of these chemicals are used not only in industrial operations but also in research activities.
Methylene Chloride	Grab	2x/month	2x/month	Organic chemicals are used ubiquitously in industry for their cleaning and solvent properties. Due to the carcinogenicity of some of these compounds, discharge standards are very stringent. Many of these chemicals are used not only in industrial operations but also in research activities.

Table 6-1 *(continued)*
Summary of Liquid Effluent Compliance Monitoring Program

Parameter	Sample Type	Required Frequency	Actual Frequency	Rationale
Outfall 001 (EA) – STP Discharge *(continued)*				
1,1,1-trichloroethane	Grab	2x/month	2x/month	Organic chemicals are used ubiquitously in industry for their cleaning and solvent properties. Due to the carcinogenicity of some of these compounds, discharge standards are very stringent. Many of these chemicals are used not only in industrial operations but also in research activities.
2-butanone	Grab	2x/month	2x/month	Organic chemicals are used ubiquitously in industry for their cleaning and solvent properties. Due to the carcinogenicity of some of these compounds, discharge standards are very stringent. Many of these chemicals are used not only in industrial operations but also in research activities.
Fecal coliform	Grab	2x/month	2x/month	Fecal coliform are present in raw sanitary waste. The presence of fecal coliform in the effluent indicates poor disinfection of the treated effluent.
BOD/TSS Removal	Calculated	Monthly	Monthly	Secondary treatment standard criteria.
Whole Effluent Toxicity	Composite	Quarterly	Quarterly	To determine if the concentrations of contaminants in the STP discharge are toxic to aquatic organisms, effluent toxicity studies are performed.
Outfall 002 (HN)				
pH	Grab	Monthly	4x/month	The discharge of cooling tower blowdown could result in discharge with elevated pH. To ensure that the quality of groundwater is not compromised, the pH of this discharge is monitored.
Oil and Grease	Grab	Monthly	Monthly	Parking lot runoff from rain events could result in the discharge of oil and grease.
Chloroform	Grab	Quarterly	Quarterly	Disinfection byproducts are discharged from the domestic water system and cooling tower blowdown.
Bromodichloro-methane	Grab	Quarterly	Quarterly	Disinfection byproducts are discharged from the domestic water system and cooling tower blowdown.
1,1,1-trichloroethane (TCA)	Grab	Quarterly	Quarterly	TCA has been detected in groundwater used for both domestic and process cooling water supply.

Table 6-1 *(continued)*

Summary of Liquid Effluent Compliance Monitoring Program

Parameter	Sample Type	Required Frequency	Actual Frequency	Rationale
Outfall 002 (HN) *(continued)*				
Hydroxyethylidene-diphosphonic acid (HEDP)	Grab	Quarterly	Quarterly	HEDP is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Tolyltriazole (TTA)	Grab	Quarterly	Quarterly	TTA is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Outfall 003 (HO)				
pH	Grab	Monthly	4x/month	The discharge of cooling tower blowdown could result in discharge with elevated pH. To ensure that the quality of groundwater is not compromised, the pH of this discharge is monitored.
Oil and Grease	Grab	Monthly	Monthly	Parking lot runoff from rain events could result in the discharge of oil and grease.
1,1,1-trichloroethane (TCA)	Grab	Quarterly	Quarterly	TCA has been detected in groundwater used for both domestic and process cooling water supply.
Hydroxyethylidene-diphosphonic acid (HEDP)	Grab	Quarterly	Quarterly	HEDP is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Tolyltriazole (TTA)	Grab	Quarterly	Quarterly	TTA is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
2,2-Dibromo-nitrilo-propionamide (DBNPA)	Grab	Quarterly	Quarterly	DBNPA is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Zinc	Grab	Quarterly	Quarterly	Zinc is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Outfall 004 (HP)				
pH	Grab	Monthly	Monthly	To ensure the quality of groundwater is not compromised, the pH of this discharge is monitored.
1,1,1-trichloroethane (TCA)	Grab	Quarterly	Quarterly	TCA has been detected in groundwater used for both domestic and process cooling water supply.

Table 6-1 *(continued)*

Summary of Liquid Effluent Compliance Monitoring Program

Parameter	Sample Type	Required Frequency	Actual Frequency	Rationale
Outfall 005 (HS)				
pH	Grab	Monthly	4x/month	The discharge of cooling tower blowdown could result in discharge with elevated pH. To ensure that the quality of groundwater is not compromised, the pH of this discharge is monitored.
Oil and Grease	Grab	Monthly	Monthly	Parking lot runoff from rain events could result in the discharge of oil and grease.
Hydroxyethylidene-diphosphonic acid (HEDP)	Grab	Quarterly	Quarterly	HEDP is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Tolyltriazole (TTA)	Grab	Quarterly	Quarterly	TTA is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Copper	Grab	Quarterly	Quarterly	Copper is a component of tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Outfalls 006 and 006B				
pH	Grab	Monthly	4x/month	The discharge of cooling tower blowdown could result in discharge with elevated pH. To ensure that the quality of groundwater is not compromised, the pH of this discharge is monitored.
Oil and Grease	Grab	Monthly	Monthly	Parking lot runoff from rain events could result in the discharge of oil and grease.
Hydroxyethylidene-diphosphonic acid (HEDP)	Grab	Quarterly	Quarterly	HEDP is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Tolyltriazole (TTA)	Grab	Quarterly	Quarterly	TTA is a component of cooling tower treatment chemicals. The discharge of residual cooling tower reagents is strictly controlled.
Outfall 007 (HX)				
PH	Grab	Monthly	Monthly	The water treatment plant uses lime (calcium hydroxide) to remove iron from groundwater. To ensure lime dosing is not excessive, the pH is monitored.

Table 6-1 *(continued)*

Summary of Liquid Effluent Compliance Monitoring Program

Parameter	Sample Type	Required Frequency	Actual Frequency	Rationale
Outfall 007 (HX) *(Continued)*				
Iron (total)	Grab	Monthly	Monthly	Discharge of iron to groundwater is controlled to prevent degradation of groundwater quality. The predominant fraction of iron in this discharge is in particulate and does not migrate to groundwater.
Iron (dissolved)	Grab	Monthly	Monthly	To determine the potential impact to groundwater, a filtered sample is analyzed for iron, and reported as the dissolved fraction.
Outfall 008 (HW)				
pH	Grab	Monthly	4x/month	The discharge of cooling tower blowdown could result in discharge with elevated pH. To ensure that the quality of groundwater is not compromised, the pH of this discharge is monitored.
Oil and Grease	Grab	Monthly	Monthly	Parking lot runoff from rain events could result in the discharge of oil and grease.
1,1,1-trichloroethane	Grab	Quarterly	Quarterly	Outfall 008 receives stormwater runoff from the warehouse area. Since chemicals are stored in this area of the property, organic analyses are performed to ensure precipitation is not exposed to chemicals during handling.
1,1-dichloroethylene	Grab	Quarterly	Quarterly	Outfall 008 receives stormwater runoff from the warehouse area. Since chemicals are stored in this area of the property, organic analyses are performed to ensure precipitation is not exposed to chemicals during handling.
Outfall 009				
Sampling of Outfall 009 is not required under BNL's SPDES permit.				
Outfall 010				
pH	Grab	Monthly	4x/month	The discharge of boiler blowdown could result in discharge with elevated pH. To ensure that the quality of groundwater is not compromised, the pH of this discharge is monitored.
Oil and Grease	Grab	Monthly	Monthly	Parking lot runoff from rain events could result in the discharge of oil and grease.

Table 6-2

Summary of BNL Environmental Surveillance Program for Liquid Effluents

Analytical Parameter	Sample Type	Frequency	Rationale
STP Influent			
pH	Real-time Continuous	Real-time Continuous	To ensure that wastewater entering the STP does not compromise effluent quality, real-time monitoring is performed at three locations: Manhole 192, at the clarifier influent, and at the clarifier effluent.
Conductivity	Real-time Continuous	Real-time Continuous	To ensure that wastewater entering the STP does not compromise effluent quality, real-time monitoring is performed at three locations: Manhole 192, at the clarifier influent, and at the clarifier effluent.
Gross Beta	Real-time Continuous	Real-time Continuous	To ensure that wastewater entering the STP does not compromise effluent quality, real-time monitoring is performed at three locations: Manhole 192, at the clarifier influent, and at the clarifier effluent.
Metals	24-hour Composite	2x/month	To characterize the influent waste stream, samples are collected and analyzed for metals twice per month. These data are used to assess potential impacts to the Peconic River in the event of a plant upset, as well as assess the treatment efficiency of the STP.
Radioactivity	24-hour Composite	Daily	To ensure no radioactivity is discharged to the STP, daily composite samples are collected and analyzed for gamma-, beta-, alpha-emitters, and tritium. A monthly composite is also analyzed for strontium-90.
STP Effluent			
pH, conductivity, dissolved oxygen, temperature	Grab	Daily	To confirm real-time monitoring, a daily grab sample is collected and analyzed using field-deployed meters.
Water Quality Parameters	24-hour Composite	Monthly	Chlorides, sulfates, and nitrates are monitored monthly for characterization purposes.
Radioactivity	24-hour Composite	Daily	To ensure no radioactivity is discharged to the environment, daily composite samples are collected and analyzed for gamma-, beta- and alpha-emitters and tritium. A monthly composite is also analyzed for strontium-90.
Metals	24-hour Composite	Monthly	To characterize the STP effluent stream and confirm compliance sample results, samples are collected and analyzed for metals on a monthly basis. These data are used to assess the treatment efficiency of the STP.

Table 6-2 *(continued)*
Summary of BNL Environmental Surveillance Program for Liquid Effluents

Analytical Parameter	Sample Type	Frequency	Rationale
Recharge Basins			
pH, conductivity, dissolved oxygen, temperature	Grab	Monthly	A grab sample is collected and analyzed using field deployed meters.
Water Quality Parameters	24-hour composite	Quarterly	Chlorides, sulfates, and nitrates are monitored on a monthly basis for characterization purposes.
Radioactivity	24-hour Composite	Quarterly	To characterize discharges to the recharge basins and ensure these effluents do not pose an environmental risk, a daily composite sample is collected and analyzed for gamma-, beta-, and alpha-emitters, and tritium on a quarterly basis.
Metals	24-hour Composite	Quarterly	To characterize discharges to the recharge basins and ensure these effluents do not pose an environmental risk, samples are collected and analyzed for metals on a quarterly basis.
Volatile Organic Compounds (VOCs)	Grab	Quarterly	To characterize discharges to the recharge basins and ensure these effluents do not pose an environmental risk, samples are collected and analyzed for VOCs on a quarterly basis.

7 SURFACE WATER MONITORING

7.1 Introduction

Surface water monitoring is conducted in order to establish well-defined histories of the physical, biological, and chemical baseline conditions of local water bodies; as well as to assess the impacts of U.S. Department of Energy (DOE) facilities on local water quality.

Wastewater discharges from the Brookhaven National Laboratory (BNL) Sewage Treatment Plant (STP) are discharged to the headwaters of the Peconic River. To ensure that this discharge does not compromise the quality of the Peconic River, it is monitored routinely (see Chapter 6 for a full description of the effluent monitoring program). BNL operations also have the potential to impact the Peconic River through interaction with developed portions of the site, including accelerator facilities and roadways, and through interaction with groundwater that may be potentially contaminated by past activities.

This chapter provides a full description of the surface water monitoring program conducted at BNL, with a discussion of the rationale for the siting of sample collection locations and specification of analytical parameters.

7.2 Rationale and Design Criteria

7.2.1 Drivers

The monitoring of liquid effluents at BNL is performed in accordance with DOE Order 5400.1 [1988], *General Environmental Protection Program*, which requires that monitoring be conducted in order to:

- Verify compliance with federal, state, and local regulations,
- Determine compliance with commitments made in the Environmental Impact Statements, Environmental Assessments, or other official documents,
- Evaluate the effectiveness of effluent treatment and control,
- Identify potential environmental problems,
- Support permit revision and/or reissuance, and
- Detect, characterize, and report unplanned releases.

The details of the effluent monitoring program and a full description of the applicable drivers are contained in Chapter 6.

Additionally, DOE Order 5400.1 requires that surveillance monitoring be conducted to measure the effects, if any, of DOE activities onsite and offsite, establish baselines of environmental quality, and to characterize and define trends in the physical, chemical, and biological condition of environmental media. The New York State Department of Environmental Conservation (NYSDEC) has established ambient water quality standards for the Peconic River and other local water bodies. These standards have been codified under Parts 700-706 of Title 6 of the New York Code of Rules and Regulations [6 NYCRR Parts 700-706].

7.2.2 Monitoring Objectives

The objectives of the surface water monitoring program are to:

- Establish a baseline water quality for the Peconic River upstream of the BNL site,
- Establish a baseline water quality for the Carmans River (control site),
- Determine the onsite impact, if any, of BNL operations on the Peconic River, and
- Determine offsite impact, if any, of BNL operations on the Peconic River Estuary.

These objectives are achieved by the implementation of a routine surface water monitoring program. This program includes the collection and analysis of water samples from the Carmans River and the Peconic River. The Peconic River is monitored offsite and upstream of the BNL boundary, at several locations on the BNL site, and offsite downstream from the BNL site boundary. To assess the environmental health of both the Carmans and Peconic River, the analytical results are compared with state established water quality standards. The data from the water samples are also inter-compared to determine if BNL has any impact on the Peconic River water quality.

7.2.3 Potential Sources and Contaminants

The Peconic River enters the BNL site at the northwest corner, west of the Relativistic Heavy Ion Collider (RHIC) ten o'clock experimental hall. The Peconic River traverses the RHIC site, exiting at the ring on the east side of the two o'clock experimental hall. To facilitate construction of the RHIC, a corrugated metal conduit was installed under the ring at the ten o'clock and two o'clock positions to permit continuous river flow. The Peconic River is an intermittent stream in the RHIC area, with flow occurring predominantly in the spring and fall (a gaining stream) and completely drying up during dry periods (a losing stream). Several areas of low topography, and areas with near surface silts and clays, located within the northern sections of RHIC accumulate water during the wet seasons.

After exiting the RHIC, the Peconic River flows easterly, then in a southeasterly direction, and exits the site along the southeast boundary of the BNL site. With the exception of the RHIC construction, there has been nominal development along the Peconic River corridor. Recent construction activities included the construction of monitoring stations within the river for the measurement of flow and collection of flow-proportional samples. The Peconic River does flow through an area of BNL formerly used to study the effects of nuclear fallout in the 1960s. During these studies, the native vegetation was subjected to a radiation field emitted from a sealed cobalt-60 source and the effects on the vegetation noted.

The BNL STP discharges treated sanitary effluents to the Peconic River at Outfall 001 (sample location EA). This discharge is shown in Figures 7-1 and 3-3 and is located approximately at the midpoint of the Peconic River on the BNL site. Due to the STP contribution, the Peconic River flow is continuous downstream for several hundred yards throughout the year. During dry periods, the river again becomes a losing stream and all water evaporates or percolates to recharge groundwater. During periods of extensive precipitation, such as the spring or fall, flow is continuous throughout the BNL site.

In addition to contributions from the STP, surface runoff and groundwater comprise the only other contributed sources of water to the Peconic River. Potential contaminants include all constituents related to the STP discharge: sediment, oil, and grease from surface runoff or contaminants contributed from groundwater. Investigation of the Peconic River conducted under the Comprehensive Environmental

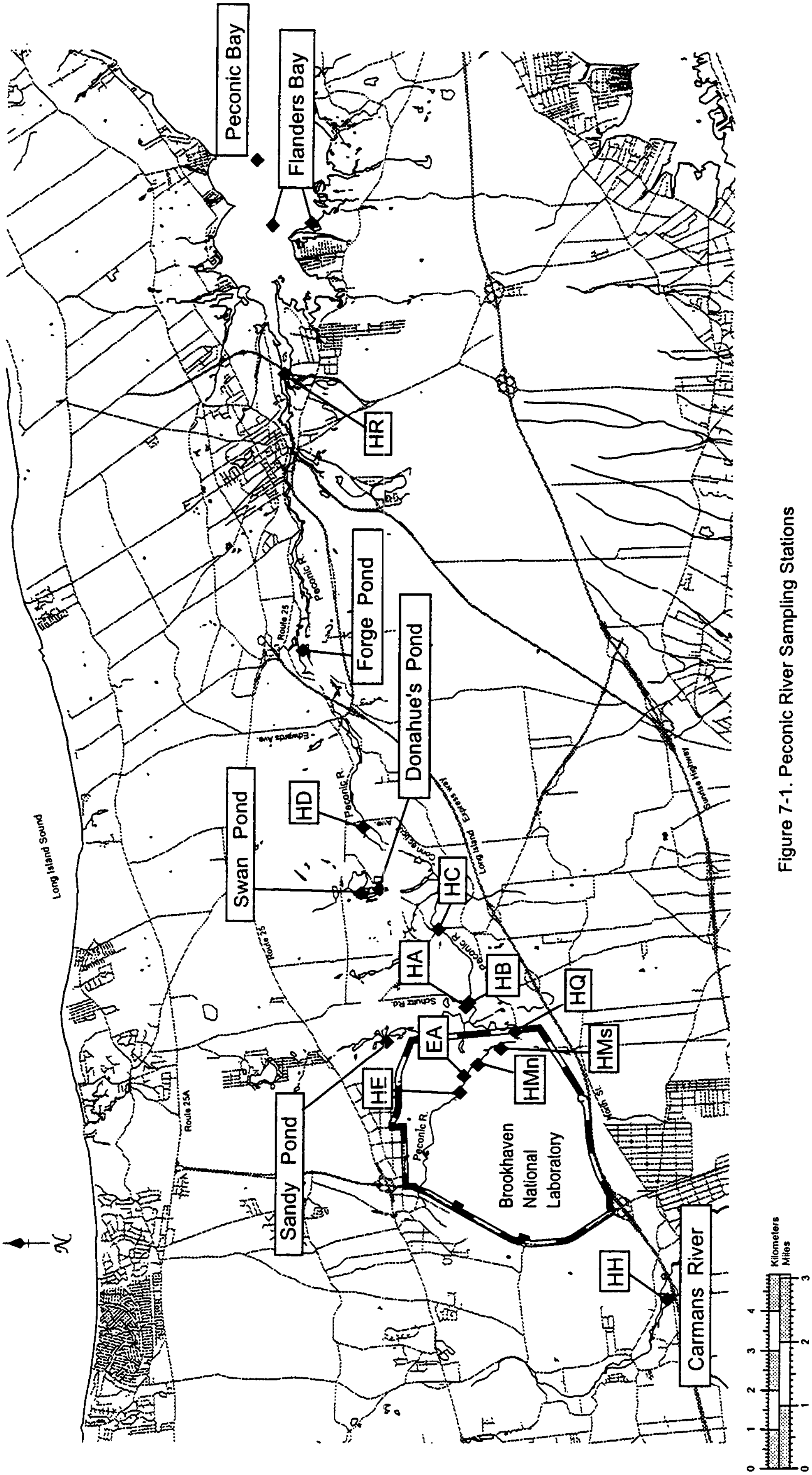

Figure 7-1. Peconic River Sampling Stations

Response, Compensation, and Liability Act (CERCLA) program showed that historical releases of radiological materials, polychlorinated biphenyls (PCBs), pesticides, and inorganics has resulted in their accumulation within the Peconic River sediments [ITC 1998]. Resuspension of these sediments due to scouring can result in the migration of these contaminants offsite.

The Peconic River is sampled at five offsite locations between the southeast site boundary and Riverhead, New York (stations HA, HB, HC, HD and HR), at four locations onsite (stations HE, HMn, HMs, HQ) (see Figures 7-1 and 3-3), and at one station offsite and upstream of BNL, west of the RHIC's Ten O'clock Experimental Hall (not shown on figures). The Carmans River, located west of the site, is sampled at station HH to determine background or ambient conditions. Samples are collected and later analyzed for radiological parameters (gross alpha, gross beta, and tritium activity, as well as strontium-90 and other gamma-emitting radionuclides), nonradiological parameters (e.g., metals, volatile organic compounds [VOCs]), and water quality parameters).

7.2.4 Collection Methods and Procedures

Sample collection is conducted using either grab or composite methodologies. Several of the onsite Peconic River stations are equipped with flow measuring devices and sample collection systems. The combination of these two devices permit the collection of flow-proportional composite samples. Environmental Monitoring Standard Operating Procedures (SOPs) have been developed and are maintained by the Environmental Services Division (ESD) field program staff. The flow measuring device consists of a pre-engineered measuring device (H-flume or Parshall flume) and an ultrasonic level transmitter. The flow rate is calculated by the level-sensing device using standard mathematical relationships and the height of flow through the flume. The flow is totalized and recorded on a strip chart and mechanical totalizer. Samples are collected using an ISCO refrigerated sampler. This sampler consists of a computer controlled peristaltic pump and a refrigerator. Flow signals are relayed to the sampler from the flow-measuring device and samples are collected at a predetermined rate. All collected samples are composited into a sample collection container contained in the refrigerated portion of the sampler.

Grab samples are collected at monitoring locations that are not equipped with permanent sampling systems. SOPs for the collection of grab samples are also maintained by the ESD field program staff. These procedures are available for review through the ESD web site at http://www.esh.bnl.gov/esd/.

Collected samples are transferred to pre-preserved sample collection containers. Preservatives, sample size, and storage requirements are specified by the analytical methods.

7.3 Extent and Frequency of Monitoring

7.3.1 Criteria for Selecting Sample Locations

Selection of monitoring locations is based upon three main objectives:

- *Determine the Background Water Quality.* To assess the quality of background, samples are collected at two locations. The sample station located upstream of the BNL site provides water quality data for the Peconic River upstream of BNL. Flow in this portion of the river is, however, inconsistent due to the seasonal variations. Samples collected along the Carmans River (HH) provide background water quality for a comparable Long Island fresh water stream. Samples are collected from a section of the Carmans River that experiences year-round flow.

- *Determine Onsite Impacts.* Water samples are collected at four locations onsite to determine the effects, if any, of BNL operations on the Peconic River. Samples collected at river station HE are used to assess the Peconic River quality downstream of the RHIC and upstream of the STP discharge. Impacts due to site runoff contributions from developed areas can be assessed by comparing the sample results to background samples. Flow at River station HE is, however, intermittent. Consequently, sample collection is limited to high flow periods only. Samples are collected at stations HMn and HQ to assess water quality downstream of the STP discharge. Station HMn is located in a section of the Peconic River that experiences continuous flow. Station HQ is located at the site boundary and is subject to intermittent flow. Station HQ data are used to assess the Peconic River quality prior to leaving the site. Station HMs is located along a tributary of the Peconic River that receives runoff from several areas of the BNL site, including developed and nondeveloped portions located along the south and east and including the former landfills, the former Hazardous Waste Management Facility, and the Central Steam Facility. Flow at HMs is intermittent.

- *Determine Offsite Impacts of BNL Operations on the Peconic River.* To assess the impacts of BNL operations on the Peconic River offsite, five monitoring stations are sampled. Locations HA, HB, HC, and HD are located downstream of the BNL site boundary, within the intermittent portion of the river, and upstream of other non-BNL water sources. Station HR is located in the town of Riverhead in a continuous flow portion of the river. Station HR is also located downstream of several other Peconic River tributaries and downstream of the Riverhead municipal sewage treatment plant discharge. Water quality data collected at HR are used to assess impacts from other non-BNL sources.

7.3.2 Sample Collection Frequency

With the exception of stations HQ and HMn, all Peconic River and Carmans River monitoring stations are sampled on a quarterly basis, as flow permits. Due to the direct influence of STP discharges on the river quality at stations HQ and HMn, these stations are sampled several times weekly. The frequent monitoring of the stations HQ and HMn permits the assessment of STP releases on downstream receptors.

7.3.3 Analytical Parameters

The surface water monitoring program assesses a broad spectrum of analytical parameters. These parameters include those chemical constituents specified in the BNL State Pollutant Discharge Elimination System (SPDES) permit (i.e., metals, VOCs, and wet chemistry parameters) and the full spectrum of radiological parameters (gross alpha, gross beta, tritium, and strontium-90).

7.4 Analytical Methodologies and Laboratory Procedures

All surface water samples are analyzed by the BNL Analytical Services Laboratory (ASL). A full description of the analytical methods, quality assurance procedures, and assessment of laboratory performance are provided in Chapter 12. The ASL uses standard methods of analysis approved by the U.S. Environmental Protection Agency (EPA). Quality assurance requirements are specified by the analytical methods. All data are reviewed internally to assure acceptable quality.

7.5 Data Analysis

The data received from the ASL are reviewed to determine if there are any impacts to the Peconic River attributable to BNL operations. Data are assessed against state-developed water quality standards and are intercompared to determine if concentrations within the Peconic River downstream of BNL are different from background or control locations. The data and assessment are summarized in the annual *Site Environmental Report* (SER).

7.6 References

6 NYCRR Parts 700-705. 1999. New York State Department of Environmental Conservation. "Classifications and Standards of Quality and Purity." *New York Codes, Rules, ands Regulations*.

DOE Order 5400.1. 1988. *General Environmental Protection Program.* U.S. Department of Energy, Washington, D.C.

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8 GROUNDWATER MONITORING

8.1 Introduction

Brookhaven National Laboratory (BNL) has a comprehensive groundwater protection and management program. A summary of this program is presented in the *BNL Groundwater Protection Management Plan Program Description* [Paquette *et al.* 1998]. A key element of the groundwater protection program is monitoring. BNL's extensive groundwater monitoring network is designed to evaluate groundwater contamination from historical operations (under the Environmental Restoration [ER] program), and active research and support facility operations (under the Environmental Surveillance [ES] program), and to determine whether measures taken to protect or restore groundwater quality are effective.

8.2 Geology and Hydrology

In order to understand the rationale and design criteria for the BNL groundwater monitoring program, it is important to understand the geology and hydrology of the area.

The BNL site is underlain by approximately 1,300 feet of unconsolidated Pleistocene and Cretaceous sediments overlying Precambrian bedrock. The unconsolidated sediments, subdivided from youngest to oldest, are:

- Upper Pleistocene deposits (Upper Glacial aquifer),
- Gardiners Clay (Gardiners Clay confining unit),
- Magothy Formation (Magothy aquifer), and
- Raritan Formation (Raritan Clay confining unit and Lloyd aquifer).

Table 8-1 provides a description of the geologic and hydraulic properties of the geologic units underlying the BNL site. A brief description of the Upper Pleistocene, Gardiners Clay, and Magothy Formation is provided below, and a generalized hydrogeologic cross section through Long Island and the BNL site is presented in Figure 8-1. More detailed descriptions on the hydrogeology of the BNL site can be found in [deLaguna 1963; Warren *et al.* 1968; and Scorca *et al.* 1999].

Upper Glacial Aquifer

The Upper Pleistocene deposits at BNL primarily consist of 130 feet to 200 feet of broadly stratified glacio-fluvial outwash deposits composed of silica-rich medium to coarse-grained sand and gravel. Thin layers of silt and clay have been observed within the outwash deposits, but do not represent significant barriers to groundwater flow. Near surface silt and clay deposits are located along the lowlands of the Peconic River watershed. Although the full areal extent of these deposits has not been determined, their presence is inferred beneath marshes and areas of ponded water, which are wide-spread in the eastern portion of the site [Warren *et al.* 1968].

Groundwater in the Upper Glacial aquifer beneath BNL generally exists under unconfined conditions. However, in the areas along the Peconic River where low permeability near surface silt and clay deposits exist, semi-confined conditions may occur. Depth to groundwater varies from several feet below land surface within the lowlands near the Peconic River, to as much as 75 feet in the higher elevation areas located in the central and western portions of the site. The groundwater table is in the Upper Glacial aquifer. Shallow groundwater flow directions in the BNL area are influenced by natural drainage systems, varying between being eastward along the Peconic River, southeastward toward the Forge River, and southward toward the Carmans River (see Figure 2-8). Additionally, supply well pumping and recharge induced stresses on the aquifer system are considerable in the central area of the site. Groundwater flow directions in the southwest corner of the site are also influenced by municipal water supply pumpage.

In most areas of the site, the natural groundwater flow velocity within the Upper Glacial aquifer is estimated to be approximately 0.75 feet per day (ft/d) [Geraghty and Miller 1996]. However, flow velocities in recharge areas may be as high as 1.45 ft/d, while velocities up to 28 ft/d have been calculated for areas near BNL potable and process supply wells [Woodward-Clyde Consultants 1993]. The BNL site is located within a Suffolk County Department of Health Services (SCDHS) designated deep-flow recharge area for the Magothy and Lloyd aquifers [Koppleman 1978; SCDHS 1987]. Comparison of water level measurements from Glacial aquifer and Magothy aquifer wells indicate significant downward flow across the BNL site [Scorca *et al.* 1999].

Gardiners Clay Aquitard

The Gardiners Clay is Pleistocene (Sangamon) in age and unconformably overlies the Magothy Formation. The Gardiners Clay deposits at BNL are composed of green-gray, silty and sandy clay ranging from 2 feet to 15 feet in thickness. Thin sand and gravel zones have been observed within the Gardiners, which may reduce the effectiveness of this unit as a barrier to vertical groundwater flow. Where present, the Gardiners acts as a confining to semi-confining unit between Upper Glacial and Magothy aquifers.

On a regional scale, the Gardiners Clay has a wedge-shaped geometry which thickens to the south to a maximum of 150 feet in the Great South Bay area [deLaguna 1963]. The northern limit of the Gardiners Clay as a continuous unit is thought to be approximately 2 miles south of BNL [Smolensky *et al.* 1989; Scorca *et al.*, 1999].

To date, very little information exists on the hydraulic characteristics of the Gardiners Clay deposits at BNL. Limited studies by Warren *et al.* [1968] indicate that the permeability of the Gardiners Clay is approximately 0.3 gallons per day per square foot (gpd/ft^2). Sandy and silty zones that have been observed within the Gardiners Clay may reduce the units' ability to restrict vertical groundwater movement. However, a hydraulic head differential across the Gardiners Clay has been observed in the southeast corner of BNL, between a shallow Upper Glacial well and a nearby upper Magothy well, indicating that the clay is sufficiently impermeable to restrict the downward movement of groundwater in this area. Due to the lack of continuous Gardiners Clay deposits, however, the Upper Glacial and Magothy aquifers may be hydraulically connected in a number of areas across the BNL site. In some areas of the site where the Gardiners Clay is absent, glacial sediments have been found to lie directly upon sandy zones or clay units within the uppermost Magothy.

Magothy Formation

The Magothy Formation is characterized by Cretaceous aged terrestrial to transitional marine (deltaic) interbedded gray sand, gravel, silt, and clay. In the BNL area, the Magothy ranges from 800 to 890 feet in thickness [deLaguna 1963]. The basal 100 to150 feet of the Magothy is composed primarily of coarse sand and gravel. Numerous discontinuous clay deposits are found within the uppermost Magothy underlying the BNL site. An erosional unconformity exists between the Magothy Formation and the overlying Pleistocene deposits (Gardiners Clay or glacial deposits). Within the BNL area, the upper surface of the Magothy Formation ranges from 80 to 160 feet below mean sea level. Two significant erosional valleys have been identified at BNL. With a relief of 70 feet or more, the erosional valleys reflect severe post-Gardiners erosion, which could have resulted from a combination of glacial scouring and the release of large amounts of glacial melt water. The erosional valleys were later filled with glacial sands and gravel, and reworked Magothy and Gardiners Clay sediments. The glacial sediments that fill these valleys rest directly upon Magothy sands or discontinuous clay layers within the upper Magothy.

The Magothy aquifer is the thickest hydrogeologic unit on Long Island. Where it is overlain by Gardiners Clay, groundwater in the Magothy aquifer exists under confined conditions. Where the Gardiners Clay is absent, sand-rich zones within the uppermost portions of the Magothy may be hydraulically connected with the Upper Glacial aquifer. In these areas, the uppermost sections of the Magothy are under unconfined conditions. However, due to the presence of numerous discontinuous clay layers within the upper Magothy, the degree of confinement is likely to increase with depth. Although the upper Magothy clay units appear to be discontinuous, these clay units are likely to form significant local barriers to groundwater movement.

Data on the hydraulic characteristics of the Magothy aquifer below the BNL site are limited. Busciolano *et al.* [1998] provide recent data on groundwater flow directions within the Magothy, with flow directions being similar to the Upper Glacial aquifer, but less affected by surface drainage patterns. It is estimated that groundwater flow velocities within the Magothy may range between 0.03 to 0.14 ft/d [Warren *et al.* 1968].

8.3 Rationale and Design Criteria

8.3.1 Drivers

8.3.1.1 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

On December 21, 1989, the BNL site was included as a Superfund site on the National Priorities List (NPL). The U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and New York State Department of Environmental Conservation (NYSDEC) have integrated DOE's response obligations under the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), and New York State (NYS) hazardous waste regulations into a comprehensive Federal Facilities Agreement (FFA). This Interagency Agreement (IAG) was finalized and signed by these parties in May 1992. The ER program's groundwater monitoring program is conducted in accordance with IAG approved sampling and analysis plans.

8.3.1.2 New York State Regulations, Permits and Licenses

The monitoring programs for the Current Landfill and Former Landfill are designed in accordance with post-closure Operation and Maintenance (O&M) requirements specified in 6 NYCRR (New York Code of Rules and Regulations) Part 360, "Solid Waste Management Facilities." These monitoring programs are being conducted as part of the ER program.

The BNL Major Petroleum Facility (MPF) is operated under NYSDEC License No. 01-1700. This license requires BNL to perform routine groundwater monitoring. Together with approved engineering controls, the groundwater monitoring program is used to verify that bulk fuel storage operations have not impacted groundwater quality. The engineering controls and monitoring program for the MPF are described in the BNL Spill Prevention, Control and Countermeasures (SPCC) Plan.

The BNL Waste Management Facility (WMF) is a NYSDEC permitted waste storage facility (NYSDEC Permit No. 1-422-00032/00102-0). Although not specifically required under RCRA regulations for this type of facility, BNL voluntarily developed a groundwater monitoring program for the WMF. This program, which is described in the WMF's RCRA Part B Permit, was initiated because of the close proximity of the WMF to two of BNL's potable water supply wells (see initial groundwater assessment in Paquette, 1994). This program is specifically designed to provide a secondary means of verifying the effectiveness of the facility's administrative and engineered controls.

8.3.1.3 DOE Orders

DOE Order 5400.1, Chapter IV - *Environmental Monitoring Requirements* states that "Groundwater that is or could be affected by DOE activities shall be monitored to determine the effects of operations on groundwater quality and quantity and to demonstrate compliance with DOE requirements and applicable federal, state and local laws and regulations."

8.3.1.4 Groundwater Quality and Classification

In Suffolk County, drinking water supplies are obtained exclusively from groundwater aquifers (e.g., the Upper Glacial aquifer, the Magothy aquifer, and to a limited extent the Lloyd aquifer). The Long Island aquifer system has been designated by the EPA as a Sole Source aquifer system, pursuant to Section 1424(e) of the Safe Drinking Water Act (SDWA). Groundwater in the sole source aquifers underlying the BNL site is classified as "Class GA Fresh Groundwater" by the State of New York (6 NYCRR Parts 700-705). The best usage of Class GA groundwater is as a source of potable water supply. As such, federal drinking water standards, NYS Drinking Water Standards (NYSDWS), and NYS Ambient Water Quality Standards (NYSAWQS) for Class GA groundwater are used as groundwater protection and remediation goals.

For drinking water supplies, the federal maximum contaminant levels (MCLs) set forth in 40 CFR (Code of Federal Regulations) 141 (primary MCLs) and 40 CFR 143 (secondary MCLs) apply. In NYS, the SDWA requirements pertaining to the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code [10 NYCRR Part 5], which is enforced by the SCDHS as an agent for the NYS Department of Health (NYSDOH). These regulations are applicable to any water supply that has at least five service connections or regularly serves at least 25 individuals. BNL supplies water to a population of approximately 3,500 employees and visitors, and therefore, must comply with these regulations. In addition, DOE Order 5400.5, *Radiation Protection of the Public and Environment*, establishes Derived Concentration Guides (DCGs) for radionuclides not covered by existing federal or state regulations.

BNL evaluates the potential impact of radiological and nonradiological levels of contamination by comparing analytical results to NYS and DOE reference levels. Nonradiological data from groundwater samples collected from surveillance wells are usually compared to NYSAWQS [6 NYCRR Part 703.5]. Radiological data are compared to the NYSDWS (for tritium, strontium-90, and gross beta), NYSAWQS (for gross alpha, radium-226, and radium-228) and 40 CFR 141/DOE DCGs (for determining the 4 mrem/yr dose for other beta-/gamma-emitting radionuclides).

8.3.2 Monitoring Objectives

The primary objectives of the groundwater monitoring program are to:

- Analyze the hydrogeologic regime to support groundwater protection, management and remediation initiatives;
- Determine natural background concentrations for comparison purposes (The site background wells provide information on the chemical and radiological composition of groundwater that has not been

affected by activities at BNL. These background data are a valuable reference for comparison with groundwater quality data from areas that have been affected. This well network can also provide warning of any contaminants originating from potential sources of contamination that may be located upgradient of the BNL site.);

- Demonstrate compliance with applicable groundwater protection and remediation requirements;
- Ensure that potable water supplies meet all regulatory requirements;
- Provide timely information regarding BNL operations that could potentially adversely impact groundwater resources;
- Define the extent and degree of groundwater contamination resulting from historical or current operations;
- Provide early warning of the arrival of a leading edge of a plume to trigger contingency remedial actions to protect a potential receptor (outpost detection monitoring);
- Evaluate progress that groundwater treatment systems are making on plume remediation. Determine whether remediation programs and systems are effective (i.e., performing to specifications) or need modification;
- Determine whether administrative and engineered control measures designed to protect the groundwater are effective;
- Ensure that the quality and type of data collected are sufficient for Groundwater Contingency Planning; and
- Conduct groundwater monitoring in a cost-effective manner, based upon a technically sound sampling and analysis strategy.

8.3.3 Potential Sources

Potential sources and contaminants monitored at BNL are described below. The sources are separated into three categories:

- Background water quality monitoring,
- Historical sources monitored under the BNL ER program, which oversees BNL's CERCLA activities, and
- Actively (operational sources) monitored under the ES program.

The following information is provided for each source area: source area description, description of groundwater quality, criteria for selecting groundwater monitoring locations, and sampling frequency and analysis. Details on sampling parameters, frequency and analysis by well are listed in Tables 8-3 and 8-5. General locations of wells monitored as part of the ER and ES programs are presented in Figures 8-3 and 8-4, respectively. Detailed figures showing locations of facilities and groundwater flow are found in other documents [Paquette 1998; Dorsch and Wachino 1999]. Specific analytical results and information on plume locations and concentrations are found in the *BNL Site Environmental Report* (SER) [BNL 1999d] and the 1998 ER Sitewide Groundwater Monitoring Report [Dorsch and Wachino 1999].

Assessment of the adequacy of the BNL groundwater monitoring well network is an ongoing process. The need for additional monitoring wells at either new or significantly modified facilities is usually identified during the BNL Facility Design Review process. New wells may also be required for the ER program to account for changes in plume position or when additional monitoring is required near groundwater treatment systems.

8.3.3.1 Background Groundwater Monitoring Program

Area Description: Ambient (or background) groundwater quality for the BNL site is monitored through a network of 13 wells located in the northern portion of the site and in offsite areas to the north (see Figure 8-3).

Description of Groundwater Quality: Historically, low levels of Volatile Organic Compounds (VOCs) have been routinely detected in several background wells that are screened in the deeper portions of the Upper Glacial aquifer (e.g., wells 17-03, 17-04, 18-03 and 18-04). During 1998, the highest concentration detected was tetrachloroethylene (PCE) at 2.6 micrograms per liter (μg/L) in offsite Well 000-119. This well is screened in the middle Upper Glacial aquifer, and is located immediately north of the northwest corner of the site. Radionuclide concentrations were consistent with background levels.

Criteria for Selecting Sample Locations: The sampling of wells located to the north of BNL and along BNL's northern boundary provides information on background groundwater quality for the BNL site. Background quality is defined as the quality of groundwater that is completely unaffected by BNL operations.

Sampling Frequency and Analysis: Analytical parameters for groundwater samples include the Contaminants of Concern (COC) that have been identified through the groundwater characterization work performed as part of the various remedial investigations and removal actions at BNL (Table 8-3).

8.3.3.2 Known or Potential Sources of Contamination

Historical Activities: Using historical and current environmental monitoring data, 29 Areas of Concern (AOCs) have been identified at the BNL site. The characteristics of each AOC have been documented in the BNL Site Baseline Report [SAIC 1992]. These 29 AOCs have been grouped into six Operable Units (OUs) based upon relative proximity of AOCs, similarity of contamination problems, similar geology and hydrology, and similar phases of remedial action to be performed. Under the IAG, Remedial Investigation/Feasibility Studies (RI/FSs) have been conducted for each OU. All of the OUs contain source areas that are known to have affected groundwater quality at the site.

Active Research and Support Facilities: BNL facilities that have been identified as having the potential to impact groundwater quality include: the Alternating Gradient Synchrotron (AGS) complex, the Relativistic Heavy Ion Collider (RHIC), the Brookhaven Linear Accelerator (LINAC) Isotope Producer (BLIP), the Brookhaven Medical Research Reactor (BMRR), the Sewage Treatment Plant (STP), Building 830 (Environmental and Waste Technology Center), the Biology Department Greenhouses, the Rifle and Shotgun Ranges, the Major Petroleum Facility (MPF), the Site Maintenance and Motor Pool area, and the onsite Gasoline Service Station. Additional information on these facilities is available in the BNL Groundwater Monitoring Improvements Plan for fiscal year (FY) 1998 and FY 1999 [Paquette 1998].

The BNL groundwater monitoring program is evaluated at least annually to reflect changes in monitoring requirements, or for the incorporation of new surveillance wells. Changes to the sampling schedule that occur throughout the year are documented in monthly Environmental Monitoring Schedules and annually in a "Proposed Changes to the Environmental Monitoring Plan" document (see, for example, Flores, 1999).

8.3.3.2.1 Areas Monitored Under Environmental Restoration Program

8.3.3.2.1.1 Operable Unit (OU) I

Operable Unit I consists of three source areas: the former Hazardous Waste Management Facility (HWMF), the Current Landfill, the Former Landfill, and the Animal/Chemical Pits and Glass Holes Area. The downgradient portion of the OU IV AOC 5 (1977 Fuel Oil/Solvent Spill) is addressed under OU I. There are a total of five individual monitoring programs that have been designed to address groundwater contamination originating from these source areas.

Removal Action (RA) V Program

Source Area Description: The Former HWMF was BNL's central RCRA receiving facility for processing, neutralizing, and storing hazardous and radioactive wastes before offsite disposal and until 1997 when a new HWMF was constructed at another location on the BNL property. Several spills consisting of hazardous materials have been documented in this area.

The Current Landfill operated from 1967 through 1990, and was permanently closed under the ER program in 1995. It was used to dispose of putrescible waste, sludge containing precipitated iron from the Water Treatment Plant (WTP), and anaerobic digester sludge from the STP. The latter contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill.

The Current Landfill and Former HWMF plumes become commingled south of the HWMF due, at least partially, to the pumping and recharge effects of the Former Spray Aeration System, which operated from 1985 to 1990 in a effort to treat VOC contaminated groundwater originating from the HWMF. The plume extends offsite, approximately 3,000 feet south of the site boundary. The Current Landfill/HWMF plume is currently being remediated using a groundwater extraction and treatment system consisting of two wells screened in the deep portion of the Upper Glacial aquifer at the site boundary (RA V Treatment System). Groundwater extracted by this system is treated for VOCs by air stripping and recharged to the ground in a basin located to the northwest of the Current Landfill.

Description of Groundwater Quality: The primary VOCs found onsite in this plume include chloroethane, 1,1,1-Trichloroethane (TCA), and 1,1-Dichloroethane (DCA), whereas the compounds detected offsite consist of TCA, 1,1-Dichrloroethylene (DCE), Trichloroethylene (TCE), and chloroform. Chloroethane, TCA, and DCA are in the shallow Upper Glacial aquifer near the source areas and in the deep Upper Glacial aquifer at the site boundary and offsite. TCA, DCE, TCE, and chloroform are found in the middle to deep Upper Glacial aquifer offsite south of North Street in North Shirley.

There are two areas of the plume currently displaying VOC concentrations of less than 100 µg/L. These areas are located immediately downgradient of the Current Landfill/HWMF and offsite south of North Street. The continued operation of the RA V groundwater treatment system at the site boundary is reducing concentrations and shrinking the width of the plume in this area.

Tritium was detected below NYSAWQS in a number of Current Landfill/HWMF wells during 1998. Offsite Well 000-137 has reported tritium concentrations above detection limits but well below the NYSAWQS since 1997. Strontium-90 was detected in two wells (88-26 and 98-30) in the Current Landfill and Former HWMF areas during 1999 at concentrations less than the NYSDWS.

Criteria for Selecting Sample Locations: The RA V monitoring program uses a network of 47 monitoring wells located in areas downgradient of the Current Landfill and HWMF (Figure 8-4). The wells are designed to:

- Monitor VOC and radiological contamination of groundwater in the shallow zone of the Upper Glacial aquifer at, and immediately adjacent to, the HWMF,

- Monitor VOC and radiological contaminant plumes located south of the Current Landfill and HWMF (and extending offsite) that have been commingled due, in part, to the effects of the former Spray Aeration Groundwater Remediation System, which was located to the south of the HWMF, and

- Evaluate the effectiveness of the RA V groundwater pump-and-treat system that was initiated in December 1996 at the southern site boundary using wells EW-1 and EW-2. The monitoring program will characterize the effects of this treatment system on the contaminant plume, and provide data necessary to make decisions on the future operations of the system.

Sampling Frequency and Analysis: The wells are monitored four times per year (see Table 8-2). Samples are analyzed quarterly for VOCs, tritium, and strontium-90 and annually for gross alpha/beta and gamma spectroscopy (see Table 8-3).

Current Landfill Program

Source Area Description: The Current Landfill operated from 1967 through 1990, and was permanently capped and closed under the ER program in 1995. It was used to dispose of putrescible waste, sludge containing precipitated iron from the WTP, and anaerobic digester sludge from the STP. The latter contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill.

Description of Groundwater Quality: During 1999, VOCs were routinely detected in wells located downgradient of the Current Landfill including chloroethane and benzene. Chloroethane was detected at concentrations exceeding the NYSAWQS in monitoring Wells 87-11, 87-23, 87-27, 88-109, and 88-110. Benzene was found in monitoring wells 87-11, 88-109, and 088-110 at concentrations exceeding the NYSAWQS. Tritium was occasionally detected in downgradient Wells 87-11, 87-23, 87-27, 88-21, 88-109, and 88-110 below the NYSAWQS.

Criteria for Selecting Sample Locations: The Current Landfill was capped in November of 1995. The Current Landfill monitoring program, consisting of a network of 11 monitoring wells located immediately adjacent to the landfill was designed to provide post-closure monitoring of this landfill as per NYSDEC requirements (Figure 8-5). These wells are used to determine the cap's effectiveness in preventing the continued leaching of contaminants from the landfill, and to document the anticipated long-term improvements to groundwater quality.

Sampling Frequency and Analysis: The wells are monitored quarterly (see Table 8-2). The samples are analyzed for VOCs, ethylene dibromide (EDB), Semivolatile Organic Compounds (SVOCs), pesticides/Polychlorinated Biphenyls (PCBs), metals, cyanide, gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 (see Table 8-3) quarterly.

Former Landfill Program

Source Area Description: The Former Landfill initially was used by the United States Army during World Wars I and II. BNL then used the southeast corner of the landfill from 1947 through 1966 to dispose of construction and demolition debris, sewage sludge, chemical and low level radioactive waste, used equipment, and animal carcasses. From 1960 through 1966, BNL waste, glassware containing chemical and radioactive waste, and animal carcasses containing radioactive tracers were disposed of in shallow pits in an area directly east of the Former Landfill. From 1966 through 1981, BNL continued to dispose of used glassware in shallow pits located directly north of these chemical/animal pits. The landfill was capped and closed under the ER program in November 1996.

Description of Groundwater Quality: The primary chemical contaminants observed from the Former Landfill are carbon tetrachloride, TCA, DCE, TCE, chloroform, and strontium-90 in the shallow Upper Glacial aquifer. VOC concentrations were below NYSAWQS during 1999. Strontium-90 was detected above NYSAWQS in well 097-64.

Criteria for Selecting Sample Locations: The Former Landfill was capped in November of 1996. The Former Landfill monitoring program, consisting of a network of 8 monitoring wells located immediately adjacent to the landfill was designed to provide post-closure monitoring of this landfill as per NYSDEC requirements (Figure 8-6). The program was initiated following the capping of the Former Landfill in November 1996, and will verify whether the cap effectively prevents the continued leaching of contaminants from the landfill and document anticipated long-term improvements to groundwater quality.

Sampling Frequency and Analysis: These wells are monitored quarterly (see Table 8-2). The samples are analyzed for VOCs, EDB, SVOCs, pesticides/PCBs, metals, cyanide, gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 (see Table 8-3) quarterly.

Chemical/Animal Holes Strontium-90 Program

Source Area Description: BNL waste, glassware containing chemical and radioactive waste, and animal carcasses containing radioactive tracers were disposed of in shallow pits in an area directly east of the Former Landfill from 1960 through 1966. From 1966 through 1981, BNL continued to dispose of used glassware in shallow pits located directly north of these chemical/animal pits. Remediation of this area, consisting of waste excavation, disposal and treatment, was completed in September 1997.

Description of Groundwater Quality: Strontium-90 has been routinely detected in groundwater in the Chemical/Animal Holes Area. The highest strontium-90 concentrations have been detected in Well 106-16. The strontium-90 plume(s) extend to an area immediately south of Princeton Avenue. VOCs are also detected in shallow groundwater downgradient of this area at concentrations generally below NYSAWQS.

Criteria for Selecting Sample Locations: A network of 24 monitoring wells is used to monitor the Chemical/Animal Holes Area (Figure 8-7, Table 8-3). Wells are located to monitor the plume extent and provide for early warning of plume migration using sentinel wells. Locations for sentinel wells were selected with the assistance of the BNL Regional Groundwater Model (Geraghty and Miller 1996). The sentinel wells are screened in the middle Upper Glacial aquifer.

Sampling Frequency and Analysis: The wells are monitored on a semiannual basis (see Table 8-2). Samples are analyzed annually for VOCs and strontium-90 (see Table 8-3).

Operable Unit (OU) I/IV Program

Source Area Description: The source areas for the plume(s) monitored by this program are the Former Landfill, Chemical/Animal Holes and OU IV 1977 fuel oil/solvent spill site areas. Descriptions of these areas are provided in the OU IV AOC 6, Former Landfill, and Chemical/Animal Holes program sections of this plan.

Description of Groundwater Quality: The primary chemical contaminants observed in the downgradient portion of the plume(s) originating from the OU IV 1977 fuel oil/solvent spill site, Former Landfill, and

Chemical/Animal Holes areas are carbon tetrachloride, TCA, DCE, TCE, and chloroform. In general, the VOCs are found in the mid-Upper Glacial aquifer at the southern site boundary, and in the deep Upper Glacial aquifer offsite to the south. The area of the plume showing the highest VOC concentration is offsite in the vicinity of Stratler Drive in North Shirley, New York. A zone of VOC contamination, consisting primarily of TCA, DCA, and DCE was detected in the Upper Magothy aquifer. Additional characterization and the installation of permanent wells to monitor this contamination will be addressed in calendar year (CY) 2000.

Criteria for Selecting Sample Locations: A network of 24 monitoring wells is used to monitor the downgradient portion of the OU IV 1977 fuel oil/solvent spill site, Former Landfill, Animal/Chemical Pits, and Glass Holes plumes (see Table 8-3 and Figure 8-8). Well locations were selected based on data obtained during Remedial Investigation characterization activities. Wells are located to monitor the extent of the plume and as sentinel wells positioned downgradient of the current leading edge of the plume. Locations for sentinel wells were selected with the assistance of the BNL Regional Groundwater Model. These wells are screened in the deep Upper Glacial aquifer.

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). Samples are analyzed quarterly for VOCs and annually for gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 (see Table 8-3).

8.3.3.2.1.2 Operable Unit (OU) III

Operable Unit III contains multiple source areas and commingled plumes. There are currently two operating groundwater remediation systems and several more under design/construction. There are a total of eight individual monitoring programs related to these issues.

Central Program

Source Area Description: There are a number of low level (less than 100 parts per billion [ppb]) VOC groundwater contamination source areas that are located in the central, developed areas of BNL that are not addressed by specific monitoring programs (i.e., Building 96 [Warehouse], Carbon Tetrachloride Tank) but are significant enough in nature to warrant monitoring. Some identified sources that were evaluated during the OU III RI/FS include spill areas within the AGS Complex, and Building 208 (Site Maintenance Equipment Storage), located within the Supply and Materiel area.

Description of Groundwater Quality: The primary VOCs detected in these areas are TCA and PCE. Concentrations of these VOCs range up to 100 ppb, however, in most locations concentrations range form nondetect (ND) to 20 ppb.

Criteria for Selecting Sample Locations: The monitoring well network established to monitor the relatively low level VOC contamination in the central areas of the site is comprised of 22 wells (see Table 8-3 and Figure 8-9). The monitoring locations provide groundwater quality data in the vicinity of source areas which aids in the definition of VOC plumes which extend downgradient from this area of the site. This network is also being supplemented by data from Facility Monitoring Wells installed during 1999 that were sampled for VOCs as well as radionuclides.

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). Samples are analyzed for VOCs quarterly and for gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 on a semiannual basis (see Table 8-3).

Building 96 Program (Warehouse)

<u>*Source Area Description:*</u> Solvents, including PCE and TCA, were historically used at a former vehicle maintenance and drum storage area located immediately west of the Supply and Materiel area. There are no documented spills. However, soil and groundwater characterization efforts conducted in this area in conjunction with the OU III RI revealed high levels of PCE, particularly in shallow groundwater. These findings are indicative of historical solvent spills associated with activities conducted at the former vehicle maintenance and drum storage areas.

<u>*Description of Groundwater Quality*</u>: The primary VOC of concern is PCE which was detected in 1999 at concentrations up to 4,300 ppb (monitoring well 095-84). TCA has also been detected in this area at concentrations less than 100 ppb. Groundwater contamination in this area is present at or slightly below the water table.

<u>*Criteria for Selecting Sample Locations*</u>: The monitoring well network is being designed to monitor the PCE plume originating in this source area and the effectiveness of a groundwater remediation system which will be constructed during CY 2000 (see Table 8-3 and Figure 8-10). The network currently consists of 6 wells that will be augmented with additional wells to be installed in conjunction with the remediation system construction this year.

<u>*Sampling Frequency and Analysis:*</u> The wells are sampled quarterly (see Table 8-2). Samples are analyzed for VOCs (see Table 8-3).

Carbon Tetrachloride Program

<u>*Source Area Description:*</u> An underground storage tank (UST), located in the vicinity of the corner of Rowland Street and Rochester Street was excavated and removed in April 1998. The UST had been used at the former Chemistry Department Complex in the 1950s, and contained carbon tetrachloride. It now appears that the contamination was caused by the inadvertent release of residual carbon tetrachloride from the tank during the removal process. Subsequent groundwater characterization efforts during the summer and fall of 1998 successfully characterized the extent of the carbon tetrachloride plume. A summary of the data from this groundwater characterization project can be found in *Summary Report for the Carbon Tetrachloride Investigation* [BNL 1999c]. A groundwater remediation system consisting of groundwater extraction wells and carbon treatment was initiated in the fall of 1999.

<u>*Description of Groundwater Quality*</u>: Historically, samples collected from Well 85-06 showed low level concentrations of carbon tetrachloride. Well 85-06 was damaged during the tank removal and replaced with well 85-98. Sampling of the new well in June 1998 revealed carbon tetrachloride contamination approaching 100,000 µg/L. A subsequent groundwater characterization effort found a carbon tetrachloride plume extending approximately several hundred feet to the southeast of the source area.

<u>*Criteria for Selecting Sample Locations*</u>: A monitoring well network consisting of nine wells was designed to monitor the extent of the plume and the effectiveness of the remediation on the plume (see Table 8-3 and Figure 8-11). The BNL Regional Groundwater Model was used to site well locations. Sentinel wells are in place to detect the arrival of the leading edge of the plume.

<u>*Sampling Frequency and Analysis:*</u> The wells are sampled quarterly (see Table 8-2). Samples are analyzed for VOCs (see Table 8-4).

Boundary Program

Source Area Description: The source area for the plume(s) monitored by this program are those located in the central, developed areas of the site discussed above (AGS, Building 96, Carbon Tetrachloride Tank, Building 208, and possibly other unknown sources). The VOC plumes at the south boundary are commingled and the exact source areas are difficult to determine for some contaminants. This is partially due to the significant periodic changes in groundwater flow patterns created by historical and ongoing groundwater pumping and recharge effects across the site.

Description of Groundwater Quality: The primary constituents of the VOC plumes found in this area are PCE, TCE, TCA, and carbon tetrachloride. Concentrations of these constituents range up to 500 ppb. VOC concentrations at the south boundary have decreased following the initiation of the southern boundary groundwater extraction and treatment system in the summer of 1997. The groundwater extraction system consists of seven wells screened in the deep Upper Glacial aquifer. Extracted groundwater is treated by air stripping and recharged to the OU III Basin located north of Princeton Avenue.

Criteria for Selecting Sample Locations: The monitoring well network consists of 40 wells and was designed to monitor the VOC plume(s) in this area of the southern site boundary as well as the effectiveness of the groundwater remediation system (see Table 8-3 and Figure 8-12).

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). Samples are analyzed for VOCs quarterly with the exception of shallow wells, which are analyzed for VOCs semiannually. Tritium is analyzed quarterly and gross alpha/beta, gamma spectroscopy, and strontium-90 are analyzed on a semiannual basis. The details of sample frequency and analyses are provided in Table 8-4.

OffSite Program

Source Area Description: The source area for the plume(s) monitored by this program are those located in the central, developed areas of the site as discussed above (AGS, Building 96, Carbon Tetrachloride Tank, Building 208, and possibly other unknown sources). The VOC plumes at the south boundary and offsite are commingled and the exact source areas are difficult to determine for some contaminants. This is partially due to the significant periodic changes in groundwater flow patterns created by historical and ongoing groundwater pumping and recharge effects across the site.

Description of Groundwater Quality: The primary contaminant found in the OU III offsite areas is carbon tetrachloride. This contaminant was detected at concentrations slightly exceeding 100 ppb during 1999 in well 000-131. PCE, TCA and TCE are also detected in this area at lesser concentrations.

Criteria for Selecting Sample Locations: The monitoring network is comprised of 20 wells which monitor the extreme downgradient extent of the OU III VOC plumes and serve as sentinel wells which are located beyond the leading edge of the plume (see Table 8-3 and Figure 8-13). Locations for sentinel wells, which are screened in the deep Upper Glacial aquifer, were selected with the assistance of the BNL Regional Groundwater Model.

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). Samples are analyzed for VOCs quarterly and for gross alpha/beta, gamma spectroscopy, and tritium on a semiannual frequency (see Table 8-4).

Air Sparge-Industrial Park Program

Source Area Description: The source area for the plume(s) monitored by this program are those located in the central, developed areas of the site as discussed above (AGS, Building 96, Carbon Tetrachloride Tank, Building 208, and possibly other unknown sources). The VOC plumes at the south boundary are commingled and the exact source areas are difficult to determine for some contaminants. This is partially due to the significant periodic changes in groundwater flow patterns created by historical and ongoing groundwater pumping and recharge effects across the site.

Description of Groundwater Quality: The primary contaminant found in the OU III offsite areas is carbon tetrachloride, which was detected at concentrations up to 5,400 ppb during 1999 in well 000-130. PCE, TCA, and TCE are also detected in this area at lesser concentrations.

Criteria for Selecting Sample Locations: The monitoring well network consists of 38 wells and is designed to monitor the VOC plume(s) in the vicinity of the industrial park south of the site and the effectiveness of the in-well air sparge groundwater treatment system on this portion of the high concentration OU III VOC plume(s) (see Table 8-3 and Figure 8-3).

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). The samples are analyzed quarterly for VOCs (see Table 8-4).

AOC 29 High Flux Beam Reactor (HFBR) Program

Source Area Description: Following the January 1997 discovery of tritium in wells south of the HFBR, it was determined that the HFBR's spent fuel pool was leaking tritiated water at a rate of approximately six to nine gallons per day. (Note: To prevent additional leakage, the HFBR's spent-fuel pool was completely emptied by December 1997.) Additional detailed source area groundwater characterization work was conducted in 1999 to define the high concentration portion of the plume directly south of the spent fuel pool.

Description of Groundwater Quality: Tritium was detected at concentrations exceeding 4,000,000 picoCuries per liter (pCi/L) during groundwater characterization investigations conducted in 1999. The high concentration portion of the tritium plume (greater than 500,000 pCi/L) extend south from the HFBR spent fuel pool to Temple Place. The plume extends south to the vicinity of Weaver Road. A groundwater extraction and recharge system was installed and remediation initiated in 1998 along Princeton Avenue. Two extraction wells screened in the mid Upper Glacial aquifer remove groundwater at this location. The water is treated for VOC contamination using carbon filtration and recharged to the RA V Basin. Tritium concentrations in the vicinity of the remediation system have since declined to ND. Due to the proximity of this plume to VOC plumes originating north of this area a number of the HFBR wells are also sampled and analyzed for VOCs and therefore serve a dual purpose. In addition, some of the HFBR wells are optimally located to serve as sentinel and/or bounding wells for the Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility (WCF) strontium-90 plume located immediately to the west.

Criteria for Selecting Sample Locations: A monitoring well network consisting of 112 wells was designed to monitor the extent of the plume, the source area and the effectiveness of the groundwater remediation system (see Table 4 and Figure 8-15). Due to the proximity of the HFBR to artificial pumping and recharge locations the plume is subject to changing stresses which have warranted an extensive monitoring network. The BNL Regional Groundwater Model was utilized to assist with the placement of wells. A source area groundwater remediation system consisting of pumping and removal of highly tritiated water will commence in early CY 2000. Additional monitoring wells will be installed to address the effectiveness of the remediation and changes in tritium concentrations immediately downgradient of the HFBR spent fuel pool.

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). The sample frequency for wells monitoring the planned source remediation system has not been determined at this time. Samples are analyzed for tritium quarterly and VOCs semiannually (Table 8-4).

Brookhaven Graphite Research Reactor/Waste Concentration Facility Strontium-90 Program

Source Area Description: Groundwater quality in the areas surrounding the WCF, former BGRR and its associated Pile Fan Sump has been affected by strontium-90 contamination. A groundwater characterization effort utilizing temporary wells was undertaken in 1997 to better define the extent of strontium-90 contamination in the areas of the WCF, the BGRR, and the Pile Fan Sump. New monitoring wells were installed in the spring of 1999 to allow for better long-term monitoring of the strontium-90 plumes.

Description of Groundwater Quality: Areas of strontium-90 contamination in groundwater extend south from the BGRR, WCF, and the Pile Fan Sump. Strontium-90 concentrations are generally less than 50 pCi/L with the exception of well 065-175, located south of the WCF where concentrations up to 361 pCi/L were detected during 1999.

Criteria for Selecting Sample Locations: A monitoring well network consisting of 57 wells was designed to monitor the strontium-90 plumes associated with the BGRR, WCF, and Pile Fan Sump (see Table 8-3 and Figure 8-16). Fourteen wells monitored under this program are also sampled as part of the AOC 29 HFBR Tritium program. Sampling events are coordinated between the two programs to eliminate any duplication of effort. The 14 wells which were originally installed as part of the AOC 29 HFBR program are utilized either as sentinel wells or to bound the strontium-90 plumes to the east.

Sampling Frequency and Analysis: The wells are sampled semiannually (See Table 8-2). Samples are analyzed for strontium-90 (see Table 8-4).

8.3.3.2.1.3 Operable Unit (OU) IV

The OU IV area contains two significant source areas: The 1977 fuel oil/solvent spill site (AOC 5) and the Building 650 (Reclamation Facility) Sump Outfall area (AOC 6). There are individual monitoring programs which address these two distinct plumes.

OU IV AOC 5 Program

Source Area Description: In 1977, a 23,000 to 25,000 gallon mixture of Number 6 fuel oil and mineral spirits was released from a ruptured pipe used to transfer the contents from a UST to aboveground storage tanks at the Central Steam Facility (CSF). In addition, several small spills of Number 6 fuel oil from the CSF fuel unloading area were documented between 1988 and 1993, and it is suspected that small volumes of solvents, such as PCE, have been released to the ground in the vicinity of the CSF. Eighteen wells are used to monitor this area. VOC contamination originating from the CSF area is currently monitored under two programs: the OU IV 1977 spill area cleanup program (AOC 5), and the OU I/IV program which monitors the downgradient (south of Brookhaven Avenue) component of the OU IV plume.

Description of Groundwater Quality: The primary chemical contaminants found in the OU IV plume near the 1977 spill site are TCA, PCE, DCE, TCE, toluene, ethylbenzene, and xylenes. However, monitoring data suggest that there may have been additional historical solvent spills in the vicinity of the

CSF (primarily PCE). In general, VOCs are present in the shallow Upper Glacial aquifer near the source area and in the deep portion of the Upper Glacial aquifer at the southern site boundary and just offsite.

An air sparging/soil vapor extraction (AS/SVE) remediation system has been in operation since November 1997, to remediate VOC and semi-VOC contamination of soils and groundwater near the spill site. Since the start of remediation, significant decreases in VOC concentrations were observed in wells located near the 1977 spill site. However, at this time it is not clear whether the reduction in VOC concentrations is due to the AS/SVE System, shifting of the plume due to AS operation or a combination of both.

Criteria for Selecting Sample Locations: A network of 26 wells was designed to monitor the effectiveness of the groundwater remediation system and extent of the VOC plume associated with the 1977 spill (see Table 8-3 and Figure 8-17). Locations were selected with the assistance of the BNL Regional Groundwater Model. Consideration was given during the well placement planning process to the proximity of the RA V and HO Recharge basins and their associated effects on local groundwater flow patterns. Sixteen of the wells sampled under this program are also utilized for monitoring for radionuclide contamination originating from the Building 650 Sump Outfall Area. Sampling events are coordinated between the two programs to eliminate any duplication of effort.

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). Samples are analyzed for VOCs and SVOCs (see Table 8-4). The wells which are also utilized for the OU IV AOC 6 (Building 650 Sump Outfall) program are analyzed semiannually for gross alpha/beta, gamma spectroscopy, strontium-90, and tritium.

OU IV AOC 6

Source Area Description: Building 650 was constructed for the decontamination of radioactively contaminated clothing and heavy equipment. These operations date back to at least 1959. A drainage pipe from the outdoor decontamination pad behind Building 650 leads to a natural depression in a wooded area approximately 800 feet northeast of Building 650. The natural wooded depression is referred to as the Building 650 Sump Outfall Area. There is an area of radiological contaminated soil approximately 90 feet by 90 feet in this area that has acted as a source for groundwater contamination.

Description of Groundwater Quality: Soil and groundwater contamination at the Building 650 Sump Outfall is due to the historical discharge of radionuclides to the Building 650 sump. Historically, strontium-90 has been detected at concentrations above the NYSDWS in a number of the wells located downgradient of the Building 650 Sump Outfall (Wells 76-13, 76-24, 76-168 and 076-169).

Criteria for Selecting Sample Locations: A monitoring network was designed to address the extent of strontium-90 contamination originating from the Building 650 Sump Outfall area. The network consists of 22 wells that are located to define the limits of strontium-90 contamination and serve as early warning monitoring for downgradient migration of the plume (see Table 8-3 and Figure 8-18).

Sampling Frequency and Analysis: The wells are sampled semiannually (see Table 8-2). Samples are analyzed for gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 (see Table 8-4).

8.3.3.2.1.4 Operable Unit (OU) V Sewage Treatment Plant Program

Source Area Description: The BNL STP has received historical contaminant discharges since 1947. Contaminants including VOCs, metals, and radionuclides have been introduced to groundwater via the sand filter beds and discharges to the Peconic River.

Description of Groundwater Quality: The primary chemical contaminants that are found in the STP plume are TCE and TCA. A VOC plume extends from the STP to the southeastern site boundary and offsite to the vicinity of the Long Island Expressway (LIE). The depth of contamination is shallow in onsite areas and migrates to the deep Upper Glacial aquifer offsite.

Inorganic contaminants were identified in soils and sediments during the OU V RI/FS, including mercury and hexavalent chromium. These contaminants were not detected in groundwater samples during 1999. In addition, offsite wells were sampled and analyzed for pesticides and PCBs. Analytical data indicate the presence of 4,4''-DDD (dichlorodiphenyldichloroethane) and 4,4''-DDT (dichlorodiphenyltrichloroethane) in Well 600-19. 4,4''-DDT was also detected in well 600-21. Detectable levels of tritium have been found in site boundary wells 50-02 and 61-05. Tritium was not detected in any of the STP offsite monitoring wells during 1999.

Criteria for Selecting Sample Locations: A monitoring network of 34 wells was designed to address groundwater contamination in the vicinity of the STP, at the boundary and offsite (see Table 8-3 and Figure 8-19). Sentinel wells were installed downgradient of the leading edge of the offsite VOC plume. The BNL Regional Groundwater Model was utilized to aid in the placement of these wells.

Sampling Frequency and Analysis: Wells are sampled semiannually (see Table 8-2). Samples are analyzed for VOCs, Pesticides/PCBs, water quality parameters, metals, and tritium (see Table 8-4).

8.3.3.2.1.5 Operable Unit (OU) VI Ethylene Dibromide (EDB) Program

Source Area Description: In the 1970s, EDB was used as a fumigant in the BNL Biology Department's agricultural fields located in the southeast portion of the site. Groundwater characterization work undertaken in 1995-96 found low level detections of EDB in groundwater in the vicinity of the source area and higher levels of EDB migrating to the southern site boundary and offsite.

Description of Groundwater Quality: An EDB contaminant plume extends from BNL's southeastern site boundary to an area south of North Street. Contamination migrates down to the mid Upper Glacial aquifer at the site boundary and the deep Upper Glacial aquifer offsite. The highest EDB concentration in 1999 was observed in offsite Well 000-175 at 5 ppb.

Criteria for Selecting Sample Locations: A network of 27 wells has been designed to monitor the EDB plume form the source area in the BNL Biology department's agricultural fields to locations on private property south of North Street (see Table 8-3 and Figure 8-20). The monitoring network was enhanced during 1999 with additional wells that defined the leading edge of contamination and sentinel wells that will provide early warning of plume migration.

Sampling Frequency and Analysis: The wells are sampled quarterly (see Table 8-2). Samples are analyzed for VOCs, gross alpha/beta, and tritium on an annual basis. Analyses are performed for EDB, TOC, carbon dioxide (CO_2), ethene, and ethane quarterly (see Table 8-4).

8.3.3.2.2 Source Areas Monitored under Environmental Surveillance Program

BNL's ES program includes monitoring at active waste processing and temporary storage facilities to comply with RCRA, waste-treatment facilities, operational monitoring around accelerators, and in other areas of known or suspected soil and groundwater contamination. In September 1998, BNL finalized a *Groundwater Monitoring Improvements Plan* [Paquette 1998] which identified active research and support facilities that required improved groundwater monitoring programs. As a result of this evaluation, over 80 new groundwater monitoring wells were installed during CY 1999 and CY 2000.

The facilities monitored under the ES program include: the Alternating Gradient Synchotron complex, the Relativististic Heavy Ion Collider, the Brookhaven LINAC Isotope Producer, Brookhaven Medical Research Reactor, Sewage Treatment Plant, Biology Department Greenhouses, Rifle and Shotgun Ranges, Major Petroleum Facility, Site Maintenance and Motor Pool area, and the onsite Gasoline Service Station.

Alternating Gradient Synchrotron (AGS) Complex

The AGS complex is located near the northern portion of the developed area of the BNL site. The AGS began operations in the early 1960s. The AGS accelerator and experimental system are made up of four basic units: the particle injection source, the booster accelerating ring, the main accelerating ring, and experimental target areas.

Secondary particles are created near beam loss points, beam targets and beam stops. These particles have the potential to escape into the soils surrounding the accelerator tunnels or into the soils underlying target and beam stop areas in the experimental hall areas (such as Building 912). Beam stops are the sinks used to absorb the energy and associated radiation from beams that have completed their utility. The stops are typically made up of ilmenite loaded concrete or iron. The length and dimensions of the beam stops are designed to assure that the radiation generated is attenuated to the greatest extent practicable. Although considerable effort is taken to design appropriate shielding and other engineering controls into these systems, many secondary particles will still interact with soils surrounding the tunnels and underlying floors. In the soils, these secondary particles interact with the silicon and oxygen atoms that make up most of the quartz-rich sands and gravels that are native to the BNL site. The types of radionuclides created include tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15, and sodium-22. Once present in the soils, these radionuclides can be leached downward into groundwater by means of rainwater percolation. These leaching processes are usually quite slow and, therefore, only radionuclides with long half-lives such as tritium ($t_{1/2}$ = 12.3 years) and sodium-22 ($t_{1/2}$ = 2.6 years) are likely to be detected in the groundwater below the AGS. BNL has been taking steps to either reduce the amount of radioactivity produced in soils (by means of additional shielding or modifying operating procedures) or to prevent the leaching of these materials to groundwater by the construction of impermeable caps.

Another potential source of groundwater contamination is the inadvertent release of activated water from the AGS's primary cooling water systems. Several dedicated primary cooling water systems are distributed throughout the AGS facility supplying water to the magnets and radio frequency caves. Because of secondary radiation generated near the beam lines, radionuclides (primarily tritium), are produced in the cooling water. Historically, accidental spills of activated water were routed into floor drains that were originally connected to the storm drain system [BNL 1997]. In the 1960s and 1970s, however, stormwater was routed to two former recharge basins located just to the north of the AGS complex. Water entering the AGS area storm drain systems is presently discharged to either Basin HN, located approximately 1,200 feet north of the AGS complex, or to Basin HT, located directly north of the LINAC.

AGS Building 912

<u>Source Area Description</u>: Building 912 (Experimental Area Group) consists of five interconnected structures. The equipment in the building include the beam lines (A, B, C, and D Lines) with magnets, instrumentation, high voltage electrostatic devices, beam targets, radiation shielding, cooling water

systems and experimental detectors. A typical beam line contains bending and focusing electro-magnets along with their associated electrical power supplies, cooling water systems and vacuum pipes.

Beam loss and production of secondary particles at proton target areas results in the activation of adjacent equipment, floors, and probably the soils beneath the building's floor. The highest levels of soil contamination beneath Building 912 are expected at the B-Line target cave [Beavis *et al.* 1993; BNL 1993].

The present target design includes shielding which is likely to significantly reduce the production of additional soil activation. During the earlier years of AGS operation, less shielding was used directly below the target areas (i.e., essentially it consisted of the 1.5 foot thick floor slab). Although the water used to cool these target stations becomes highly activated, the water is contained within a closed loop water system. Stormwater infiltration around the building is controlled by paving and stormwater drainage systems that direct most of the water to recharge basins located to the north of the AGS complex. Therefore, it is thought that most of the potentially activated soils underlying the beam targets and stops are protected from surface water infiltration. However, additional evaluation is needed to ensure that floor drains or other sub-floor water handling systems are not located near these activated areas, and that they are not leaking.

<u>Description of Groundwater Quality</u>: In 1999, BNL established a groundwater surveillance well network immediately upgradient and downgradient of Building 912. This network consists of 17 shallow Upper Glacial aquifer wells (Figure 8-21). Monitoring conducted during 1999 indicated the presence both tritium and sodium-22 in wells downgradient of Building 912 at concentrations well below the applicable drinking water standards. Tritium and Na-22 were also detected in several of the upgradient wells. These radionuclides are due to activated soils located near the g-2 Experiment and the former U-Line target. In addition to radionuclides, TCA is routinely detected in the WCF wells at concentrations that are slightly above the NYSAWQS. The presence of VOCs in groundwater in the AGS area is the result of historical discharges of solvents to cesspools and surface spills.

<u>Criteria for Selecting Sample Locations</u>: Seventeen shallow Upper Glacial aquifer wells have been installed upgradient and downgradient of Building 912. The wells were positioned to be directly downgradient of significant beam stop and target areas within Building 912. The downgradient wells consist of a combination of wells screened from five feet above to ten feet below the water table, and wells screened from 15 to 25 feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of the uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table. The downgradient wells screened from 15 to 25 feet below the water table allow for the detection of contaminants originating from upgradient sources (e.g., the g-2 experimental area and the former U-Line target area).

<u>Sampling Frequency and Analysis</u>: The wells will be monitored four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). Some of the wells will be sampled semiannually for VOCs. Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

AGS Booster

<u>Source Area Description</u>: The AGS Booster is a circular accelerator with a circumference of nearly 660 feet (200 meters), and is connected to the northwest portion of the main AGS ring and the LINAC. The

AGS Booster, which has been in operation since 1994, receives either a proton beam from the LINAC or heavy ions from the Tandem Van de Graaff. The Booster accelerates protons and heavy ions prior to injection into the main AGS ring. In order to dispose of the beam during studies, a beam scraper system consisting of a beam kicker and an absorber block was constructed at the 10/11 o'clock portion of the Booster (Figure 8-21).

The AGS Booster beam scraper is an area where the interaction of secondary particles and soil surrounding the Booster tunnel will result in production of tritium and sodium-22. Although internal shielding around the beam scraper was designed to keep radiation levels in soils below DOE As Low As Reasonably Achievable (ALARA) guidelines, a landfill-type geomembrane cap was constructed over the scraper region to provide an extra margin of protection. The cap extends 15 feet upstream and 45 feet downstream of the beam scraper and is covered with a soil-crete mixture. If the cap, in concert with the overlying soil-crete cover, is effective at preventing water from leaching through the activated soils, the radioactivity will be confined to the region outside the Booster tunnel, allowing for the radioactivity to decay in place.

Description of Groundwater Quality: The AGS Booster area is monitored by two downgradient surveillance wells that were installed in 1999. Available data indicate only the presence of trace concentrations of Na-22 (less than 3 pCi/L).

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the AGS Booster area is to the south-southeast. Monitoring wells 064-51 and 064-52 are located approximately 250 feet downgradient of the beam stop (Figure 8-4). Two nearby upgradient wells (054-61 and 054-61) are used to provide data on background radionuclide concentrations. The wells are screened from five feet above to ten feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of the uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table.

Sampling Frequency and Analysis: The wells will be monitored four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). Some of the AGS Booster wells may be sampled semiannually for VOCs (see Table 8-3). Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

AGS E-20 Catcher

Source Area Description: The E-20 beam catcher that was used from 1984 to 1999. It is located at the 5 o'clock position of the AGS ring (Figure 8-21). The E-20 Catcher is a minimum aperture area of the AGS ring, and is used to pick up or "scrape" protons that move out of acceptable pathways. The E-20 Catcher is subject to injection, transition, ejection, and losses studies, and picks up about 80 to 90 percent of all of these losses.

Like other beam loss areas within the AGS complex, the E-20 Catcher is an area where the soils surrounding the AGS tunnel may have become activated by the interaction with secondary particles. Construction records indicate that AGS tunnel at the E-20 Super Period is partially covered by layers of sand, styrofoam, and soil-crete. The presence of low levels of tritium and Na-22 in downgradient monitoring wells indicates that the soil-crete cover is not effective in preventing rainwater infiltration through the activated soils surrounding the E-20 Catcher.

Description of Groundwater Quality: In 1999, two shallow Upper Glacial aquifer wells were installed downgradient of the E-20 Catcher area. Data from one of these wells (064-56) indicate low levels of both tritium (up to 5,800 pCi/L) and sodium-22 (up to 71 pCi/L). In January 2000, four Geoprobe wells were installed near Well 064-56 to better define the extent of the tritium and sodium-22 plume. Detectable levels of tritium and sodium-22 were found in samples from three of the four temporary wells. The well installed furthest to the northeast (064-063) did not contain tritium or sodium above detectable levels. The highest concentrations of sodium-22 and tritium were found in well 064-065 at concentrations of 704 pCi/L and 40,400 pCi/L, respectively. These wells are located approximately 12' and 24' southwest of permanent well 064-056 respectively.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the E-20 Catcher area is to the south-southeast. Two downgradient wells (064-55 and 064-56), located approximately 100 feet to the south-southeast of the E-20 Catcher area, are used to assess potential impacts to groundwater quality (Figure 8-21). The wells are screened from five feet above to ten feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table.

Sampling Frequency and Analysis: The wells will be monitored four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). The wells may be sampled semiannually for VOCs (see Table 8-3). Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

Building 914

Source Area Description: Building 914 houses the transfer line between the main AGS Ring and the Booster (Figure 8-21). Due to beam loss near the extraction (kicker) magnet, the extraction area of Building 914 is heavily shielded with iron. Since the extraction area is housed in a large building structure, soil activation is likely to be limited to the areas below the floor of the building. As with other beam loss areas within the AGS complex, soil activation could result in the introduction of tritium and sodium-22 to the groundwater below the facility. Formal assessments of the possible concentration of radionuclides in soils using the Cascade Simulation (CASIM) model have not been conducted to date. Water infiltration through potentially activated soils is likely to be minor, because the soils are isolated beneath the floor of the building, and portions of the transfer tunnel are covered with a soil-crete mixture.

Description of Groundwater Quality: Monitoring data from the downgradient wells indicate the presence of trace amounts of tritium (less than 500 pCi/L) and sodium-22 (less than 10 pCi/L). Neither tritium or Na-22 are detectable in the upgradient wells. The VOC 1,1,1-TCA has also been routinely detected at concentrations above the NYSAWQS of 5 µg/L in samples from well 064-03, and is likely to have originated from the historical discharge of solvents to several sanitary cesspools located in the northwest, in the Building 919 area.

Criteria for Selecting Sample Locations: Groundwater quality in the Building 914 transfer line area is monitored by two upgradient wells (054-08 and 054-61) and three downgradient wells (064-03, 064-53 and 064-54). The predominant groundwater flow direction in the Building 914 area is to the south-southeast (Figure 8-21). The wells are screened from five feet above to ten feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table.

Sampling Frequency and Analysis: The wells will be monitored four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). The wells may be sampled semiannually for VOCs (see Table 8-3). Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

g-2 Beam Target and Stop

Source Area Description: The g-2 Experiment runs off of the AGS V-Line, and includes a target building and beam stop located north of the 1 o'clock region of the AGS Ring (Figure 8-21). Although the g-2 Beam Stop is made of iron, which is expected to absorb most of the beam energy, some activation of the soil overlying the stop is expected to occur. The beam target building and beam stop were built upon a concrete pad that extends over several acres in the V-Line target area.

Based upon the original design of the g-2 Experiment, it was anticipated that activation products would be produced in the soils surrounding the g-2 Beam Stop and, potentially, some of the soils underlying the beam target and stop. Although these concentrations were expected to be very low (less than 2,000 pCi/L in rainwater leachate) a gunnite cap, coated with a reinforced emulsion waterproofing, was constructed over the beam stop area. However, in November 1999, very high levels of tritium (concentrations up to 1,800,000 pCi/L) were detected in Geoprobe wells located downgradient of the g-2 Experiment area. The source of this tritium was determined to be an activated soil shield covering a section of the g-2 beam line. This activation occurred due to unexpected beam losses at the g-2 beam line magnet VQ12. To prevent additional rainwater infiltration of these activated soils, in December 1999 the gunnite cap was extended to cover the entire VQ12 magnet area and the g-2 Beam Stop.

Description of Groundwater Quality: Monitoring data from the downgradient wells indicate the presence of high levels of tritium (up to 1,800,000 pCi/L) and sodium-22 (up to 60 pCi/L). Only trace amounts of tritium are detectable in the upgradient wells. The VOC 1,1,1-TCA has also been routinely detected at concentrations above the NYSAWQS of 5 µg/L in several of the wells, and is likely to have originated from the historical discharge of solvents to several sanitary cesspools located in the northwest, in the Building 919 (g-2 Experiment Building) area.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the g-2 beam target and stop area is to the south-southeast, although the flow may be slightly more easterly during periods of extended operation of potable supply well 10 (Figure 8-21). The g-2 VQ12 magnet soil activation and g-2 Beam Stop areas are monitored using two upgradient wells (054-65 and 0054-66) and six downgradient wells (054-07, 054-67, 054-68, AGS-36, AGS-37 and AGS-38). The wells are generally screened from five feet above to ten feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table.

Sampling Frequency and Analysis: The wells will be monitored a minimum of four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). Due to the need to closely track the g-2 tritium plume, monthly samples may be collected from select downgradient wells (see Table 8-3). Some of the g-2 area wells may also be sampled semiannually for VOCs. Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

J-10 Beam Stop

Source Area Description: The Collider-Accelerator (C-A) Department established a new beam stop at the J-10 (12 o'clock) region of the AGS in 1999 (Figure 8-21). The J-10 Beam Stop serves as the preferred repository for any beam that might be lost in the AGS ring. Activation products are likely to be produced in the soils surrounding the tunnel adjacent to J-10 Beam Stop. The J-10 Beam Stop will be subject to the same injection, transition, ejection, and losses studies presently occurring at the E-20 Catcher discussed above. The ability of rainwater to infiltrate potentially activated soils surrounding the J-20 Beam Stop is likely to be significantly reduced because the AGS tunnel has been covered by layers of sand, styrofoam, and soil-crete. In an effort to further reduce the potential for surface water to infiltrate activated soils, a gunnite cap was constructed over open soil areas overlying the J-10 region.

Description of Groundwater Quality: Data from two recently installed wells downgradient of the J-10 Beam Stop indicate the presence of trace amounts of Na-22. Tritium has not been detected.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the J-10 Beam Stop area is to the south-southeast, although the flow may be slightly more easterly during extended periods of operation of potable supply well 10 (Figure 8-21). The J-10 Beam Stop area is monitored using one upgradient well (054-62) located to the northwest of the beam stop, and two downgradient wells (054-63 and 054-64) located to the south-southeast of the stop. The wells are screened from five feet above to ten feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table.

Sampling Frequency and Analysis: The wells will be monitored four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). Some of the J-10 Beam Stop area wells may also be sampled semiannually for VOCs (see Table 8-3). Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

Brookhaven LINAC Isotope Producer (BLIP)

Source Area Description: The Brookhaven LINAC Isotope Producer facility is located at the southern end of the AGS's LINAC (Figure 8-21). When the BLIP is operating, the LINAC delivers a 200 MeV beam of protons which impinges on a series of eight targets located within the BLIP target vessel. The radionuclides produced during this interaction are later processed for pharmaceutical applications.

The BLIP targets are located at the bottom of a 30 foot underground tank. Within this tank, the targets rest inside a water-filled 18-inch diameter shaft that runs the length of the tank. The targets are cooled by a 500 gallon closed loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and activation of the soils immediately outside of the tank occurs due to the creation of secondary particles produced at the target [CDM Federal 1999]. The BLIP facility also has a 500 gallon-capacity UST used for liquid radioactive waste (change out water from the BLIP primary system).

The waste tank and its associated piping system meet all Article 12 requirements, and is registered with the SCDHS.

In February 1998, elevated levels of tritium and Na-22 were detected in wells located downgradient of BLIP. A subsequent investigation determined that source of this contamination was the activated soils surrounding the BLIP target vessel. To prevent rainwater from infiltrating the activated soils below the building, the BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive gunnite cap was installed on three sides of the building. Remediation of the activated soils, by means of soil grouting, will be conducted during CY 2000 as part of the ER program.

Description of Groundwater Quality: Both tritium and sodium-22 have been detected in the groundwater downgradient of the BLIP facility. In 1998, tritium concentrations exceeded NYSDWS in wells located directly downgradient of BLIP. However, following the implementation of the corrective measures noted above, the tritium concentrations have dropped to well below NYSDWS.

Criteria for Selecting Sample Locations: The predominant direction of groundwater flow in the BLIP facility area is to the south-southeast (Figure 8-21). The BLIP facility is monitored using two upgradient wells (54-61 and 064-46) and six downgradient wells (064-47, 064-48, AGS-07, 064-49, 064-50, and 064-02). The wells are screened from five feet above to ten feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table. These wells are used to verify that the engineering controls implemented at the BLIP are effective in preventing additional groundwater contamination.

Sampling Frequency and Analysis: The wells will be monitored four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). Some of the BLIP area wells may also be sampled semiannually for VOCs (Table 8-3). Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

Former U-Line Target Area

Source Area Description: The U-Line target area was used by the AGS Department from 1974 through 1986 (Figure 8-21). During its operation, a 28 GeV proton beam from the AGS would first strike a target and the resulting secondary particles would be selected by an arrangement of two magnetic "horns" and collimators immediately downstream of the target [Gollon *et al.* 1989]. Secondary particles desired for research would be focused by the horns, and other particles would either strike the collimators or be defocussed and enter the surrounding shielding. The entire assembly was located in a ground-level tunnel covered with an earthen berm. Internal shielding was stacked around the horns. Although the U-Line target has not been in operation since 1986, the associated tunnel, shielding, and overlying soils remain in place.

The former U-Line target and horns are areas where the interaction of secondary particles with soil surrounding the tunnel resulted in production of tritium and sodium-22. Gollon *et al.* [1989] detected both tritium and sodium-22 in soil samples obtained beneath the original target location. Because an impermeable cap did not cover the tunnel, the activated soils above and on the sides of the tunnel structure would have been exposed to rainwater. Because this facility has not been used since 1986, the tritium and sodium-22 that either remains as residual soil contamination or that was leached to groundwater would have decayed by one and five half-lives, respectively.

Description of Groundwater Quality: Existing groundwater monitoring well 54-01 was installed in the mid-1980s to evaluate the potential impact of soil activation at the U-Line target area [Gollon *et al.* 1989]. However, groundwater samples collected soon after the well was installed were nondetectable for both tritium and sodium-22 [Gollon *et al.* 1989]. Although the well has been frequently sampled since 1992, only trace amounts of sodium-22 (up to 3 pCi/L) have been detected. A review of available well construction data indicates that the well may be screened five to ten feet below the water table, which is too deep to effectively monitor a nearby source such as the U-Line target area. The solvent TCA has been routinely detected in well 54-01. The TCA is likely to have originated from the historical discharge of solvents to nearby cesspools or spills in the former Bubble Chamber area located to the north-northwest of the former U-Line target area (OU III, AOC-14). A second monitoring well, well 54-07, is located approximately 200 feet downgradient of the g-2 Beam Stop and 600 feet south of the former U-Line target area. The well is screened within the upper 10 to 15 feet of the Upper Glacial aquifer, and has been monitored routinely since 1992. Tritium and sodium-22 were detected. Based upon groundwater flow pathways, the tritium and sodium-22 are likely to have originated from the former U-Line target area. Furthermore, TCA has been routinely detected in samples from well 54-07. As with the TCA detected in well 54-01, the TCA detected in well 54-07 is likely to have originated from the former Bubble Chamber area located to the north-northwest of the former U-Line target area.

Criteria for Selecting Sample Locations: To determine whether residual soil contamination in the Former U-line target area is impacting groundwater quality, a series of shallow Upper Glacial aquifer wells were installed in early CY 2000. The predominant groundwater flow direction in the former U-Line target area is to the south-southeast, although the flow may be slightly more easterly during periods of extended operation of potable supply well 10.

The Former U-Line area is monitored by one upgradient (MW-AGS-30) three downgradient wells (MW-AGS-31, -32, and -33) (Figure 8-21). Data from well 045-066, installed upgradient of the g-2 beam target and stop, will also be used to evaluate potential releases from the former U-Line target area. The wells are screened from five feet above to ten feet below the water table. These screen positions are required because the wells are installed very close to suspected tritium source areas, and will allow for the sampling of uppermost few feet of the aquifer following seasonal fluctuations in water table position. The recent detection of high levels of tritium within the uppermost three to four feet of the aquifer downgradient of the HFBR, BLIP, and g-2 Experiment facilities has underscored the need to perform routine monitoring of groundwater quality at the water table.

Sampling Frequency and Analysis: The wells will be monitored four times per year (Table 8-4). Samples will be collected quarterly for tritium and gamma analyses, and semiannually for gross alpha/beta (Table 8-5). Some of the Former U-Line target area wells may also be sampled semiannually for VOCs (Table 8-3). Because the VOCs are due to historical discharges and spills, the samples will be analyzed as part of the ER program (OU III).

8.3.3.2.3 Relativistic Heavy Ion Collider (RHIC)

The RHIC facility consists of a the Collider ring which is 12,578 feet in circumference, the beam injection system (consisting of the W-, X- and Y-Lines), six experimental halls, and a number of support buildings (Figure 8-22). The RHIC tunnel was constructed at grade and is covered by earthen shielding which is elevated approximately 30 feet above the grade of Ring Road. A portion of the headwaters for the Peconic River enter and exit the ring by means of culverts located in the northwest and east sections of the RHIC ring.

Within the RHIC facility, there are two areas where radionuclides may be produced in the soils outside of the Collider tunnel from beam loss during operational periods. The first area contains the beam stops that are located at the 10 o'clock position of the ring, and the second contains the collimators that are located at the 8 o'clock region. Secondary particles created at the internal beam stop and collimator areas have the potential to escape into the soils immediately surrounding those areas. The types of radionuclides created from interacting secondaries include tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15, and sodium-22 [Stevens 1987; BNL 1991].

Although levels of soil activation are expected to be very low, BNL installed geomembrane covers over the beam stop and collimator areas as a means of preventing rainwater from leaching through the soils at the source of radionuclide production (see discussions in Paquette, 1998). With the installation of the caps, it is anticipated that most of the radioactivity produced at the RHIC beam stops and collimators will decay in place.

Beam Stop Area

Source Area Description: The RHIC beam stops are located at the 10 o'clock intersection region of the RHIC (Building 1010), and are the place where the vast majority (approximately 85 percent) of the beam energy will end up. Consequently, there is concern that direct activation of soils surrounding the RHIC tunnel may impact groundwater quality in areas surrounding the beam stops. The beam stops are located approximately 200 feet to the north and south of the centerline of Building 1010. The southern beam stop is located approximately 200 feet north of the culvert that conveys the Peconic River below the RHIC ring.

To limit the potential impact that the RHIC Project may have on groundwater quality, landfill-type caps (using geomembrane fabric) were installed over the two beam stop areas prior to the start up.

Description of Groundwater Quality: During CY 1999, four quarters of pre-operational monitoring was conducted to establish a baseline data set for groundwater quality in the RHIC beam stop area. These data indicate nondetectable levels of either tritium or Na-22. All metals and anion concentrations are consistent with natural background levels.

Criteria for Selecting Sample Locations: To evaluate the effectiveness of the caps overlying the RHIC beam stops, a series of shallow Upper Glacial aquifer wells were installed directly upgradient and downgradient of each of the stops (Figure 8-22). The predominant groundwater flow direction in the RHIC beam stop area is to the southeast. The RHIC beam stop area was built in the low lying portion of the Peconic River drainage system. The depth to groundwater below the tunnel floor is approximately 15 feet, whereas in low lying areas off the RHIC berm, near the Peconic River, the depth to groundwater can be as little as five feet or less. Furthermore, recently installed borings at the 9 o'clock position of RHIC indicate portions of the tunnel may have been constructed over low permeability fine sands, silts, and clays that are indicative of stream deposition. These low permeability deposits may retard the percolation of rainwater, which may result in perched or semiperched water table conditions.

As a means of verifying that the operation of the RHIC beam stops will not impact groundwater quality, one well was installed directly upgradient of each beam stop (wells 025-003 and 025-004), and two wells were installed directly downgradient of each beam stop (wells 025-005/025-006 and 025-007/025-008). The upgradient wells were installed on top of the bermed area overlying the RHIC tunnel, as close as possible to the upgradient side of each beam stop (within 10 feet). The wells are screened from five feet above to ten feet below the water table. As with wells installed near the other tritium source areas described above, these screen positions allow for the sampling of the uppermost few feet of the aquifer following seasonal fluctuations in water table position.

Sampling Frequency and Analysis: The new wells will be monitored quarterly for gamma spectroscopy and tritium analyses, and semiannually for gross alpha/beta (Table 8-4 and 8-5). Furthermore, because the southern beam stop is located within 200 feet of the culvert for the Peconic River, surface water samples will be collected to verify that potentially activated groundwater is not being discharged to the stream bed during high transient water table conditions (see Surface Water Monitoring program, Chapter 7). When surface water is present, water samples will be collected at a sample location near the Ring Road quarterly for tritium analysis and gamma spectroscopy.

Collimator Area

Source Area Description: The RHIC limiting aperture collimators are identified areas of beam loss, and are therefore areas where creation of secondary particles may result in the activation of soils surrounding the RHIC tunnel. The collimator areas are located at the 8 o'clock region of the RHIC (Figure 8-22).

In an effort to reduce the potential impact that the RHIC Project may have on groundwater quality, landfill-type caps (using geomembrane liners) were constructed over the collimator areas prior to the start of beam operations at RHIC (see discussions in Paquette, 1998). The caps will prevent the infiltration of precipitation through the most highly activated soils surrounding the tunnel, and thereby limiting the leaching of radionuclides to groundwater.

Description of Groundwater Quality: During CY 1999, four quarters of pre-operational monitoring was conducted to establish a baseline data set for groundwater quality in the RHIC beam stop area. These data indicate nondetectable levels of either tritium or Na-22. All metals and anion concentrations are consistent with natural background levels.

Criteria for Selecting Sample Locations: To evaluate the effectiveness of the geomembrane caps, a series of shallow Upper Glacial aquifer wells were installed adjacent to and downgradient of the collimator areas. The predominant groundwater flow direction in the RHIC collimator area is to the southeast, which is parallel to the RHIC tunnel in this region. Four wells (043-001, 043-002, 044-013, and 044-014) were installed directly downgradient of the collimator portion of the tunnel (Figure 8-22). Because the direction of groundwater flow is nearly parallel with this portion of the RHIC tunnel, the wells were installed close to the tunnel on both the east and west sides. The downgradient wells were installed as couplets, with shallow wells screened from five feet above to ten feet below the water table, and deeper wells screened from 15 to 25 feet below the water table. In an effort to establish a more direct means of evaluating groundwater quality close to the potentially activated soils, two wells (034-005 and 034-006) were installed along the top of the RHIC tunnel, approximately 150 feet to the north and south of beam crossing point located within Building 1008. The wells are positioned adjacent to the front edge of the collimators, where the predicted highest levels of soil activity will occur. Assessment of background radionuclide concentrations will be accomplished utilizing Upper Glacial aquifer wells 17-01 and 25-01. (Note: Well 017-001 is monitored as part of the ER's Site Background Monitoring program.)

Sampling Frequency and Analysis: The wells will be monitored quarterly for tritium and gamma spectroscopy, and semiannually for gross alpha/beta (Tables 8-4 and 8-5).

8.3.3.2.4 Brookhaven Medical Research Reactor (BMRR)

Source Area Description: The BMRR is a 3 MW light water reactor used for biomedical research, most notably of which is Boron Neutron Capture Therapy for brain tumor treatment. The BMRR's primary cooling water system consists of a recirculation piping system that contains 2,550 gallons of water. The tritium concentration in the primary water is currently 465 µCi/L, for a total tritium content of 4.5 Ci. Unlike the High Flux Beam Reactor, the BMRR does not have a spent fuel storage canal or pressurized imbedded piping systems that contain radioactive liquids. Historically, fuel elements that required storage are either stored within the reactor vessel, or were transferred to the HFBR spent fuel canal. The primary system's piping is fully exposed within the containment structure, and is accessible for routine visual inspections. Excess heat is transferred by means of heat exchangers with once through (secondary) cooling water which is obtained from process supply well 105 or the BNL Chilled Water System. This secondary water is discharged to recharge basin HP located 800 feet to the south of the Medical Department complex.

Low levels of tritium have been detected in several monitoring wells located directly downgradient of the BMRR facility. Review of systems and operations within the BMRR facility identified two potential sources for the tritium detected in the groundwater: (1) spills that occurred during the transfer of radioactive liquids to a former above ground storage tank; and (2) a floor drain system and associated sump that had received primary cooling water on a number of occasions. Although small volume releases did occur while transferring liquids to the tank on several occasions, the most likely source for the tritium detected in the groundwater is the floor drain system and associated unlined 150 gallon capacity SU-2 sump located in the basement of the BMRR. Records indicate a total of 16 spills or discharges totaling nearly 800 gallons of primary water to the floor drains or directly to the SU-2 sump. The last such discharge occurred in January 1987. Although most of the primary water that was discharged was properly disposed of, recent qualitative leak-rate testing indicates that the sump and/or floor drain piping system is not entirely leak tight and some amount of radioactive water may have leaked to the underlying soils. Furthermore, throughout the history of the BMRR, secondary (nonradioactive) coolant water was routinely discharged to the SU-2 sump and floor drain system. Leakage of secondary water could have provided sufficient water volume to drive the tritium through the unsaturated zone and into the groundwater below the reactor building.

To prevent future release of radioactive materials to the soils and groundwater below the BMRR, the floor drain system was abandoned. Although the last documented discharge of primary water to the SU-2 sump and floor drain system occurred in January 1987, continued use of the sump and floor drain system is likely to leach any residual contamination from the unsaturated zone into the groundwater. BNL also sealed the SU-2 sump, and a plastic container was installed in the sump pit. A liquid sensor installed in the sump will be used to detect any liquids outside the plastic container.

<u>Description of Groundwater Quality</u>: The highest tritium levels (approximately 18,000 pCi/L) are detected in temporary wells installed within 50 feet of the BMRR.

<u>Criteria for Selecting Sample Locations</u>: To evaluate the effectiveness of the corrective actions noted above, a series of shallow Upper Glacial aquifer wells were installed immediately upgradient and downgradient of the BMRR (Figure 8-23). The direction of groundwater flow in the area of the Brookhaven Medical Research Facility is predominantly to the south-southeast. The groundwater monitoring well network consists of one upgradient (084-028) and three downgradient wells (084-012, 084-013, and 084-027). The wells are screened from five feet above to ten feet below the water table. As with other wells BNL installed immediately downgradient of radionuclide source areas (described above), these screen positions allow for the sampling of uppermost few feet of the aquifer following seasonal fluctuations in water table position.

<u>Sampling Frequency and Analysis</u>: The five new wells will be sampled quarterly (Table 8-4). Groundwater will be tested for tritium, gross alpha/beta, and gamma spectroscopy (Table 8-5). Samples will be tested for strontium-90 if elevated gross beta values are detected.

8.3.3.2.5 Sewage Treatment Plant (STP)

The STP processes sanitary sewage for BNL facilities.

Sand Filter Bed Area

Source Area Description: Wastewater from the STP's clarifier is released to the sand filter beds, where the water percolates through five feet of sand before being recovered by an underlying clay tile drain system which transports the water to the discharge point at the Peconic River (State Pollution Discharge Elimination System [SPDES] Outfall 001). Approximately 15 percent (0.1 MGD) of the water released to the filter beds is either lost to evaporation or to direct groundwater recharge. At the present time, six sand filter beds are used in rotation.

Because of the known historical, and potential future accidental radiological and chemical releases to the sanitary system, it is necessary to monitor groundwater quality within the STP filter bed area. Due to past chemical and radiological releases to the sanitary system, the filter bed sands have been shown to be contaminated with radionuclides and heavy metals. For example, the filter bed sands were contaminated with low levels of cesium-137 and strontium-90 in 1988 as the result of a release of radioactive water from the WCF to the sanitary system. Although the most heavily contaminated soils were remediated, soil sampling conducted during the OU V RI revealed that low levels of cesium-137 remain. Analysis of the filter bed sand also indicates that heavy metals such as mercury, silver, chromium, and lead are also present in the filter bed sands [ITC 1998]. These radionuclides and heavy metals continue to leach from the sand filter beds at a slow rate [Schroeder *et al.* 1998]. Because as much as 15 percent of the water released to the filter beds is subject to direct groundwater recharge, it is necessary to conduct long-term monitoring of the groundwater within the filter bed area.

Description of Groundwater Quality: Historically, low levels of tritium, cesium-137, strontium-90, heavy metals, and VOCs have occasionally been detected in the filter bed area wells. Comparisons of cesium-137 and strontium-90 concentrations in both STP influent and effluent suggest that their presence in STP effluent and groundwater is likely to be the result of leaching of previously contaminated filter bed sands [BNL 1998]. Since 1998, tritium levels have dropped to near detection limit levels.

Criteria for Selecting Sample Locations: The groundwater monitoring program in the STP filter bed area is designed to supplement BNL's extensive Effluent Monitoring program that is conducted in accordance the BNL's SPDES Permit. In the STP area, a broad groundwater mound has formed below the plant's filter beds, where it is estimated that up to 0.1 MGD of STP effluent may be recharged directly to groundwater (Figure 8-24). Shallow groundwater in the filter bed area generally flows in a radial pattern due to this mounding effect. The groundwater surveillance network at the STP filter bed area consists of six shallow Upper Glacial aquifer wells (038-002, 038-003, 039-007, 039-008, MW-STP-01 and MW-STP-02).

Sampling Frequency and Analysis: The Sand Filter Bed wells will be monitored semiannually (Table 8-4). The groundwater samples will be analyzed for water quality (anions), VOCs, tritium, gamma spectroscopy and, as required, for strontium-90 (Table 8-5).

Emergency Holding Ponds

Source Area Description: Two emergency hold-up ponds are located to the east of the sand filter bed area. The hold-up ponds are used for the emergency storage of sanitary waste when the influent flow exceeds the STP's capacity or when the influent contains contaminants in concentrations exceeding BNL administrative limits and/or SPDES permit effluent release criteria. The hold-up ponds are equipped with fabric reinforced (hypalon) plastic liners, that are heat-welded along all seams.

To ensure that an accidental contaminant release is detected prior to reaching the STP and ultimately the Peconic River, real-time monitoring of the STP influent is conducted for radioactivity (gamma-emitting radionuclides), pH, conductivity, and oil. Effluent that does not meet BNL and/or SPDES permit effluent release criteria are diverted to one of the two lined holding ponds, until the effluent meets the release criteria.

The lined emergency holding ponds lack secondary containment and leak detection devices. Although BNL performs routine maintenance on these ponds, the possibility exists that undetected leaks could occur in the liners. Because the holding ponds have been and could be used to temporarily store water that is contaminated with either chemical or radioactive materials at concentrations well above drinking water standards, BNL is installing new liners and leak detection devices in the ponds.

Description of Groundwater Quality: There are no groundwater monitoring wells currently located directly downgradient of the emergency hold-up ponds. The closest downgradient monitoring wells are located approximately 300 feet to the east. Downgradient wells 039-003 and 039-009 are screened within the uppermost 10 feet of the Upper Glacial aquifer. Historically, monitoring results from these wells indicate low to nondetectable levels of radionuclides. Furthermore, metals concentrations have been below the applicable NYSAWQS, and no VOCs have been detected in these wells.

Criteria for Selecting Sample Locations: In early CY 2000, BNL installed three shallow Upper Glacial aquifer monitoring wells to provide a means of verifying that the operations at the emergency hold-up ponds do not impact groundwater quality (Figure 8-24). The wells (MW-STP-03, MW-STP-04, and MW-STP-05) are screened from five feet above to ten feet below the water table, and are located directly downgradient of the ponds.

Sampling Frequency and Analysis: The wells will be monitored semiannually for water quality (anions), VOCs, tritium, gross alpha, gross beta, and gamma spectroscopy (Tables 8-4 and 8-5).

8.3.3.2.6 Major Petroleum Facility (MPF)

Source Area Description: The MPF is the holding area for fuels used at the CSF. Fuel oil for the CSF is held in a network of seven above ground storage tanks. The tanks, which have a combined capacity to contain up to 1.7 million gallons of No. 6 fuel oil and 660,000 gallons of No. 2 fuel oil, are connected to the CSF by above ground pipelines that have secondary containment and leak detection devices. All fuel storage tanks are located in bermed containment areas that have a capacity to hold more than 110 percent of the volume of the largest tank located within each bermed area. The bermed areas have bentonite clay liners consisting of either Environmat (consisting of bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soils to form an impervious soil/clay layer. As of December 1996, all fuel unloading operations were consolidated in one centralized building that has secondary containment features. Presently, the MPF stores primarily No. 2 and No. 6 fuel oil. Groundwater contaminants from these products can travel both as free product and in dissolved form with advective groundwater flow.

An SPCC Plan is in place for the MPF. Most spills of consequence are likely to occur within the bermed containment areas. The clay liners within the containment berms are designed to prevent petroleum product from entering the soils. However, the undersides of the tanks are supported by concrete ringwalls and are not lined with clay. Outside of a complete dislodgement of the tank from its foundation, however, leakage through the containment system would primarily be limited to the liner-ring wall interface or leakage from the base of a tank. If sizable, these types of leaks would be evident through noticeably rapid changes in product level in the tank. Otherwise, minor leakage might continue unabated until aquifer impacts were realized in the groundwater monitoring wells. Since antecedent moisture in the vadose zone beneath the tanks is constrained to a large extent by the liner system, a certain volume from these minor leaks would be stored in the unsaturated soils, until field capacity is reached.

Description of Groundwater Quality: Groundwater surveillance conducted to date has not detected floating product or dissolved contamination that is attributable to the MPF bulk oil storage operations.

Criteria for Selecting Sample Locations: The initial groundwater monitoring program for the MPF was established in 1989 in accordance with the NYS licensing requirements for this facility. The present surveillance well network at the MPF consists of one upgradient and seven downgradient wells (Figure 8-25). The wells are screened across the water table so that free petroleum product (i.e., oil floating on top of the groundwater) can be detected. The predominantly southerly direction of groundwater flow at the MPF serves as the basis for the placement of the monitoring wells. Wells 076-016, 076-017 and MW-MPF-02 generally monitor tank batteries on the west side of the facility, whereas wells 076-18, 076-19, MW-MPF-01 and MW-MPF-03 monitor the more easterly group of tanks. Well 076-025 functions as the upgradient observation point for ambient water quality.

Sampling Frequency and Analysis: In accordance with the NYSDEC Operating Permit, the MPF wells are routinely monitored for both floating and dissolved product. The monitoring program includes sampling the wells two times a year for dissolved phase product (Tables 8-4 and 8-5). The samples are analyzed by a NYS certified contractor laboratory using EPA Method 625. Samples may also be analyzed for VOCs. Floating product determination measurements are conducted on a monthly basis.

8.3.3.2.7 Biology Department Greenhouses

Source Area Description: The Biology Department facility (Building 463) includes 11 greenhouses where various types of plants are grown for biological research. Eight of the greenhouses have dirt floors and three presently have concrete floors.

Pesticides, such as Endosulphan II, and fertilizers have been routinely used in the greenhouses. Records also indicate that copper sulfate was also applied to the dirt floors on an annual basis up to 15 years ago (see discussions in Paquette, 1998). Endosulphan II has been detected in soil samples collected from a dry well located within Greenhouse 10. A comprehensive sampling of the soils in the greenhouses has not been conducted, and it is likely that other pesticides have been used over the operational history of the facility.

Description of Groundwater Quality: There are no groundwater monitoring wells located directly downgradient of the Biology Department greenhouses. Existing wells located south of the greenhouses are either located too far away or not in the proper groundwater flow pathway to adequately monitor this facility. Process well 9 is located at the southern end of the Greenhouse area. The well, which is used by the Biology Department for filling fish tanks, is screened 65 to 70 feet below the water table. Although TCA is routinely detected in water samples from supply well 9, it is likely to have originated from identified TCA source areas located upgradient of the Biology Department such as spill sites located in the AGS research and support areas. Although water samples from well 9 have not been analyzed for pesticides, it is unlikely that potential contaminants from the green houses would be detected because the well is screened 65 feet below the water table and is pumped at very low rate.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the Biology Department greenhouse area is to the southeast (Figure 8-26). In early CY 2000, two shallow Upper

Glacial aquifer wells (temporarily designated MW-BIO-01 and MW-BIO-02) were installed downgradient of the greenhouse area, with one well located directly downgradient of the drywell located in Greenhouse 10. The wells were installed with fifteen foot screens that are positioned from five feet above to ten feet below the water table.

Sampling Frequency and Analysis: For CY 2000, the two new wells will be sampled semiannually (Table 8-4). The samples will be analyzed by a NYSDOH certified contractor laboratory for pesticides using EPA Method 608, and by the BNL Analytical Services Laboratory (ASL) for metals and water quality parameters (Table 8-5). If the initial samples indicate low or nondetectable levels of pesticides and metals, the sampling frequency for the greenhouse area wells may be reduced to once per year.

8.3.3.2.8 Motor Pool and Site Maintenance Area

Source Area Description: The Motor Pool (Building 423) and Site Maintenance Facility (Building 326) are attached structures located along West Princeton Avenue. The BNL Motor Pool area consists of a five bay automotive repair shop that includes office and storage spaces. The Site Maintenance Facility provides office space, supply storage, locker room, and lunch room facilities for custodial, grounds, and heavy equipment personnel. Both facilities have been used continuously since 1947.

Potential environmental concerns at the Motor Pool include the historical use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. In August 1989, the USTs, pump islands, and associated piping were upgraded to comply with Suffolk County Article 12 requirements for secondary containment, leak detection devices and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes two 8,000 gallon-capacity USTs used for the storage of unleaded gasoline, one 260 gallon-capacity UST used for waste oil, and one 3,000 gallon-capacity UST for No. 2 fuel oil. The facility also has five vehicle lift stations. The hydraulic fluid reservoirs for the lifts are located above ground and have secondary containment. However in February 1998, it was discovered that hydraulic fluid was leaking from one of the lift stations. The lift was excavated and soils below the lift were found to be contaminated with hydraulic oil. Approximately 50 cubic yards of what appeared to the most contaminated soils were removed.

The only environmental concern associated with the Site Maintenance Facility (Building 326) is the discovery of a historic oil spill directly south of the building. During the removal of an underground propane tank in December 1996, the surrounding soils were noticed to have a distinct petroleum staining and smell. The site was excavated to the extent that the footings of the building were almost undermined. Although approximately 60 cubic yards of contaminated soil were removed, there was clear evidence that contaminated soils remained.

Description of Groundwater Quality: In 1996, two wells (102-05 and 102-06) were installed downgradient of the gasoline UST and pump island area to provide a means of verifying groundwater quality. During CY 1997, TCA was detected in UST area well 102-06 at concentrations slightly exceeding the NYSAWQS. Methyl tertiary butyl ether (MTBE) was also detected in well 102-06. The TCA probably originated from the historical use of degreasers as part of vehicle repair operations. MTBE is currently widely used as an additive for unleaded gasoline as an anti-knock agent. It was first introduced as a gasoline additive in 1977. Therefore, the MTBE detected in samples from well 102-06 may have originated from minor gasoline releases prior to the 1989 upgrade of the USTs. No other gasoline breakdown products have been detected (i.e., benzene, xylenes, ethylbenzene, and toluene [BTEX]). Both wells are also checked for the presence of floating product. No floating products have been observed.

Although analysis of post excavation soil samples confirmed the presence of residual contamination (810 µg/kg of unspecified lubricating oil), hydraulic oil products have not been detected in groundwater wells located downgradient of the hydraulic lift station in Building 423.

In wells located downgradient of the Building 326 oil spill area, no hydrocarbon breakdown products have been detected. However, the solvent TCA has been detected at concentrations exceeding the NYSAWQS.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the Motor Pool area is to the south (Figure 8-28). In response to a NYSDEC request, BNL installed six new monitoring wells in the Building 423/326 area to evaluate the potential impacts of the two oil spills. One well (102-008) was installed upgradient of the Building 423/326 area to provide background water quality data, and one well (102-009) was installed directly downgradient of the Building 423 vehicle lift station. Four wells were installed downgradient of the Building 326 fuel oil spill site. The wells are screened across the water table so that free petroleum product (i.e., oil floating on top of the groundwater) can be detected.

Sampling Frequency and Analysis: In accordance with a NYSDEC spill response agreement, the wells are currently monitored quarterly for VOCs and SVOCs, and monthly for floating product (Tables 8-4 and 8-5). Because no dissolved or floating product related to the oil spills have been detected, BNL has requested that the monitoring program be reduced in frequency. Upon NYSDEC concurrence, the monitoring program will likely be reduced to semiannual groundwater sampling and floating product measurements for CY 2000.

8.3.3.2.9 Service Station

Source Area Description: Building 630 is a commercial automobile service station that is privately operated under contract with BNL. The station, which was built in 1966, is used for automobile repair and gasoline sales.

Potential environmental concerns at the Service Station include the historical use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. When the service station was built in 1966, the UST inventory consisted of two 8,000 gallon-capacity and one 6,000 gallon-capacity tanks for the storage of gasoline, and one 500 gallon-capacity tank for used motor oil. An inventory discrepancy discovered in 1967 suggested that up to 8,000 gallons of gasoline might have leaked from one of the USTs. There are no records of remedial actions other than replacement of the tank.

In August 1989, the USTs, pump islands, and associated piping were upgraded to comply with Suffolk County Article 12 requirements for secondary containment, leak detection devices and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes three 8,000 gallon-capacity USTs used for the storage of unleaded gasoline, and one 500 gallon-capacity UST used for waste oil. The facility also has three vehicle lift stations. The hydraulic fluid reservoirs for the lifts are located above ground and have secondary containment.

Description of Groundwater Quality: In 1996, two wells (085-016 and 085-017) were installed downgradient of the gasoline UST and pump island area to provide a means of verifying groundwater quality. Tetrachloroethylene (PCE) was detected in both wells at concentrations exceeding the NYSAWQS. Carbon tetrachloride and MTBE were also detected in well 85-17. Well 085-017 is located approximately 100 feet downgradient of the UST area. The PCE probably originated from the historical use of degreasers as part of vehicle repair operations. MTBE is currently widely used as an additive for unleaded gasoline as an anti-knock agent. It was first introduced as a gasoline additive in late 1977 [Stout *et al.* 1998]. Therefore, the MTBE detected in samples from well 086-017 may have originated from gasoline releases prior to the 1989 upgrade of the USTs. No other gasoline breakdown products have been detected (i.e., BTEX). Both wells are also checked for the presence of floating product. No floating product has been observed.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the Motor Pool area is to the south (Figure 8-27). In an effort to improve BNL's ability to monitor groundwater quality near the service station's UST area, one upgradient well (MW-SS-01) and two downgradient wells (MW-SS-02 and MW-SS-03) are being installed during CY 2000. The wells were installed with fifteen foot screens that are positioned from five feet above to ten feet below the water table, to allow for the detection of floating petroleum products.

Sampling Frequency and Analysis: The wells will be monitored semiannually for VOCs, SVOCs, and floating product (Tables 8-4 and 8-5).

8.3.3.2.10 Live Fire Range

Source Area Description: The BNL Live Fire Range consists of a six-position, 100-yard, bermed outdoor small arms and grenade range. The primary use of the current facility is to allow members of the BNL Police Group to practice and qualify in the use of firearms and to gain experience in the use of smoke and tear gas grenades. The range is also occasionally used by federal law enforcement agencies and the Brookhaven Employees Recreation Association (BERA).

The BNL Live Fire Range was constructed in 1986, and is located immediately to the north of the BNL STP. The eastern half of the range is located within 200 feet of the Peconic River. BNL utilized this same location as a practice range from 1963 until the present facility was constructed in 1986. Prior to 1963, the Police Group trained at a former Army (Camp Upton era) rifle range located north of Route 25. The small arms and grenade ranges are co-located, side-by-side, and have a combined area of 87,516 square feet. The bullet stop (rear berm) of the live fire range is an earthen berm, and is screened for lead on an annual basis. The bullets are known to have a typical penetration depth of approximately two to three inches into the berm. The soil of the rear berm is, therefore, screened to a depth of approximately one foot. The lead shot recovered during the screening process and the spent brass cartridges are disposed of offsite via a commercial waste handler as scrap metal. The grenade range is essentially an open field surrounded by earthen berms.

There is a potential that the use of lead bullets at the BNL Live Fire Range could cause soil contamination and potentially impact groundwater quality. Although the berm is screened for spent bullets on an annual basis, some amount of the bullets may be missed. Lead could leach into the soils as it is exposed to rain water that is typically slightly acidic. Lead can also be imparted directly onto soils as bullets impact with sand grains (typically silica sands). However, most bullets used at the range in recent years were either teflon© coated or copper jacketed, which reduces potential direct contamination or leaching of lead from the spent rounds. Furthermore, the use of CS grenades are thought to have a low probability to impact groundwater. The grenades are infrequently used, and while there is some residual chemical noticed on the soils, the active component, otho-chlorobenzalmalononitrile ($C_{10}H_5ClN_2$), has a low solubility in water.

Description of Groundwater Quality: Information on groundwater quality downgradient of the Live Fire Range is not currently available. Monitoring wells were installed in January 2000.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the Live Fire and Grenade Range area is to the east (Figure 8-24). The installation of monitoring wells downgradient of the Live Fire and Grenade Range provide a means of verifying that the facility is not impacting groundwater quality. Since the shallow aquifer system can supply water to the Peconic River during periods of high water table levels, verification of groundwater quality near the Live Fire Range is important. In January 2000, two shallow Upper Glacial aquifer wells (MW-LFR-01 and MW-LFR-02) were installed directly downgradient of the range. Groundwater data from wells located near the STP sand filter beds will be used to provide information on background (upgradient) metals concentrations.

Sampling Frequency and Analysis: For the first year (CY 2000), the wells will be sampled semiannually (Table 8-4). The samples will be analyzed for metals (Table 8-5). If the initial samples indicate low or nondetectable levels of lead, the sampling frequency may be reduced to annually.

8.3.3.2.11 Shotgun Range

Source Area Description: The BNL shotgun range is utilized for (clay) trap and skeet target shooting by the BERA. The shotgun range is located in an isolated, wooded area north of the new WMF. The range was established by the BERA in 1974. Clay targets are thrown south from the trap house into an open field that is approximately 205 feet east-west by 410 feet north-south. Although most of the shot falls within the cleared range, shooting from several of the trap line positions results in the deposition of some of the shot into the nearby wooded areas. The type of shotgun shells used at the facility typically contain lead pellets with 2 to 3 percent antimony. It is estimated that as many as 30,000 shotgun rounds per year have been used at the range [BNL 1992]. At an average of 1.125 ounces per round, as much as 2,100 pounds of lead may be deposited on the surface of the range annually.

Nationally, the use of lead shot for hunting game and its use at skeet ranges has resulted in soil and sediment contamination, and in some cases has affected groundwater quality. Similarly, the use of lead shot at the BNL shotgun range has resulted in the deposition of considerable amounts of lead, which has the potential to impact groundwater quality. In an effort to determine the potential impact to soils, a composite soil sample was collected from 17 sites within the target area of the shotgun range (see description in Paquette, 1998). The soil samples contained lead at a concentration of 96 mg/kg. While the lead content was well below the SCDHS cleanup criteria of 400 mg/kg, the sample was a composite and there may be areas with higher individual lead concentrations. Also of significant importance is the fact that the BNL shotgun range area is likely to be within the source water zone contribution for BNL potable supply well 12.

Description of Groundwater Quality: The current groundwater surveillance well network at the BNL shotgun range consists of two shallow Upper Glacial aquifer wells. One well (046-001) is located upgradient of the shotgun range, and the second well (056-006) is located to the south (nominally downgradient) of the range. Although initially intended to examine variations in groundwater flow patterns related to supply well pumping, BNL began sampling the wells in 1997 to determine lead levels in the groundwater. However, because groundwater flow is predominantly to the south-southeast, well 056-006 is not optimally positioned to properly monitor the shotgun range. Metals analyses performed on samples from the monitoring wells as well as from potable supply wells 11 and 12 have not indicated detectable levels of lead.

Criteria for Selecting Sample Locations: The predominant groundwater flow direction in the shotgun range area is to the south-southeast (Figure 8-12). However, flow directions downgradient of the range can be influenced by the operation of potable supply wells 11 and 12, and flow can be more to the south during certain periods of operation. In January 2000, two shallow Upper Glacial aquifer wells (MW-SGR-01 and MW-SGR-02) were installed at the downgradient margin of the shotgun range. The wells were installed with fifteen foot screens that are positioned from five feet above to ten feet below the water table.

Sampling Frequency and Analysis: During the first year of the monitoring program (CY 2000), the Shotgun Range area wells and existing upgradient well 46-01 will be sampled semiannually for metals (Tables 8-4 and 8-5). If the initial samples indicate low or nondetectable levels of lead, the sampling frequency for the wells may be reduced to annually.

8.3.3.2.12 Waste Management Facility

Source Area Description: The WMF is designed to safely handle, repackage, and temporarily store BNL derived wastes prior to shipment to an offsite disposal or treatment facility. The WMF has been designed with engineering controls that meet all applicable federal, state, and local environmental protection requirements. Moreover, institutional controls such as spill prevention plans, operations management plans, maintenance, and personnel training ensure that the facility will operate in a manner that is protective of the environment and human health.

The WMF consists of four buildings: the Operations Building, Reclamation Building, RCRA Waste Building, and the Mixed Waste Building (Figure 8-30). These buildings, and outlying paved areas, have been designed to ensure that spills and leaks are contained and detected prior to a release to the environment. Sealed floors and isolated drainage areas have been constructed to mitigate potential accidental releases of liquid wastes in the Reclamation Building, the RCRA Building, and the Mixed Waste Building. For added protection, sealed concrete floors in liquid waste handling and storage areas are underlain by 20 mil high-density polyethylene secondary containment membranes with monitoring access pipes. Potential outdoor spills that occur in paved areas would be mitigated by curbs and isolated drainage. Additionally, all above and below ground storage tanks have been designed, installed and maintained as required by Article 12 of the Suffolk County Sanitary Code. Above ground storage tanks have high level alarms and secondary containment. USTs located at the Waste Reclamation Building are double walled, have high level alarms and are equipped with leak detection devices.

The WMF is located adjacent to BNL potable supply wells 11 and 12, which are located south of East Fifth Avenue and just north of the WMF site. Because of the close proximity of the WMF to potable wells 11 and 12, it is imperative that the engineering and institutional controls discussed above are effective in ensuring that waste handling operations at the WMF do not degrade the quality of the soils and groundwater in this area.

Description of Groundwater Quality: The current groundwater surveillance well network at the Waste Management Facility consists of seven shallow and one middle Upper Glacial aquifer wells. Groundwater monitoring results since the start of WMF operations indicate that these operations are not impacting groundwater quality.

Analytical results indicate that all radionuclide concentrations are below applicable Federal drinking water standards [40 CFR 141]. Cobalt-60 was detected at concentrations up to 8.8 pCi/L in upgradient well 66-07; well below the drinking water standard of 200 pCi/L. The Co-60 detected in well 66-07 is due to historical leakage from the former Building 830 liquid-waste transfer line (BNL Environmental Restoration program, Area of Concern 11). Periodically, low levels of Co-60 (up to 8.1 pCi/L during 1998) have also been detected in well 56-21, which is located downgradient of the RCRA Building (see Attachments 1 and 2). The Co-60 detected in well 56-21 was likely due to past leakage from underground sanitary lines, which at one time transported liquid wastes containing this nuclide from Building 811 to the STP.

With the exception of slightly elevated silver concentrations in upgradient well 66-83, most metals concentrations were below NYSAWQS. All anion (e.g., chlorides, sulfates, and nitrates) and VOC concentrations are below NYSAWQS. Low levels (i.e., less than 3 μg/L) of several VOCs were detected in two upgradient wells (chloroform, acetone, and 2-butanone) and two downgradient wells (chloroform only). Low levels of chloroform are commonly found in groundwater in many of the developed areas of the site. In this case the chloroform detected in the shallow WMF wells is likely the byproduct of water treatment chemicals used to treat water that was discharged to Basin HO, and not current WMF operations.

Criteria for Selecting Sample Locations: The WMF's groundwater monitoring program is designed to provide a secondary means of detecting groundwater contamination in the event that a spill or leak from the WMF goes undetected using the (primary) engineering and institutional controls. Groundwater flow directions in the WMF area are highly variable. The evaluation of groundwater flow directions when supply well 11 and 12 are operating indicates that the entire WMF is within the zones of capture (or zones of influence) for the supply wells. During periods of no or limited pumping of Wells 11 and 12, the normal direction of groundwater flow in the WMF area is to the southeast. However, with continuous pumping of wells 11 and 12, combined with groundwater mounding at Basin HO, the direction of groundwater flow in the WMF area reverses, and flow pathways are northward toward supply wells 11 and 12 (Figure 8-30).

Eight wells are used to monitor for potential contaminant releases from the three main waste handling and storage buildings and assess background water quality. Four of the wells are positioned between the RCRA, Reclamation, and Mixed Waste Buildings and the supply wells, whereas the remaining four wells are used to monitor background water quality. Based upon proximity and groundwater flow directions, contaminants released from the RCRA Building would likely affect supply well 11, whereas well 12 would be affected by releases from the Reclamation and Mixed Waste Buildings.

Sampling Frequency and Analysis: In accordance with the provisions of the RCRA permit, the WMF wells are monitored quarterly for VOCs, gamma spectroscopy, and tritium, and semiannually for gross alpha/beta, metals and water quality (Tables 8-4 and 8-5).

8.3.4 Collection Methods and Procedures

8.3.4.1 Sampling

The methods used in the collection of groundwater samples and hydrogeologic measurements (i.e., geological data and water level measurements) for the Environmental Monitoring (EM) program are described in the EM Standard Operating Procedures (SOPs) and in project-specific work plans. Samples and measurements collected for some ER monitoring programs are described in specific AOC/OU Sampling and Analysis Plans. At the time of collection in the field, sample procedures, observations, and other pertinent information are documented in bound field logbooks and standardized forms. All sample identification numbers are documented on standardized BNL Chain-of-Custody forms.

Each new well is equipped with a dedicated Geoguard® bladder purge pump (typically Master-Flo Model 57200M, constructed of NSF rated PVC and Teflon®). These dedicated pumping systems eliminate the need to decontaminate pumps between well sampling events, and prevent potential cross contamination problems if the same pump is used in multiple wells. The wells are sampled in accordance with the schedule presented in Tables 8-1 and 8-3.

8.3.4.2 Procedures for Laboratory Analysis

The requirements for the analysis of groundwater samples collected under the ER and ES programs are described in the *BNL Groundwater Quality Assurance Project Plan* (QAPP) [BNL 1999a]. The specific analytical methods used for the BNL ER and ES programs are listed in the BNL Groundwater QAPP and other project-specific sampling and analysis plans.

EPA approved methods are used for performing the analyses. Samples are analyzed either by contractor laboratories or by the BNL ASL. For the ER program, most analyses are performed by NYSDOH certified contractor laboratories. For the ES program, the ASL performs most analyses. The ASL is certified by the NYSDOH for each of the analyses performed. However, samples collected for compliance with regulatory permits or other agreements are usually analyzed by NYSDOH certified contractor laboratories.

8.3.4.3 Data Quality Objectives (DQOs)

DQOs ensure that the data obtained from the groundwater monitoring program are of sufficient quality, are scientifically defensible, and have the requisite levels of precision and accuracy to support decisions related to monitoring objectives. Although most BNL sampling and analysis plans satisfy a number of the DQO steps, a more rigorous facility-by-facility (or plume-by-plume) review will be performed during CY 2000 to document appropriate decision rules and decision errors for the BNL groundwater surveillance program. This will ensure that the rationale for well placement, sampling parameters and frequency, and well abandonment is properly defined, and that the system is optimized. The DQO planning process for CY 2000 is described in the *BNL Groundwater Protection Implementation and Integration Plan* [BNL 1999b]. DQOs are also described in the BNL Groundwater QAPP.

8.2.4.4 Data Management

Environmental data are being acquired routinely during ongoing ER and ES programs. These programs currently maintain electronic and hard copy data management systems. All electronic data are maintained in the BNL Environmental Management Information System (EMIS) which consists of an environmental data management system platform linked with a geographic information system (GIS). Data/document management requirements are described in the BNL Groundwater QAPP [BNL 1999a].

8.3.4.5 Data Analysis and Reporting

Results of the BNL ES and ER programs routinely analyzed and assessed by project managers and/or hydrogeologists. The data are compared to relevant standards and goals. If unexpected levels of contamination are detected, appropriate investigations into the source of the contamination and/or remedial measures can be taken. BNL is in the process of developing a *"Groundwater Contingency Plan"* that describes the process used by BNL management to respond to the unexpected detection of contaminants in groundwater samples collected as part of the ES and ER programs.

Results are reported to the regulatory agencies and general public in a number of quarterly, semiannual and annual reports required by DOE Orders, NYS permit requirements, Suffolk County requirements, and CERCLA (OU-specific reports required under the IAG). Groundwater data from both programs are also summarized in the annual Groundwater Monitoring Report and the annual Site Environmental Report (SER).

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Table 8-1
Brookhaven National Laboratory
Environmental Monitoring Plan
Generalized Description of Geologic Units Underlying Brookhaven National Laboratory and Vicinity

Series	Geologic unit	Hydrogeologic unit	Description and water-bearing character
PLEISTOCENE	Upper Pleistocene deposits	Upper glacial aquifer	Mainly brown and gray sand and gravel deposits of moderately high horizontal hydraulic conductivity (270 ft/d average for Long Island; about 180 ft/d measured at Brookhaven National Laboratory); may also include deposits of clayey till and lacustrine clay of low hydraulic conductivity. A major aquifer.
	Upton unit	Upper glacial aquifer	Mainly greenish, with shades of yellow-green, greenish-gray, olive-brown, and gray, poorly to well sorted sand, with some silt and clay. Upper surface in some borings is marked by a clay or silty layer, generally less than 10 ft thick, that produces a noticeable response on a gamma-ray log. Horizontal hydraulic conductivity is estimated to be similar to or slightly less than that of the shallow part of the upper glacial aquifer.
	Gardiners Clay	Gardiners Clay	Green and gray clay, silt, clayey and silty sand, and some interbedded clayey and silty gravel. Unit has low vertical hydraulic conductivity (0.001 ft/d) and tends to confine water in underlying aquifer.
	Sand below Gardiners Clay	Upper glacial aquifer	Mainly light brown, olive-brown, and grayish-brown, poorly to well sorted sand. Hydrologically, unit could also be considered part of Magothy aquifer because of confinement by Gardiners Clay.
CRETACEOUS	Monmouth Group	Monmouth greensand	Interbedded marine deposits of green, dark-greenish gray, greenish-black, dark gray, and black clay, silt, and sand, containing much glauconite. Unit has low hydraulic conductivity (0.001 ft/d) and tends to confine water in underlying aquifer.
	Matawan Group and Magothy Formation, undifferentiated	Magothy aquifer	Gray, white, and brownish-gray, poorly to well sorted, fine to coarse sand of moderate horizontal hydraulic conductivity (50 ft/d). Contains much interstitial clay and silt, and lenses of clay of low hydraulic conductivity. Generally contains sand and gravel beds of low to high conductivity in basal 100 to 200 ft. A major aquifer.
	grayish-brown clay		Dark grayish-brown to yellow-brown, solid to silty clay, in some layers laminated with beds of very fine sand up to 1 in. thick. Unit is encountered in upper part of Magothy Formation. Has low hydraulic conductivity and tends to confine water.
	Unnamed clay member of the Raritan Formation	Raritan confining unit	Gray, black, and multicolored clay and some silt and fine sand. Unit has low vertical hydraulic conductivity (0.001 ft/d) and confines water in underlying aquifer.
	Lloyd Sand Member of the Raritan Formation	Lloyd aquifer	White and gray fine-to-coarse sand and gravel of moderate horizontal hydraulic conductivity (40 ft/d) and some clayey beds of low hydraulic conductivity.
PALEOZOIC and PRECAMBRIAN	Bedrock	Undifferentiated crystalline bedrock	Mainly metamorphic rocks of low hydraulic conductivity; considered to be the base of the ground-water flow system.

From Scorca *et al.* 1999

Table 8-2
ER Calendar Year 2000
Groundwater Monitoring Schedule

PROJECT	SAMPLE EVENT	TART DAT	END DATE	# OF WELLS	VALIDATE DATA
GW Elevations	1st Qtr.	03/23/2000	03/25/2000	~800	NA
GW Elevations	2nd Qtr.	06/21/2000	06/23/2000	~800	NA
GW Elevations	3rd Qtr.	09/27/2000	09/29/2000	~800	NA
GW Elevations	4th Qtr.	12/28/2000	12/30/2000	~800	NA
Site Background	Yr. 5/Rnd.8	02/20/2000	02/22/2000	13	Yes
Site Background	Yr.5/Rnd. 9	08/20/2000	08/22/2000	13	No
Chemical/Animal Holes	Yr. 2/Round 2	06/09/2000	06/15/2000	24	Yes
Chemical/Animal Holes	Yr. 3/Round 1	12/09/2000	12/15/2000	24	No
Current LF Post Closure	Yr. 5/1st Qtr.	01/03/2000	01/04/2000	11	No
Current LF Post Closure	Yr. 5/2nd Qtr.	04/03/2000	04/04/2000	11	No
Current LF Post Closure	Yr. 5/3rdQtr.	07/03/2000	07/05/2000	11	Yes
Current LF Post Closure	Yr. 5/4thQtr.	10/03/2000	10/04/2000	11	No
Former LF Post Closure	Yr. 4/1st Qtr.	01/01/2000	01/02/2000	8	No
Former LF Post Closure	Yr. 4/2nd Qtr.	04/01/2000	04/02/2000	8	No
Former LF Post Closure	Yr. 4/3rdQtr.	07/01/2000	07/02/2000	8	Yes
Former LF Post Closure	Yr. 4/3rdQtr.	10/01/2000	10/02/2000	8	No
OU VI Post Rod	Yr. 2/Qtr. 2	01/20/2000	01/26/2000	27	Yes
OU VI Post Rod	Yr. 2/Qtr. 3	04/20/2000	04/26/2000	27	Yes
OU VI Post Rod	Yr. 2/Qtr. 4	07/20/2000	07/26/2000	27	Yes
OU VI Post Rod	Yr. 3/Qtr.1	10/20/2000	10/26/2000	27	Yes
RA V Remedial Action	Yr. 4/1st Qtr.	01/06/2000	01/17/2000	47	No
RA V Remedial Action	Yr. 4/2nd Qtr.	04/06/2000	04/17/2000	47	Yes
RA V Remedial Action	Yr. 4/3rd Qtr.	07/06/2000	07/17/2000	47	No
RA V Remedial Action	Yr. 4/4th Qtr.	10/06/2000	10/17/2000	47	No
OU I/IV	Yr. 3/1st Qtr	02/22/2000	02/25/2000	25	No
OU I/IV	Yr. 3/2nd Qtr	05/22/2000	05/25/2000	25	No
OU I/IV	Yr. 3/3rd Qtr	08/22/2000	08/25/2000	25	Yes
OU I/IV	Yr. 3/4th Qtr	11/22/2000	11/25/2000	25	No
OU III (Central)	Yr.3/2nd Qtr.	02/25/2000	03/01/2000	22	No
OU III (Central)	Yr.3/3rd Qtr.	05/25/2000	06/01/2000	22	Yes
OU III (Central)	Yr.3/4th Qtr.	08/25/2000	09/01/2000	22	No
OU III (Central)	Yr.4/1st Qtr.	11/25/2000	12/01/2000	22	No
OU III (Bldg. 96)	Yr. 1/2nd Qtr.	01/03/2000	01/06/2000	6	No
OU III (Bldg. 96)	Yr. 1/3rd Qtr.	04/03/2000	04/06/2000	6	No
OU III (Bldg. 96)	Yr. 1/4th Qtr.	07/03/2000	07/06/2000	6	No
OU III (Bldg. 96)	Yr. 2/1st Qtr.	10/03/2000	10/06/2000	6	Yes
OU III (Carbon Tet)	Yr. 1/2nd Qtr.	01/07/2000	01/10/2000	9	No
OU III (Carbon Tet)	Yr. 1/3rd Qtr.	04/07/2000	04/10/2000	9	No
OU III (Carbon Tet)	Yr. 1/4th Qtr.	07/07/2000	07/10/2000	9	No
OU III (Carbon Tet)	Yr. 2/1st Qtr.	10/07/2000	10/10/2000	9	Yes
OU III (Boundary)	Yr.3/2nd Qtr.	01/26/2000	02/03/2000	40	No
OU III (Boundary)	Yr.3/3rd Qtr.	04/26/2000	05/03/2000	40	No
OU III (Boundary)	Yr.3/4th Qtr.	07/26/2000	08/03/2000	40	Yes
OU III (Boundary)	Yr.4/1st Qtr.	10/26/2000	11/03/2000	40	No
OU III (Off-Site)	Yr.3/2nd Qtr.	03/03/2000	03/07/2000	20	No
OU III (Off-Site)	Yr.3/3rd Qtr.	06/03/2000	06/07/2000	20	Yes
OU III (Off-Site)	Yr.3/4th Qtr.	09/03/2000	09/07/2000	20	No
OU III (Off-Site)	Yr.4/1st Qtr.	12/03/2000	12/07/2000	20	No
OU III (BGRR Sr-90)	Yr. 2/Round 1	05/08/2000	05/19/2000	57	Yes
OU III (BGRR Sr-90)	Yr. 2/Round 2	11/08/2000	11/19/2000	57	No
OU III (AOC29/HFBR)	r. 3/1st Qtr. (RD 11	01/03/2000	01/31/2000	112	Yes*
OU III (AOC29/HFBR)	r. 3/2nd Qtr. (RD 1	04/03/2000	4/31/2000	112	No
OU III (AOC29/HFBR)	r. 3/3rd Qtr. (RD 13	07/03/2000	07/31/2000	112	No
OU III (AOC29/HFBR)	r. 3/4th Qtr. (RD 14	10/03/2000	10/31/2000	112	No
OU III (AS-Industrial)	Yr. 1/2nd Qtr.	02/03/2000	02/11/2000	38	Yes
OU III (AS-Industrial)	Yr. 1/3rd Qtr.	05/03/2000	05/11/2000	38	No
OU III (AS-Industrial)	Yr. 1/4th Qtr.	08/03/2000	08/11/2000	38	No
OU III (AS-Industrial)	Yr. 2/1st Qtr.	11/03/2000	11/11/2000	38	No
OU IV/AOC 5 Remedial Actio	Yr.3/2nd Qtr.	02/17/2000	02/21/2000	26	Yes
OU IV/AOC 5 Remedial Actio	Yr.3/3rd Qtr.	05/17/2000	05/21/2000	26	No
OU IV/AOC 5 Remedial Actio	Yr.3/4th Qtr.	08/17/2000	08/21/2000	26	No
OU IV/AOC 5 Remedial Actio	Yr.4/1st Qtr.	11/17/2000	11/21/2000	26	No
OU IV/AOC 6 Remedial Actio	Yr. 4/Rnd. 1	02/08/2000	02/11/2000	22	Yes
OU IV/AOC 6 Remedial Actio	Yr. 4/Rnd. 2	08/08/2000	08/11/2000	22	No
OU V Pre-ROD	Yr. 4/Rnd. 7	02/11/2000	02/18/2000	34	No
OU V Pre-ROD	Yr. 4/Rnd. 8	08/11/2000	08/18/2000	34	Yes

Note*: Monthly OU III (HFBR) wells are validated monthly.

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
106-04	Chemical/Animal Holes		X[a]																					X			2
106-13	Chemical/Animal Holes		X[a]																					X			2
106-14	Chemical/Animal Holes		X[a]																					X		X	2
106-15	Chemical/Animal Holes		X[a]																					X			2
106-16	Chemical/Animal Holes		X[a]																					X		X	2
106-17	Chemical/Animal Holes		X[a]																					X			2
106-20	Chemical/Animal Holes		X[a]																					X			2
106-21	Chemical/Animal Holes		X[a]																					X			2
106-22	Chemical/Animal Holes		X[a]																					X			2
106-23	Chemical/Animal Holes		X[a]																					X			2
106-24	Chemical/Animal Holes		X[a]																					X			2
106-25	Chemical/Animal Holes		X[a]																					X			2
106-43	Chemical/Animal Holes		X[a]																					X			2
106-44	Chemical/Animal Holes		X[a]																					X			2
106-45	Chemical/Animal Holes		X[a]																					X			2
106-46	Chemical/Animal Holes		X[a]																					X			2
106-47	Chemical/Animal Holes		X[a]																					X			2
106-48	Chemical/Animal Holes		X[a]																					X			2
106-49	Chemical/Animal Holes		X[a]																					X			2
106-50	Chemical/Animal Holes		X[a]																					X			2
106-62	Chemical/Animal Holes		X[a]																					X			2
106-63	Chemical/Animal Holes		X[a]																					X			2

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
106-64	Chemical/Animal Holes		X[a]																					X			2
114-01	Chemical/Animal Holes		X[a]																					X			2
087-09	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
087-11	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
087-23	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
087-24	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
087-26	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
087-27	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
088-109	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
088-110	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
088-21	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
088-22	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
088-23	CLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
086-42	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
086-72	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
087-22	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
097-17	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
097-277	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
097-64	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
106-02	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]		4
106-30	FLF		X	X	X[b]		X[b]	X	X	X	X	X	X					X[j]	X		X	X	X	X	X[b]	x	4
065-01	HFBR		X[h]																				X	X[k]			4

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
065-37	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
065-38	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
065-39	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
065-40	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
065-41	HFBR		X[h]																				X				4
065-42	HFBR		X[h]																				X			X	4
075-11	HFBR		X[h]																				X				4
075-12	HFBR		X[h]																				X				12
075-39	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
075-40	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
075-41	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
075-42	HFBR		X[h]																				X				12
075-43	HFBR		X[h]																				X				12
075-44	HFBR		X[h]																				X				4
075-45	HFBR		X[h]																				X				4
075-46	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
075-47	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
075-48	HFBR	BGRR/WCF	X[h]																				X	X[k]		X	4
075-50	HFBR		X[h]																				X				4
075-85	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
075-86	HFBR	BGRR/WCF	X[h]																				X	X[k]			4
075-87	HFBR	BGRR/WCF	X[h]																				X	X[k]			4

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
075-88	HFBR		X[h]																					X				4
075-89	HFBR		X[h]																					X				4
076-171	HFBR		X[h]																					X				4
076-172	HFBR		X[h]																					X				4
076-173	HFBR		X[h]																					X				4
076-174	HFBR		X[h]																					X				4
076-175	HFBR		X[h]																					X				4
076-177	HFBR		X[h]																					X				4
077-10	HFBR		X[h]																					X				4
077-11	HFBR		X[h]																					X				4
085-01	HFBR		X[h]																					X				4
085-02	HFBR		X[h]																					X				4
085-39	HFBR		X[h]																					X				4
085-40	HFBR		X[h]																					X			x	4
085-41	HFBR		X[h]																					X				4
085-65	HFBR		X[h]																					X				4
085-66	HFBR		X[h]																					X				4
085-67	HFBR		X[h]																					X				4
085-68	HFBR		X[h]																					X				4
085-69	HFBR		X[h]																					X				4
085-70	HFBR		X[h]																					X				4
085-71	HFBR		X[h]																					X				4

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride /Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
085-72	HFBR		X^h																				X			X	4
085-73	HFBR		X^h																				X				4
085-74	HFBR		X^h																				X				4
085-75	HFBR		X^h																				X				4
085-76	HFBR		X^h																				X				4
085-77	HFBR		X^h																				X				4
085-78	HFBR		X^h																				X				4
086-09	HFBR		X^h																				X				4
095-42	HFBR		X^h																				X				4
095-43	HFBR		X^h																				X				4
095-44	HFBR		X^h																				X				4
095-45	HFBR		X^h																				X				4
095-46	HFBR		X^h																				X				4
095-47	HFBR		X^h																				X				4
095-48	HFBR		X^h																				X				12
095-51	HFBR		X^h																				X				4
095-52	HFBR		X^h																				X				4
095-53	HFBR		X^h																				X				4
095-54	HFBR		X^h																				X				4
095-55	HFBR		X^h																				X				4
095-87	HFBR		X^h																				X				4
095-88	HFBR		X^h																				X				4

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride /Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
095-89	HFBR		X^h																				X				4
095-90	HFBR		X^h																				X				4
095-91	HFBR		X^h																				X				4
095-92	HFBR		X^h																				X				4
095-93	HFBR		X^h																				X				4
096-55	HFBR		X^h																				X				4
104-10	HFBR		X^h																				X				4
104-11	HFBR		X^h																				X				4
104-25	HFBR		X^h																				X				4
105-07	HFBR		X^h																				X				4
105-22	HFBR		X^h																				X				4
105-23	HFBR		X^h																				X				4
105-24	HFBR		X^h																				X				4
105-29	HFBR		X^h																				X				4
105-42	HFBR		X^h																				X				4
105-43	HFBR		X^h																				X				4
105-44	HFBR		X^h																				X				4
105-44	HFBR		X^h																				X				4
113-08	HFBR		X^h																				X				4
113-09	HFBR		X^h																				X				4
113-11	HFBR		X^h																				X				4
075-208	HFBR		X^h																				X				4

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Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
075-209	HFBR		X^h																					X				4
075-210	HFBR		X^h																					X				4
075-211	HFBR		X^h																					X				4
085-170	HFBR		X^h																					X				4
085-171	HFBR		X^h																					X				4
095-139	HFBR		X^h																					X				4
095-140	HFBR		X^h																					X				4
096-82	HFBR		X^h																					X				4
096-83	HFBR		X^h																					X				4
096-84	HFBR		X^h																					X				4
New-1	HFBR		X^h																					X				4
New-10	HFBR		X^h																					X				4
New-11	HFBR		X^h																					X				4
New-12	HFBR		X^h																					X				4
New-13	HFBR		X^h																					X				4
New-2	HFBR		X^h																					X				4
New-3	HFBR		X^h																					X				4
New-4	HFBR		X^h																					X				4
New-5	HFBR		X^h																					X				4
New-6	HFBR		X^h																					X				4
New-7	HFBR		X^h																					X				4
New-8	HFBR		X^h																					X				4

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Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
New-9	HFBR		X^h																				X				4
000-108	OU I/IV		X																		X^c	X^c	X^c	X^c		x	4
000-153	OU I/IV		X																		X^c	X^c	X^c	X^c			4
000-154	OU I/IV		X																		X^c	X^c	X^c	X^c			4
000-211	OU I/IV		X																		X^c	X^c	X^c	X^c			4
000-212	OU I/IV		X																		X^c	X^c	X^c	X^c			4
000-213	OU I/IV		X																		X^c	X^c	X^c	X^c			4
000-215	OU I/IV		X																		X^c	X^c	X^c	X^c			4
086-05	OU I/IV		X																		X^c	X^c	X^c	X^c			4
086-43	OU I/IV		X																		X^c	X^c	X^c	X^c			4
086-70	OU I/IV		X																		X^c	X^c	X^c	X^c			4
106-53	OU I/IV		X																		X^c	X^c	X^c	X^c			4
106-54	OU I/IV		X																		X^c	X^c	X^c	X^c			4
106-55	OU I/IV		X																		X^c	X^c	X^c	X^c			4
106-56	OU I/IV		X																		X^c	X^c	X^c	X^c			4
106-58	OU I/IV		X																		X^c	X^c	X^c	X^c			4
106-59	OU I/IV		X																		X^c	X^c	X^c	X^c			4
115-32	OU I/IV		X																		X^c	X^c	X^c	X^c			4
115-33	OU I/IV		X																		X^c	X^c	X^c	X^c			4
115-34	OU I/IV		X																		X^c	X^c	X^c	X^c			4
115-35	OU I/IV		X																		X^c	X^c	X^c	X^c			4
800-59	OU I/IV		X																		X^c	X^c	X^c	X^c			4

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
800-60	OU I/IV		X																		X[c]	X[c]	X[c]	X[c]		X	4
800-63	OU I/IV		X																		X[c]	X[c]	X[c]	X[c]			4
122-24	OU I/IV		X																		X[c]	X[c]	X[c]	X[c]		X	4
122-25	OU I/IV		X																		X[c]	X[c]	X[c]	X[c]		X	4
000-112	OU III (AS-I)		X																		X[d]	X[d]	X[d]				4
000-114	OU III (AS-I)		X																		X[d]	X[d]	X[d]				4
000-130	OU III (AS-I)		X																		X[d]	X[d]	X[d]			X	4
000-245	OU III (AS-I)		X																								4
000-246	OU III (AS-I)		X																								4
000-247	OU III (AS-I)		X																								4
000-248	OU III (AS-I)		X																								4
000-249	OU III (AS-I)		X																								4
000-250	OU III (AS-I)		X																								4
000-251	OU III (AS-I)		X																								4
000-252	OU III (AS-I)		X																								4
000-253	OU III (AS-I)		X																								4
000-254	OU III (AS-I)		X																								4
000-255	OU III (AS-I)		X																								4
000-256	OU III (AS-I)		X																								4
000-257	OU III (AS-I)		X																								4
000-258	OU III (AS-I)		X																								4
000-259	OU III (AS-I)		X																								4

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
000-260	OU III (AS-I)		X																									4
000-261	OU III (AS-I)		X																									4
000-262	OU III (AS-I)		X																									4
000-263	OU III (AS-I)		X																									4
000-264	OU III (AS-I)		X																									4
000-265	OU III (AS-I)		X																									4
000-266	OU III (AS-I)		X																									4
000-267	OU III (AS-I)		X																									4
000-268	OU III (AS-I)		X																									4
000-269	OU III (AS-I)		X																									4
000-270	OU III (AS-I)		X																									4
000-271	OU III (AS-I)		X																									4
000-272	OU III (AS-I)		X																									4
000-273	OU III (AS-I)		X																									4
000-274	OU III (AS-I)		X																									4
000-275	OU III (AS-I)		X																									4
000-276	OU III (AS-I)		X																									4
000-277	OU III (AS-I)		X																									4
000-278	OU III (AS-I)		X																									4
000-279	OU III (AS-I)		X																									4
000-280	OU III (AS-I)		X																									4
065-03	OU III (BGRR/WCF)		X																						X		X	2

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Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride /Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
065-04	OU III (BGRR/WCF)		X																					X			2
065-06	OU III (BGRR/WCF)		X																					X			2
065-11	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																								
065-160	OU III (BGRR/WCF)																							X			2
065-161	OU III (BGRR/WCF)																							X			2
065-162	OU III (BGRR/WCF)																							X			2
065-163	OU III (BGRR/WCF)																							X			2
065-164	OU III (BGRR/WCF)																							X			2
065-165	OU III (BGRR/WCF)																							X			2
065-166	OU III (BGRR/WCF)																							X			2
065-167	OU III (BGRR/WCF)																							X			2
065-168	OU III (BGRR/WCF)																							X			2
065-169	OU III (BGRR/WCF)																							X			2
065-170	OU III (BGRR/WCF)																							X			2
065-171	OU III (BGRR/WCF)																							X			2
065-172	OU III (BGRR/WCF)																							X			2
065-173	OU III (BGRR/WCF)																							X			2
065-174	OU III (BGRR/WCF)																							X			2
065-175	OU III (BGRR/WCF)																							X		X	2
065-176	OU III (BGRR/WCF)																							X			2
065-177	OU III (BGRR/WCF)																							X			2
065-178	OU III (BGRR/WCF)																							X			2

Table 8-3
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
065-18	OU III (BGRR/WCF)		X																						X			4
065-19	OU III (BGRR/WCF)		X																						X			4
065-20	OU III (BGRR/WCF)		X																						X			4
065-37	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
065-38	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
065-39	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
065-40	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-09	OU III (BGRR/WCF)		X																						X			4
075-10	OU III (BGRR/WCF)		X																						X			4
075-188	OU III (BGRR/WCF)																								X			2
075-189	OU III (BGRR/WCF)																								X			2
075-190	OU III (BGRR/WCF)																								X			2
075-191	OU III (BGRR/WCF)																								X			2
075-192	OU III (BGRR/WCF)																								X			2
075-193	OU III (BGRR/WCF)																								X			2
075-194	OU III (BGRR/WCF)																								X			2
075-195	OU III (BGRR/WCF)																								X			2
075-196	OU III (BGRR/WCF)																								X			2
075-197	OU III (BGRR/WCF)																								X			2
075-198	OU III (BGRR/WCF)																								X			2
075-199	OU III (BGRR/WCF)																								X			2
075-200	OU III (BGRR/WCF)																								X			2

Table 8-3
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Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
075-201	OU III (BGRR/WCF)																								X			2
075-202	OU III (BGRR/WCF)																								X			2
075-203	OU III (BGRR/WCF)																								X			2
075-39	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-40	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-41	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-46	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-47	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-48	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-85	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-86	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
075-87	OU III (BGRR/WCF)	HFBR	Sampled under HFBR Program. See HFBR for parameter list.																									
085-97	OU III (Bldg 96)		X																									4
095-84	OU III (Bldg 96)		X																									4
095-85	OU III (Bldg 96)		X																								X	4
NEW-1	OU III (Bldg 96)																											4
NEW-2	OU III (Bldg 96)																											4
NEW-3	OU III (Bldg 96)																											4
NEW-4	OU III (Bldg 96)																											4
NEW-5	OU III (Bldg 96)																											4
NEW-6	OU III (Bldg 96)																											4
114-06	OU III (Boundary)		X																			X[d]	X[d]	X	X[d]			4

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Table 8-3
ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
114-07	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
121-06	OU III (Boundary)		X^i																			X^d	X^d	X^i	X^d			2
121-07	OU III (Boundary)		X^i																			X^d	X^d	X^i	X^d			2
121-08	OU III (Boundary)		X^i																			X^d	X^d	X^i	X^d			2
121-09	OU III (Boundary)		X^i																			X^d	X^d	X^i	X^d			2
121-10	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
121-11	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
121-12	OU III (Boundary)		X^i																			X^d	X^d	X^i	X^d			2
121-13	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
121-14	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
121-18	OU III (Boundary)		X^i																			X^d	X^d	X^i	X^d			2
121-19	OU III (Boundary)		X^i																			X^d	X^d	X^i	X^d			2
121-20	OU III (Boundary)		X																			X^d	X^d	X	X^d		X	4
121-21	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
121-22	OU III (Boundary)		X																			X^d	X^d	X	X^d			2
121-23	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
122-02	OU III (Boundary)		X^i																			X	X	X	X			2
122-04	OU III (Boundary)		X																			X	X	X	X			4
122-05	OU III (Boundary)		X																			X	X	X	X			4
122-09	OU III (Boundary)		X^i																			X^d	X^d	X	X^d			2
122-10	OU III (Boundary)		X																			X^d	X^d	X	X^d			4
122-15	OU III (Boundary)		X^i																			X^d	X^d	X	X^d			2

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Table 8-3
ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
122-16	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-17	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-18	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-19	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-20	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-21	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-22	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]		X	4
124-02	OU III (Boundary)		X																		X	X	X	X			4
126-01	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
130-02	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
130-03	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
130-04	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-31	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-32	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-33	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-34	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
122-35	OU III (Boundary)		X																		X[d]	X[d]	X	X[d]			4
064-03	OU III (central)		X																		X[e]	X[e]	X[e]	X[e]			4
065-02	OU III (central)		X																		X[e]	X[e]	X[e]	X[e]			4
065-05	OU III (central)		X																		X[e]	X[e]	X[e]	X[e]			4
066-08	OU III (central)		X																		X[e]	X[e]	X[e]	X[e]			4
066-09	OU III (central)		X																		X[e]	X[e]	X[e]	X[e]			4

Table 8-3
ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
072-03	OU III (central)		X																			X^e	X^e	X^e	X^e			4
072-04	OU III (central)		X																			X^e	X^e	X^e	X^e			4
075-01	OU III (central)		X																			X^e	X^e	X^e	X^e			4
075-02	OU III (central)		X																			X^e	X^e	X^e	X^e			4
083-01	OU III (central)		X																			X^e	X^e	X^e	X^e			4
083-02	OU III (central)		X																			X^e	X^e	X^e	X^e			4
084-04	OU III (central)		X																			X^e	X^e	X^e	X^e			4
084-05	OU III (central)		X																			X^e	X^e	X^e	X^e			4
096-07	OU III (central)		X																			X^e	X^e	X^e	X^e			4
105-05	OU III (central)		X																			X^e	X^e	X^e	X^e			4
105-06	OU III (central)		X																			X^e	X^e	X^e	X^e			4
105-25	OU III (central)		X																			X^e	X^e	X^e	X^e			4
106-19	OU III (central)		X																			X^e	X^e	X^e	X^e			4
109-03	OU III (central)		X																			X^e	X^e	X^e	X^e			4
109-04	OU III (central)		X																			X^e	X^e	X^e	X^e			4
113-06	OU III (central)		X																			X^e	X^e	X^e	X^e			4
113-07	OU III (central)		X																			X^e	X^e	X^e	X^e			4
085-07	OU III (CT)		X																									4
085-13	OU III (CT)		X																									4
085-16	OU III (CT)		X																									4
085-161	OU III (CT)		X																									4
085-162	OU III (CT)		X																									4

Table 8-3
ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
085-163	OU III (CT)		X																								4
085-17	OU III (CT)		X																								4
085-98	OU III (CT)		X																							X	4
086-114	OU III (CT)		X																								4
000-101	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-102	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-104	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-105	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-107	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-131	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-97	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-98	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
000-99	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-21	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-22	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-23	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-40	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-41	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-43	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-44	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4
800-50	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}			X	4
800-51	OU III (off-site)		X																		X^{d}	X^{d}	X^{d}				4

Table 8-3
ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
800-52	OU III (off-site)		X																			X[d]	X[d]	X[d]				4
800-53	OU III (off-site)		X																			X[d]	X[d]	X[d]				4
076-02	OU IV AOC 5		X		X																							4
076-04	OU IV AOC 5		X		X																						X	4
076-05	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-06	OU IV AOC 5		X		X																							4
076-178	OU IV AOC 5		X		X																							4
076-179	OU IV AOC 5		X		X																							4
076-180	OU IV AOC 5		X		X																							4
076-185	OU IV AOC 5		X		X																							4
076-186	OU IV AOC 5		X		X																							4
076-19	OU IV AOC 5		X		X																							4
076-21	OU IV AOC 5		X		X																							4
076-05	OU IV AOC 5	AOC 6																				X[e]	X[e]	X[e]	X[e]			4
076-07	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-07	OU IV AOC 5	AOC 6																				X[e]	X[e]	X[e]	X[e]			4
076-09	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-09	OU IV AOC 5	AOC 6																				X[e]	X[e]	X[e]	X[e]			4
076-181	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-181	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-182	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-182	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4

Table 8-3
ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
076-183	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-183	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-184	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-184	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-22	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
076-22	OU IV AOC 5	AOC 6	X		X																	X[e]	X[e]	X[e]	X[e]			4
066-17	OU IV AOC 6																					X	X	X	X			2
066-18	OU IV AOC 6																					X	X	X	X			2
066-189	OU IV AOC 6																					X	X	X	X			
066-190	OU IV AOC 6																					X	X	X	X			
076-13	OU IV AOC 6																					X	X	X	X			2
076-167	OU IV AOC 6																					X	X	X	X			2
076-168	OU IV AOC 6																					X	X	X	X		X	2
076-169	OU IV AOC 6																					X	X	X	X			2
076-20	OU IV AOC 6																					X	X	X	X			2
076-24	OU IV AOC 6																					X	X	X	X			2
076-25	OU IV AOC 6																					X	X	X	X			2
076-262	OU IV AOC 6																					X	X	X	X			2
076-263	OU IV AOC 6																					X	X	X	X			2
076-264	OU IV AOC 6																					X	X	X	X			2
076-265	OU IV AOC 6																					X	X	X	X		X	2
076-27	OU IV AOC 6																					X	X	X	X			2

Table 8-3
ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride	Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
076-28	OU IV AOC 6																					X	X	X	X			2
076-314	OU IV AOC 6																					X	X	X	X			2
076-317	OU IV AOC 6																					X	X	X	X			2
076-373	OU IV AOC 6																					X	X	X	X			2
076-10	OU IV AOC 6																					X	X	X	X			2
076-10	OU IV AOC 6		X[h]																					X				4
000-122	OU V		X				X			X	X	X	X	X					X	X		X	X	X			X	2
000-123	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
000-141	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
000-142	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
000-143	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
000-144	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
000-145	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
000-146	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
000-147	OU V		X				X			X	X	X	X	X					X	X		X	X	X				2
037-02	OU V		X							X	X	X	X	X					X	X	X	X	X	X				2
037-03	OU V		X							X	X	X	X	X					X	X	X	X	X	X				2
037-04	OU V		X							X	X	X	X	X					X	X	X	X	X	X				2
041-01	OU V		X							X	X	X	X	X					X	X	X	X	X	X				2
041-02	OU V		X							X	X	X	X	X					X	X	X	X	X	X				2
041-03	OU V		X							X	X	X	X	X					X	X	X	X	X	X				2
049-05	OU V		X							X	X	X	X	X					X	X	X	X	X	X				2

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ER Groundwater Monitoring Program
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
049-06	OU V		X						X	X	X	X	X					X	X	X	X	X	X				2
050-01	OU V		X						X	X	X	X	X					X	X	X	X	X	X			X	2
050-02	OU V		X						X	X	X	X	X					X	X	X	X	X	X				2
061-03	OU V		X						X	X	X	X	X					X	X	X	X	X	X				2
061-04	OU V		X						X	X	X	X	X					X	X	X	X	X	X				2
061-05	OU V		X						X	X	X	X	X					X	X	X	X	X	X			X	2
600-15	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-16	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-18	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-19	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-20	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-21	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-22	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-23	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-24	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-25	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-26	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
600-27	OU V		X				X		X	X	X	X	X					X	X		X	X	X				2
000-110	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf			X	4
000-173	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-174	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf			x	4
000-175	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4

Table 8-3
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Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride /Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
000-176	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-177	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-178	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-179	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-180	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-181	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-201	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-209	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
058-02	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
089-13	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
089-14	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
099-06	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
099-10	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
099-11	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
100-12	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
100-13	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf			X	4
100-14	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
800-24	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
800-25	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
800-54	OU VI RA	RA V	Sampled under the RA V Program. See RA V for Parameter List																								
000-283	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4
000-284	OU VI RA		Xf	X		X								X	X	X	X				Xf		Xf				4

Table 8-3
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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
000-285	OU VI RA		X^f	X		X								X	X	X	X				X^f		X^f				4
000-124	RA V		X																		X^g	X^g	X	X^g		x	4
000-137	RA V		X																		X^g	X^g	X	X^g			4
000-138	RA V		X																		X^g	X^g	X	X^g			4
077-02	RA V		X																		X^g	X^g	X	X			4
087-21	RA V		X																		X^g	X^g	X	X			4
088-13	RA V		X																		X^g	X^g	X	X			4
088-14	RA V		X																		X^g	X^g	X	X			4
088-20	RA V		X																		X^g	X^g	X	X			4
088-26	RA V		X																		X^g	X^g	X	X		x	4
098-19	RA V		X																		X^g	X^g	X	X			4
098-21	RA V		X																		X^g	X^g	X	X			4
098-22	RA V		X																		X^g	X^g	X	X			4
098-30	RA V		X																		X^g	X^g	X	X			4
098-33	RA V		X																		X^g	X^g	X	X			4
098-58	RA V		X																		X^g	X^g	X	X			4
098-59	RA V		X																		X^g	X^g	X	X			4
098-61	RA V		X																		X^g	X^g	X	X			4
098-62	RA V		X																		X^g	X^g	X	X			4
098-63	RA V		X																		X^g	X^g	X	X			4
099-04	RA V		X																		X^g	X^g	X	X			4
107-10	RA V		X																		X^g	X^g	X	X			4

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Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
107-23	RA V		X																		X^g	X^g	X	X			4
107-24	RA V		X																		X^g	X^g	X	X			4
107-25	RA V		X																		X^g	X^g	X	X			4
107-26	RA V		X																		X^g	X^g	X	X			4
108-08	RA V		X																		X^g	X^g	X	X			4
108-12	RA V		X																		X^g	X^g	X	X			4
108-13	RA V		X																		X^g	X^g	X	X			4
108-14	RA V		X																		X^g	X^g	X	X			4
108-17	RA V		X																		X^g	X^g	X	X			4
108-18	RA V		X																		X^g	X^g	X	X			4
108-30	RA V		X																		X^g	X^g	X	X			4
115-03	RA V		X																		X^g	X^g	X	X			4
115-13	RA V		X																		X^g	X^g	X	X			4
115-14	RA V		X																		X^g	X^g	X	X		x	4
115-15	RA V		X																		X^g	X^g	X	X			4
115-16	RA V		X																		X^g	X^g	X	X			4
115-28	RA V		X																		X^g	X^g	X	X			4
115-29	RA V		X																		X^g	X^g	X	X			4
115-30	RA V		X																		X^g	X^g	X	X			4
115-31	RA V		X																		X^g	X^g	X	X			4
115-36	RA V		X																		X^g	X^g	X	X			4
115-41	RA V		X																		X^g	X^g	X	X			4

Table 8-3
ER Groundwater Monitoring Program
Fiscal Year 2000
Analytical Breakdown

Well ID	Project 1	Project 2	EPA 524.2 VOCs	EPA 504 EDB	EPA 625 Semi-VOCs	Bromide Ion EPA 3000	EPA 608 Pest/PCBs	TSS/TDS/Sufates/Chloride/Alkalinity	TK Nitrogen	Total Nitrogen	Nitrates	Nitrites	Ammonia	TOC	CO2	Ethene	Ethane	TAL Metals	Cyanide	Hexavalent Chromium	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr 90	EPA 903 Ra 226	Blind Duplicate	Frequency (events/year)
115-42	RA V		X																		X^g	X^g	X	X			4
116-05	RA V		X																		X^g	X^g	X	X			4
116-06	RA V		X																		X^g	X^g	X	X			4
800-54	RA V	OU VI	X	X		X								X	X	X	X				X^{gf}	X^g	X	X^g			4
000-118	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
000-119	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
000-120	Site Background		X					X	X	X	X	X	X					X			X	X	X	X		X	2
017-01	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
017-03	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
017-04	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
018-01	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
018-02	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
018-04	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
018-05	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
034-02	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
034-03	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2
063-09	Site Background		X					X	X	X	X	X	X					X			X	X	X	X			2

NOTES:

X^a: Collect in June '00 only.
X^b: Collect in July '00.
X^c: Collect in August '00 only.
X^d: Collect in May/June '00 only.
X^e: Collect in May/June '00, and Nov./Dec.'00only.
X^f: Collect in July '00 only.
X^g: Collect in April '00 only.
X^h: Collect in Jan./July 00 only
Xi: Collect in June/July '00 only.
X^j Includes Mercury
X^k: Collect in May '00, and Oct. '00 only.

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Table 8-4
ES Calendar Year 2000
Facility Groundwater Monitoring Schedule

PROJECT	SAMPLE EVENT	START DATE	END DATE	# OF WELLS	VALIDATE DATA
Alternating Gradient Synchrotron Facility	1st Qtr.	01/01/2000	02/15/2000	27	No (a)
	2nd Qtr.	04/01/2000	05/15/2000	42	No (a)
	3rd Qtr.	07/01/2000	08/15/2000	42	No (a)
	4th Qtr.	10/01/2000	11/15/2000	42	No (a)
Brookhaven LINAC Isotope Producer	1st Qtr.	01/01/2000	02/15/2000	7	No (a)
	2nd Qtr.	04/01/2000	05/15/2000	7	No (a)
	3rd Qtr.	07/01/2000	08/15/2000	7	No (a)
	4th Qtr.	10/01/2000	11/15/2000	7	No (a)
Relativistic Heavy Ion Collider	1st Qtr.	02/01/2000	02/26/2000	12	No (a)
	2nd Qtr.	05/01/2000	05/31/2000	12	No (a)
	3rd Qtr.	08/01/2000	08/31/2000	12	No (a)
	4th Qtr.	11/01/2000	11/30/2000	12	No (a)
New Waste Management Facility	1st Qtr.	02/01/2000	02/26/2000	8	No (a)
	2nd Qtr.	05/01/2000	05/31/2000	8	No (a)
	3rd Qtr.	08/01/2000	08/31/2000	8	No (a)
	4rd Qtr.	11/01/2000	11/30/2000	8	No (a)
Brookhaven Medical Research Reactor	1st Qtr.	03/01/2000	03/31/2000	4	No (a)
	2nd Qtr.	06/01/2000	06/30/2000	4	No (a)
	3rd Qtr.	09/01/2000	09/30/2000	4	No (a)
	4th Qtr.	12/01/2000	12/31/2000	4	No (a)
Sewage Treatment Plant	2nd Qtr.	06/01/2000	06/30/2000	9	No (a)
	4th Qtr.	12/01/2000	12/30/2000	9	No (a)
Live-Fire Range	1st Qtr.	03/01/2000	03/31/2000	2	No (a)
	3rd Qtr.	09/01/2000	09/30/2000	2	No (a)
Shotgun Range	1st Qtr.	03/01/2000	03/31/2000	3	No (a)
	3rd Qtr.	09/01/2000	09/30/2000	3	No (a)
Water Treatment Plant	2nd Qtr.	06/01/1999	06/30/1999	5	No (a)
Motor Pool (c)	1st Qtr.	02/01/2000	02/26/2000	8	Yes (a, b)
	2nd Qtr.	05/01/2000	05/31/2000	8	Yes (a, b)
	3rd Qtr.	08/01/2000	08/31/2000	8	Yes (a, b)
	4th Qtr.	11/01/2000	11/30/2000	8	Yes (a, b)
Service Station	1st Qtr.	03/01/2000	03/31/2000	5	No (a)
	3rd Qtr.	09/01/2000	09/30/2000	5	No (a)
Major Petroleum Facility (c)	2nd Qtr.	04/01/2000	04/30/2000	8	Yes (a, b)
	4th Qtr.	10/01/2000	10/29/2000	8	Yes (a, b)
Biology Greenhouses	1st Qtr.	03/01/2000	03/31/2000	2	Yes (a, b)
	3rd Qtr.	09/01/2000	09/30/2000	2	Yes (a, b)

(a): Results from BNL ASL are checked for completeness and accuracy by ASL supervisors.
(c): Results from contractor laboratories are validated by ASL supervisors using standardized EPA methods.
(c): Monthly floating product measurements are performed.

Table 8-5
ES Calendar Year 2000
Facility Groundwater Monitoring Program
Analytical Breakdown

Well ID	Area	Sub Area	EPA 524.2 VOCs	EPA 625 Semi-VOCs	EPA 608 Pest/PCBs	Sulfate/Chloride/Nitrate	Metals	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr-90	Floating Product	Frequency (events/year)
064-002	BLIP							Xa	X	X			b
054-061	BLIP							Xa	X	X			4
064-046	BLIP							Xa	X	X			4
064-047	BLIP							Xa	X	X			4
064-048	BLIP							Xa	X	X			4
064-049	BLIP							Xa	X	X			4
064-050	BLIP							Xa	X	X			4
MW-BLIP-07	BLIP							Xa	X	X			4
054-008	AGS	Bkgd. Booster/914						Xa	X	X			4
064-051	AGS	Booster Beam Stop						Xa	X	X			4
065-052	AGS	Booster Beam Stop						Xa	X	X			4
064-003	AGS	Bldg. 914						Xa	X	X			4
064-53	AGS	Bldg. 914						Xa	X	X			4
064-054	AGS	Bldg. 914						Xa	X	X			4
054-062	AGS	J-10 Beam Stop						Xa	X	X			4
054-063	AGS	J-10 Beam Stop						Xa	X	X			4
054-064	AGS	J-10 Beam Stop						Xa	X	X			4c
054-065	AGS	g-2 Beam Stop						Xa	X	X			4c
054-066	AGS	g-2 Beam Stop						Xa	X	X			4c
054-007	AGS	g-2 Beam Stop						Xa	X	X			4c
054-067	AGS	g-2 Beam Stop						Xa	X	X			4c
054-068	AGS	g-2 Beam Stop						Xa	X	X			4c
MW-AGS-36	AGS	g-2 Beam Stop						Xa	X	X			4c
MW-AGS-37	AGS	g-2 Beam Stop						Xa	X	X			4c
MW-AGS-38	AGS	g-2 Beam Stop						Xa	X	X			4c
MW-AGS-30	AGS	Fm. U-Line Target						Xa	X	X			4
MW-AGS-31	AGS	Fm. U-Line Target						Xa	X	X			4
MW-AGS-32	AGS	Fm. U-Line Target						Xa	X	X			4
MW-AGS-33	AGS	Fm. U-Line Target						Xa	X	X			4
054-069	AGS	Bldg 912						Xa	X	X			4
055-014	AGS	Bldg 912						Xa	X	X			4
065-120	AGS	Bldg 912						Xa	X	X			4
065-121	AGS	Bldg 912						Xa	X	X			4
065-122	AGS	Bldg 912						Xa	X	X			4
065-123	AGS	Bldg 912						Xa	X	X			4

Table 8-5
ES Calendar Year 2000
Facility Groundwater Monitoring Program
Analytical Breakdown

Well ID	Area	Sub Area	EPA 524.2 VOCs	EPA 625 Semi-VOCs	EPA 608 Pest/PCBs	Sulfate/Chloride/Nitrate	Metals	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr-90	Floating Product	Frequency (events/year)
065-124	AGS	Bldg 912						Xa	X	X			4
065-125	AGS	Bldg 912						Xa	X	X			4
065-126	AGS	Bldg 912						Xa	X	X			4
055-015	AGS	Bldg 912						Xa	X	X			4
055-016	AGS	Bldg 912						Xa	X	X			4
MW-AGS-25	AGS	Bldg 912						Xa	X	X			4
MW-AGS-26	AGS	Bldg 912						Xa	X	X			4
MW-AGS-27	AGS	Bldg 912						Xa	X	X			4
MW-AGS-28	AGS	Bldg 912						Xa	X	X			4
MW-AGS-29	AGS	Bldg 912						Xa	X	X			4
MW-AGS-34	AGS	Bldg 912						Xa	X	X			4
MW-AGS-39	AGS	Bldg 912						Xa	X	X			4
064-055	AGS	E-20 Catcher						Xa	X	X			4
064-056	AGS	E-20 Catcher						Xa	X	X			4
025-001	RHIC	Beam Stop Area						Xa	X	X			4
025-003	RHIC	Beam Stop Area						Xa	X	X			4
025-004	RHIC	Beam Stop Area						Xa	X	X			4
025-005	RHIC	Beam Stop Area						Xa	X	X			4
025-006	RHIC	Beam Stop Area						Xa	X	X			4
025-007	RHIC	Beam Stop Area						Xa	X	X			4
025-008	RHIC	Beam Stop Area						Xa	X	X			4
034-005	RHIC	Collimator Area						Xa	X	X			4
034-006	RHIC	Collimator Area						Xa	X	X			4
043-001	RHIC	Collimator Area						Xa	X	X			4
043-002	RHIC	Collimator Area						Xa	X	X			4
044-013	RHIC	Collimator Area						Xa	X	X			4
044-014	RHIC	Collimator Area						Xa	X	X			4
063-001	WTP					X	X						1
063-002	WTP					X	X						1
063-003	WTP					X	X						1
073-001	WTP					X	X						1
073-002	WTP					X	X						1
046-001	SG Range						X						2
MW-SGR-01	SG Range						X						2
MW-SGR-02	SG Range						X						2

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Table 8-5
ES Calendar Year 2000
Facility Groundwater Monitoring Program
Analytical Breakdown

Well ID	Area	Sub Area	EPA 524.2 VOCs	EPA 625 Semi-VOCs	EPA 608 Pest/PCBs	Sulfate/Chloride/Nitrate	Metals	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr-90	Floating Product	Frequency (events/year)
094-001	BMRR							X	X	X	Xd		4b
084-012	BMRR							X	X	X	Xd		4
084-013	BMRR							X	X	X	Xd		4
084-027	BMRR							X	X	X	Xd		4
084-028	BMRR							X	X	X	Xd		4
MW-LFR-01	LF Range						X						4
MW-LFR-02	LF Range						X						4
102-05	Motor Pool	Gasoline USTs	X	X								Xe	4f
102-06	Motor Pool	Gasoline USTs	X	X								Xe	4f
102-008	Motor Pool	Bldg 423	X	X								Xe	4f
102-009	Motor Pool	Bldg 423	X	X								Xe	4f
102-010	Motor Pool	Bldg 326	X	X								Xe	4f
102-011	Motor Pool	Bldg 326	X	X								Xe	4f
102-012	Motor Pool	Bldg 326	X	X								Xe	4f
102-013	Motor Pool	Bldg 326	X	X								Xe	4f
085-016	Gas Station	Pump Island	X	X								X	2
085-017	Gas Station	Pump Island	X	X								X	2
MW-SS-01	Gas Station	Gasoline USTs	X	X								X	2
MW-SS-02	Gas Station	Gasoline USTs	X	X								X	2
MW-SS-03	Gas Station	Gasoline USTs	X	X								X	2
055-003	WMF	Bkgd.	X			X	X	X	X	X			4
055-010	WMF	Bkgd.	X			X	X	X	X	X			4
056-021	WMF	RCRA Bldg.	X			X	X	X	X	X			4
056-022	WMF	Rad. Bldg.	X			X	X	X	X	X			4
056-023	WMF	Rad. Bldg.	X			X	X	X	X	X			4
066-007	WMF	Bkgd	X			X	X	X	X	X			4
066-083	WMF	Mixed Waste Bldg.	X			X	X	X	X	X			4
066-084	WMF	Bkgd.	X			X	X	X	X	X			4
MW-BIO-01	BIO	Greenhouses			X	X	X						2
MW-BIO-02	BIO	Greenhouses			X	X	X						2
76-16	MPF		X	X									2
76-17	MPF		X	X									2
76-18	MPF		X	X									2
76-19	MPF		X	X									2
76-25	MPF		X	X									2

3 of 4

Table 8-5
ES Calendar Year 2000
Facility Groundwater Monitoring Program
Analytical Breakdown

Well ID	Area	Sub Area	EPA 524.2 VOCs	EPA 625 Semi-VOCs	EPA 608 Pest/PCBs	Sulfate/Chloride/Nitrate	Metals	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr-90	Floating Product	Frequency (events/year)
MW-MPF-01	MPF		X	X									2
MW-MPF-02	MPF		X	X									2
MW-MPF-03	MPF		X	X									2
038-002	STP	Filter Beds	X			X	X	X	X	X			2
038-003	STP	Filter Beds	X			X	X	X	X	X			2
039-007	STP	Filter Beds	X			X	X	X	X	X			2
039-008	STP	Filter Beds	X			X	X	X	X	X			2
MW-STP-01	STP	Filter Beds	X			X	X	X	X	X			2
MW-STP-02	STP	Filter Beds	X			X	X	X	X	X			2
MW-STP-03	STP	Holding Ponds	X			X	X	X	X	X			2
MW-STP-04	STP	Holding Ponds	X			X	X	X	X	X			2
MW-STP-05	STP	Holding Ponds	X			X	X	X	X	X			2

<u>NOTES:</u>

a: For CY00 Gross alpha/beta samples collected semiannually. For CY01/02 may be annually

b: Sampling of this well is optional.

c: Some g-2 Tritium Plume wells may be sampled on a monthly basis.

d: Sr-90 samples to be collected only if elevated gross beta values are observed.

e: Floating product determination measurements to be collected monthly.

f: Sampling to be reduced to semiannual upon NYSDEC approval

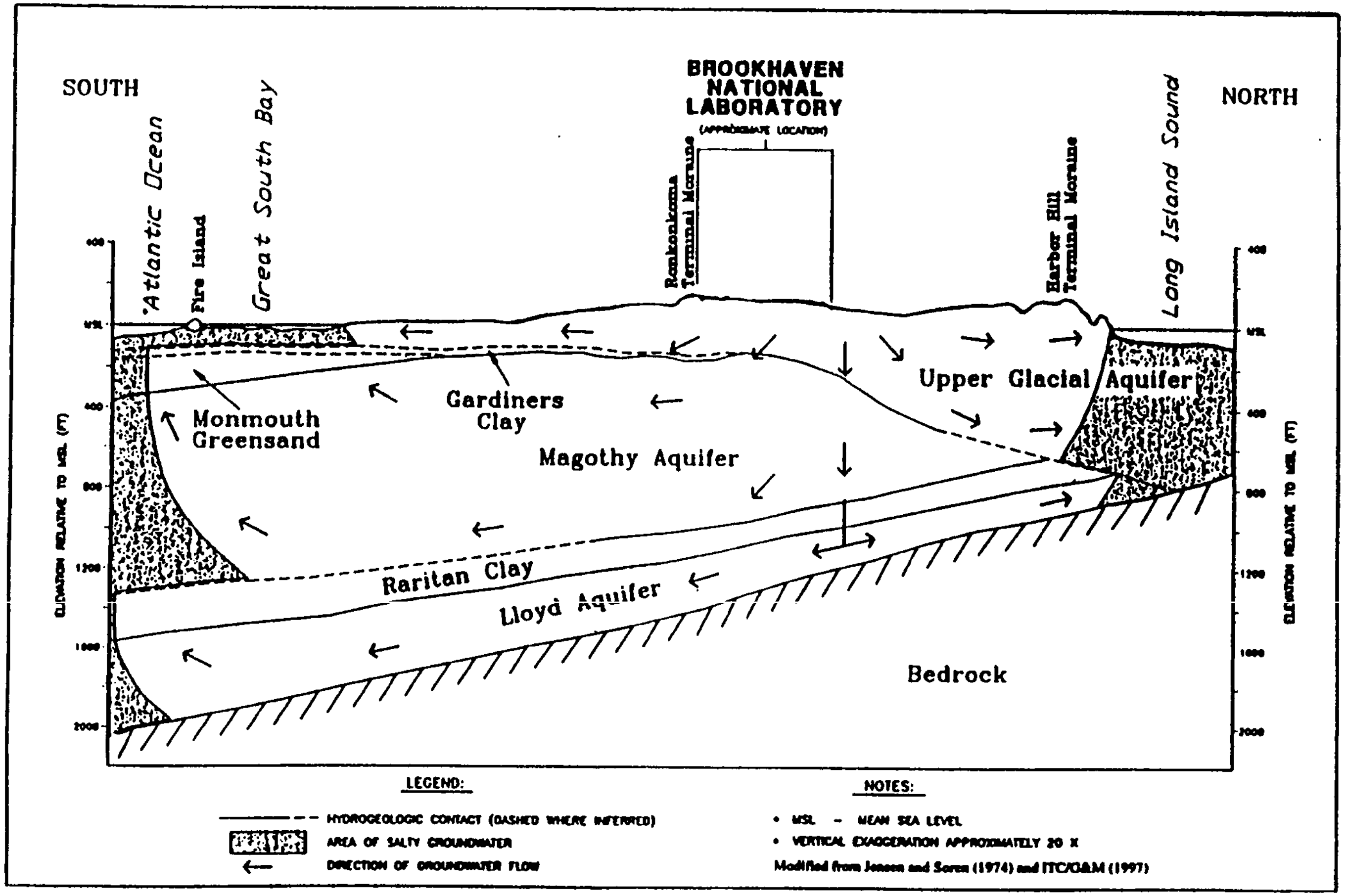

Figure 8-1
Brookhaven National Laboratory
Environmental Monitoring Plan
Generalized Geologic Cross Section in the Vicinity of Brookhaven National Laboratory

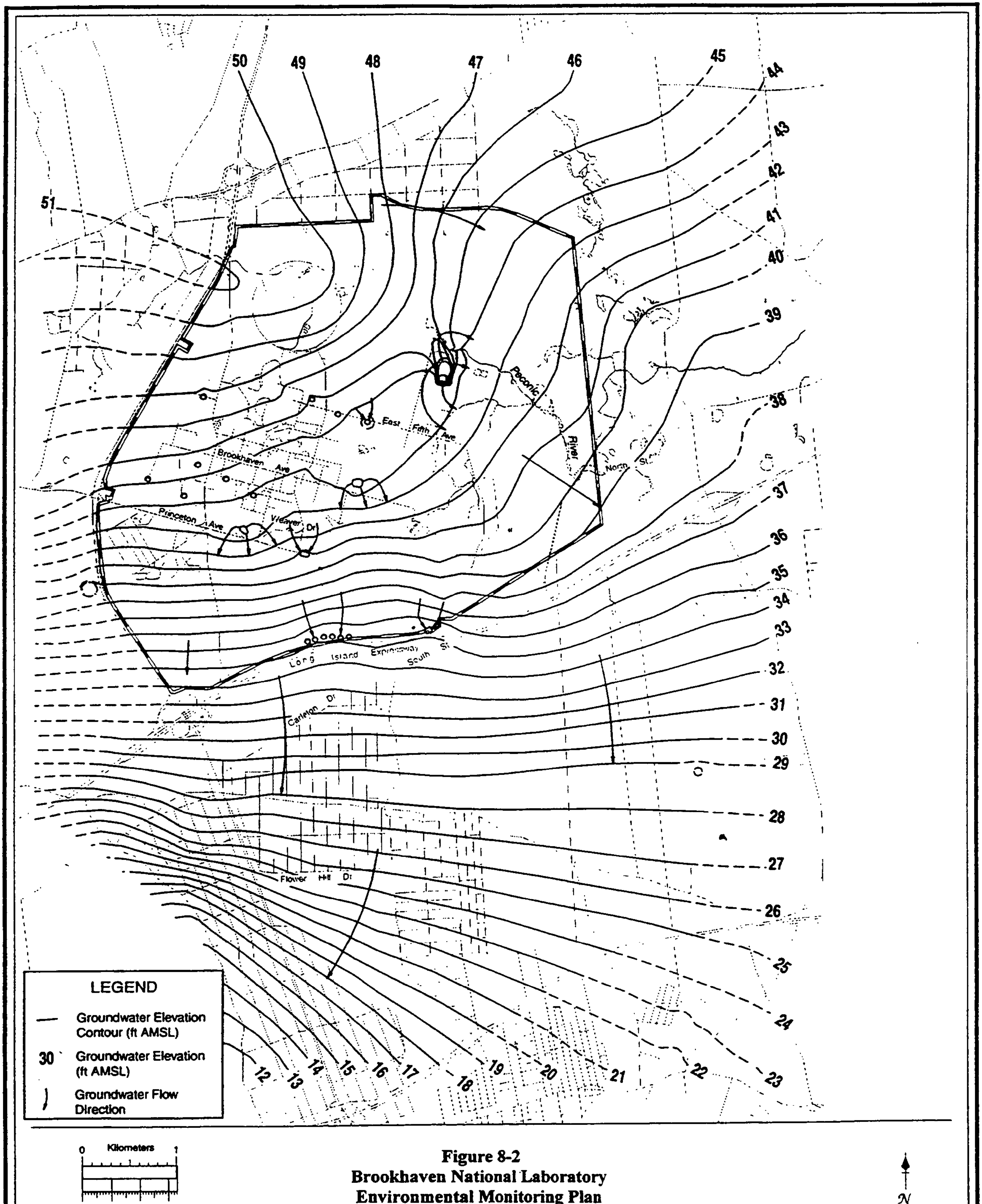

Figure 8-2
Brookhaven National Laboratory
Environmental Monitoring Plan
Groundwater Flow and Elevation (December 1998)

BROOKHAVEN
NATIONAL LABORATORY

Environmental Restoration Division

Figure 8-3

Environmental Restoration Monitoring Well Locations Sitewide Background Monitoring Program

LEGEND

● Monitoring well

SCALE

Meters: 0 100 200 300 400 500 600 700

Feet: 0 1000 2000

ALH - 02/23/00
/home4/oeraml/sitewide/gw99_swh.aml
Graphics/Sitewide/gw99_swh.ai

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NATIONAL LABORATORY

Environmental Restoration Division

Figure 8-4

Environmental Restoration Monitoring Well Locations RA V Monitoring Program

LEGEND

● Monitoring well

Current Landfill / HWMF Plume (VOCs)

SCALE

Kilometers

0 1

0 1000 2000 3000

Feet

ALH - 02/23/00
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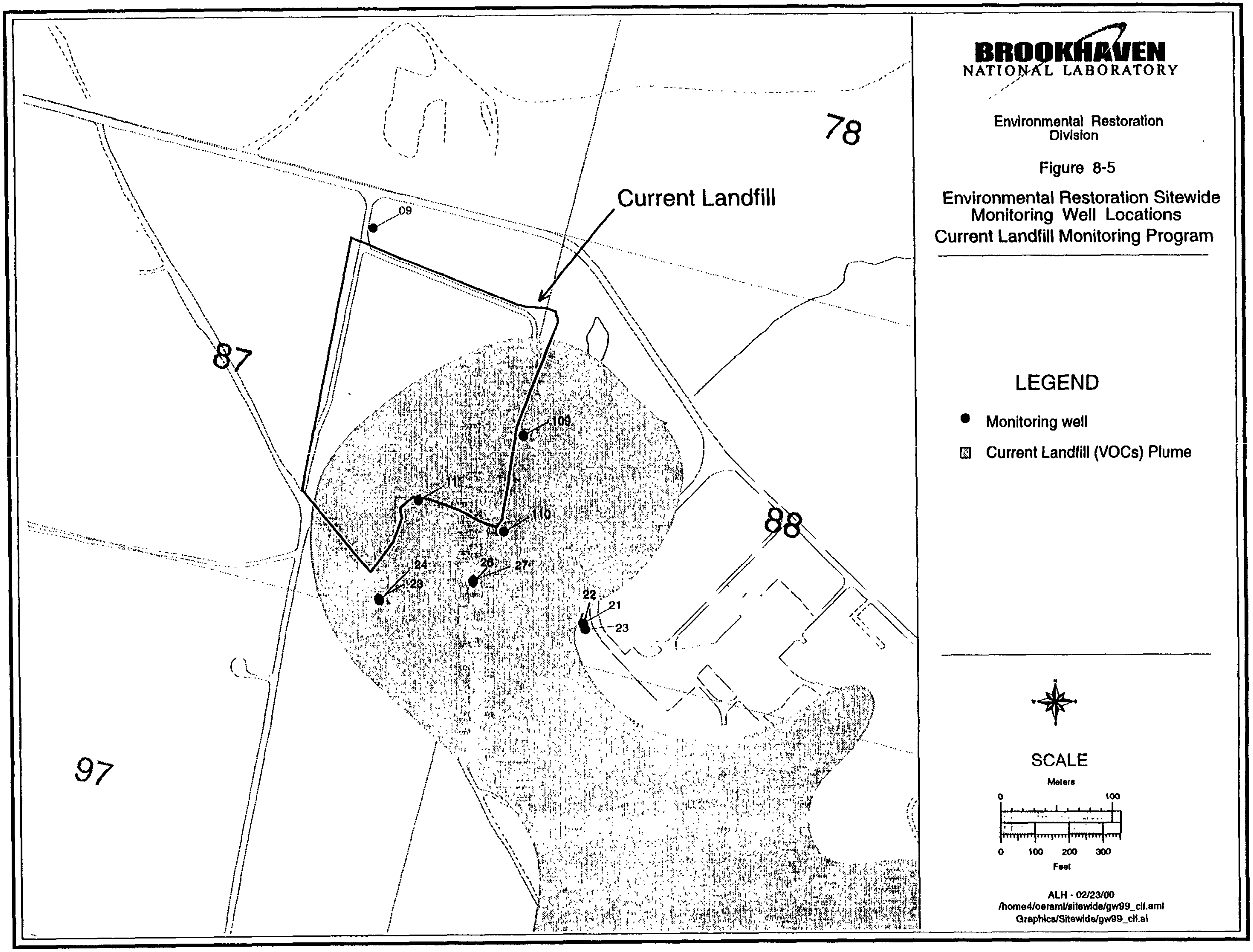
Graphics/Sitewide/gw99_rav.al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NATIONAL LABORATORY
Environmental Restoration Division
Figure 8-5
Environmental Restoration Sitewide Monitoring Well Locations
Current Landfill Monitoring Program
LEGEND
Monitoring well
Current Landfill (VOCs) Plume
SCALE
Meters
0
100
0
100
200
300
Feet
ALH - 02/23/00
/home4/ceraml/sitewide/gw99_clf.aml
Graphics/Sitewide/gw99_clf.al
Current Landfill
78
87
88
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09
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110
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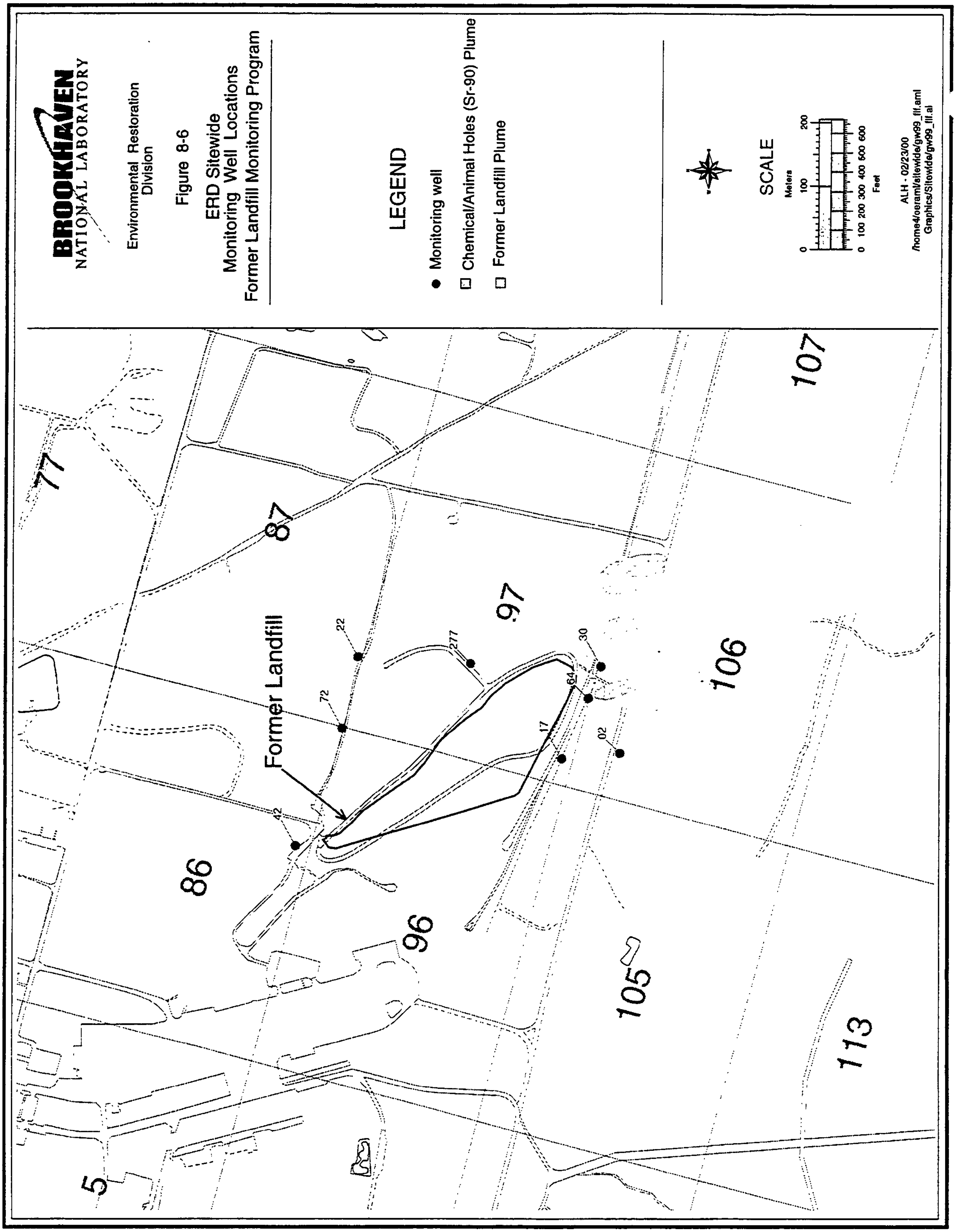
26
27
22
21
23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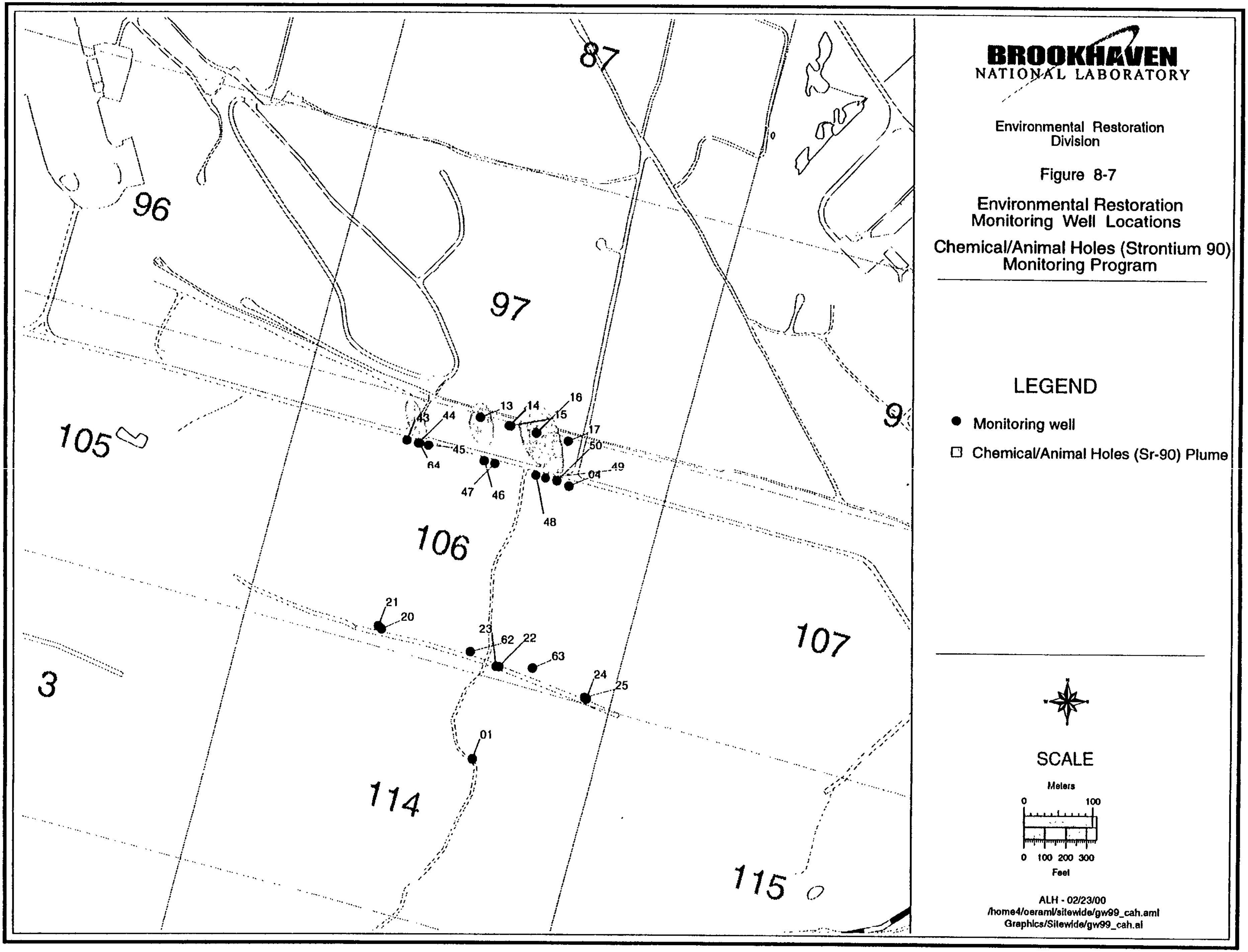
Environmental Restoration Division
Figure 8-6
ERD Sitewide
Monitoring Well Locations
Former Landfill Monitoring Program
LEGEND
Monitoring well
Chemical/Animal Holes (Sr-90) Plume
Former Landfill Plume
SCALE
Meters
0 100 200
0 100 200 300 400 500 600
Feet
ALH - 02/23/00
/home4/oeraml/sitewide/gw99_fll.aml
Graphics/Sitewide/gw99_fll.ai
Former Landfill
77
87
97
86
96
106
107
105
113
5
22
72
277
30
64
17
02
42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Environmental Restoration Division
Figure 8-7
Environmental Restoration Monitoring Well Locations
Chemical/Animal Holes (Strontium 90) Monitoring Program
LEGEND
Monitoring well
Chemical/Animal Holes (Sr-90) Plume
SCALE
Meters
0
100
0 100 200 300
Feet
ALH - 02/23/00
/home4/oeraml/sitewide/gw99_cah.aml
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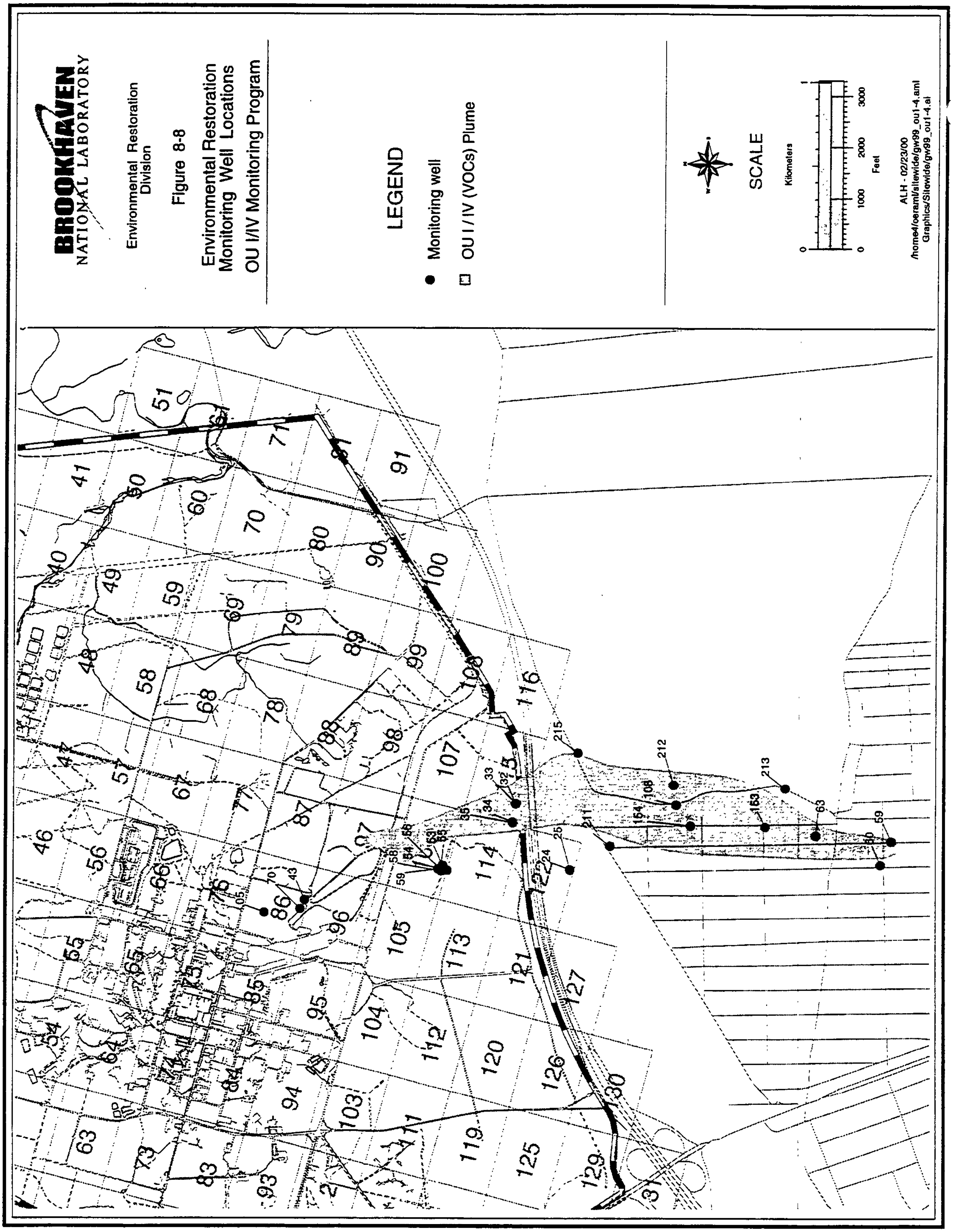
87
96
97
105
106
107
114
115
3
9
13
14
15
16
17
43
44
45
64
46
47
48
50
49
04
21
20
23
62
22
63
24
25
01


BROOKHAVEN NATIONAL LABORATORY
Environmental Restoration Division
Figure 8-8
Environmental Restoration Monitoring Well Locations
OU I/IV Monitoring Program
LEGEND
Monitoring well
OU I / IV (VOCs) Plume
SCALE
Kilometers
Feet
0 1000 2000 3000
ALH - 02/23/00
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Graphics/Sitewide/gw99_ou1-4.ai

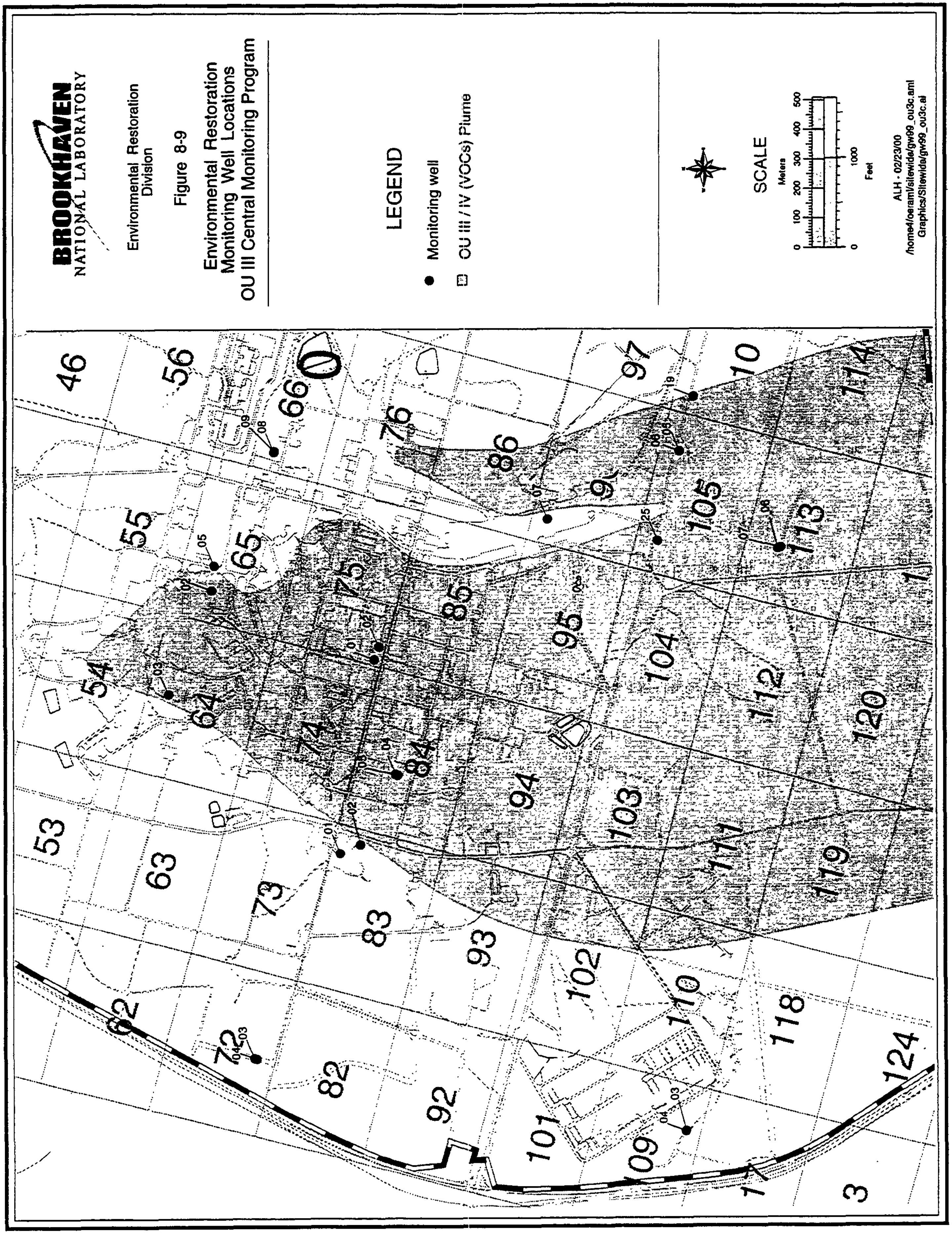
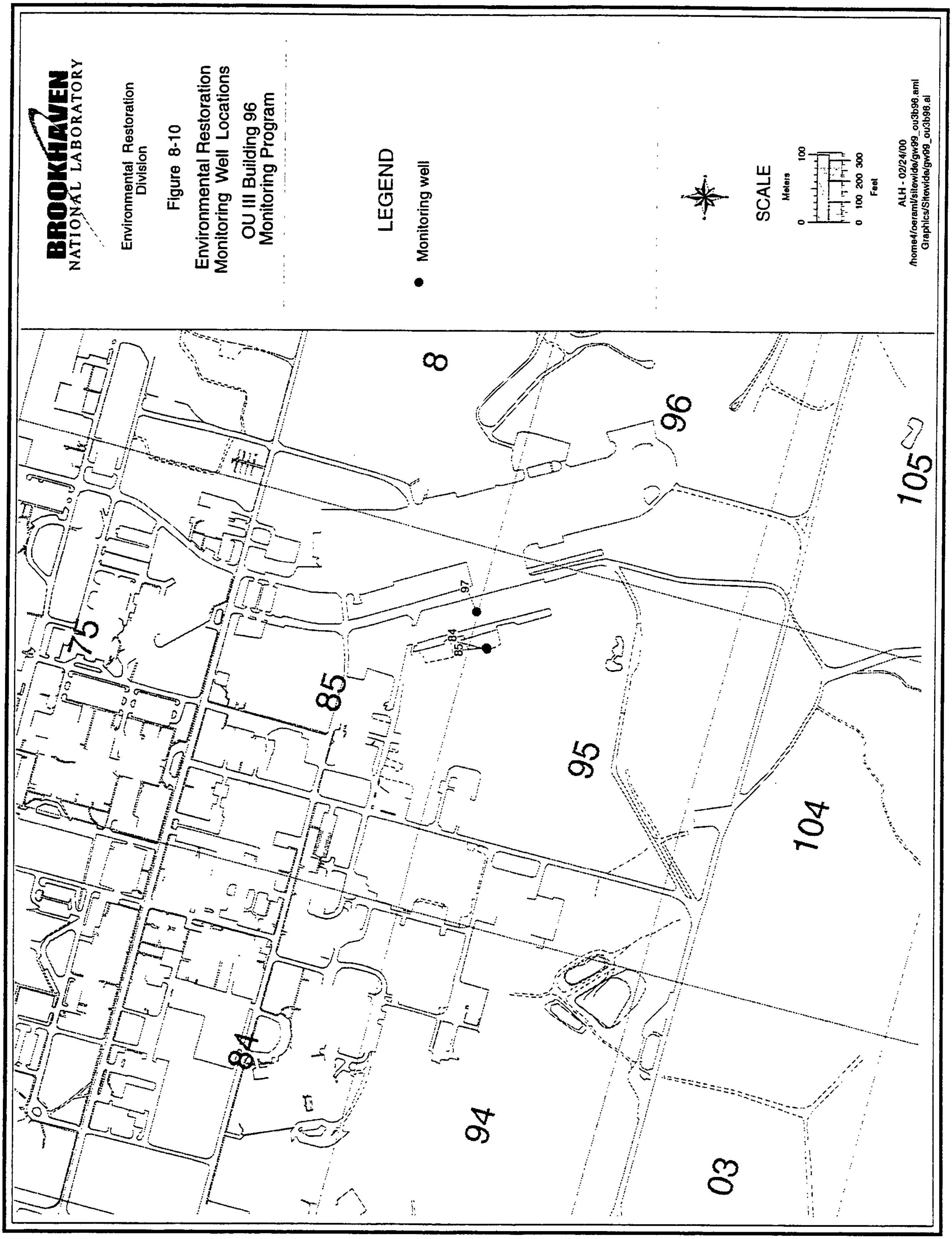
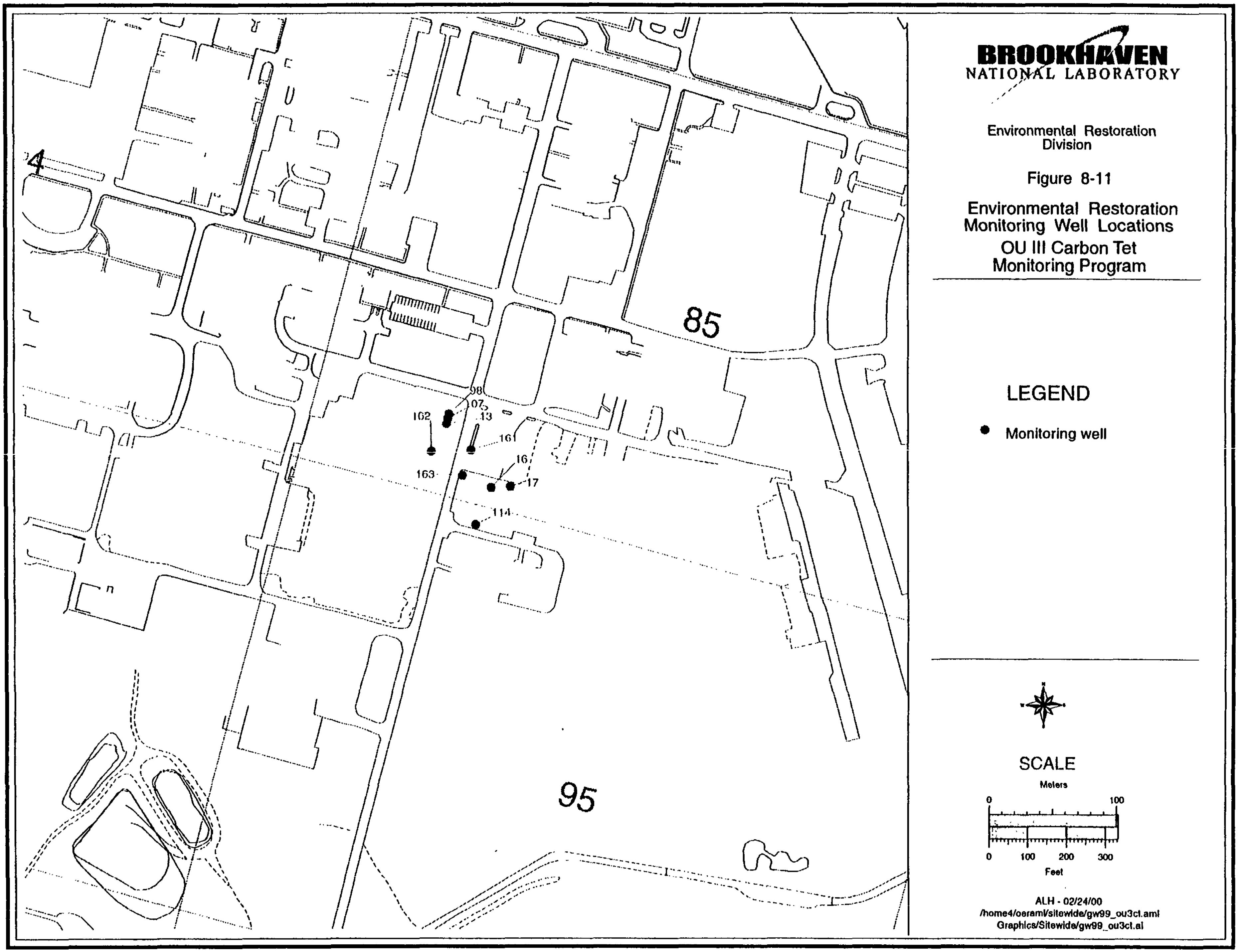


Figure 8-9
Environmental Restoration
Monitoring Well Locations
OU III Central Monitoring Program


BROOKHAVEN
NATIONAL LABORATORY
Environmental Restoration
Division
Figure 8-10
Environmental Restoration
Monitoring Well Locations
OU III Building 96
Monitoring Program
LEGEND
Monitoring well
SCALE
Meters
0
100
Feet
0 100 200 300
ALH - 02/24/00
/home4/oeraml/sitewide/gw99_ou3b96.aml
Graphics/Sitewide/gw99_ou3b96.ai
8
96
105
75
97
85-84
85
95
104
84
94
03


BROOKHAVEN
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Environmental Restoration Division
Figure 8-11
Environmental Restoration Monitoring Well Locations
OU III Carbon Tet Monitoring Program
LEGEND
Monitoring well
SCALE
Meters
0
100
0
100
200
300
Feet
ALH - 02/24/00
/home4/oeraml/sitewide/gw99_ou3ct.aml
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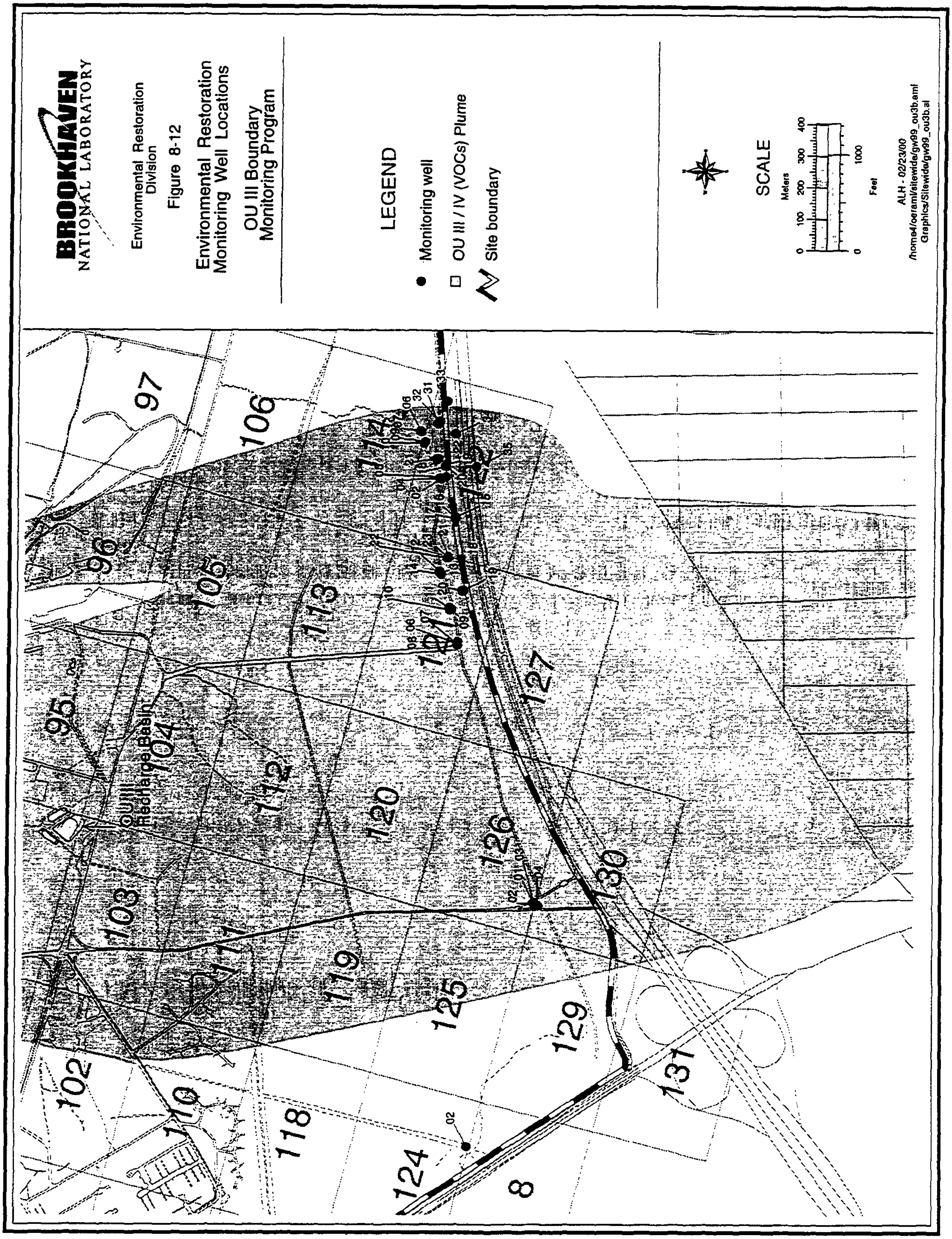
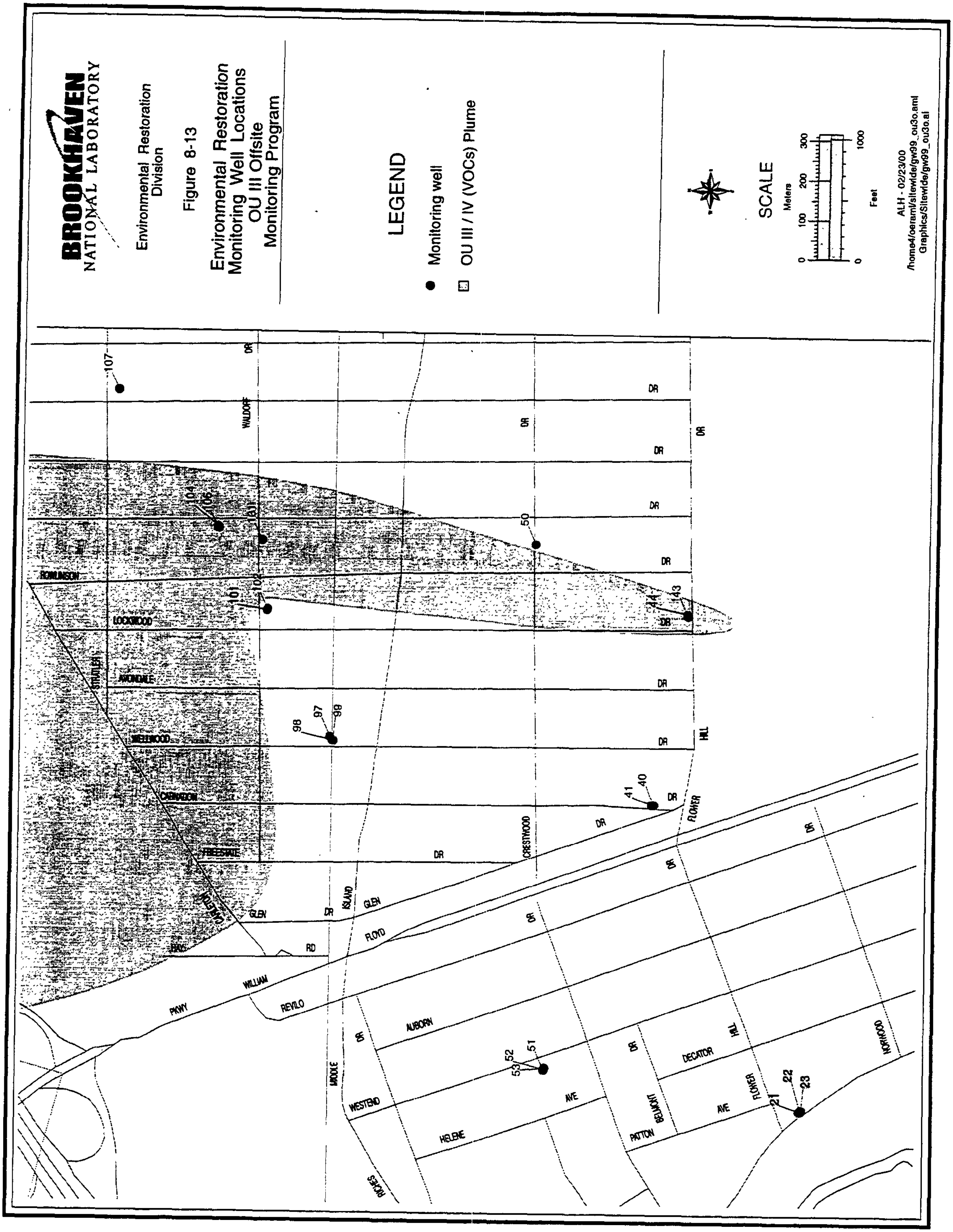
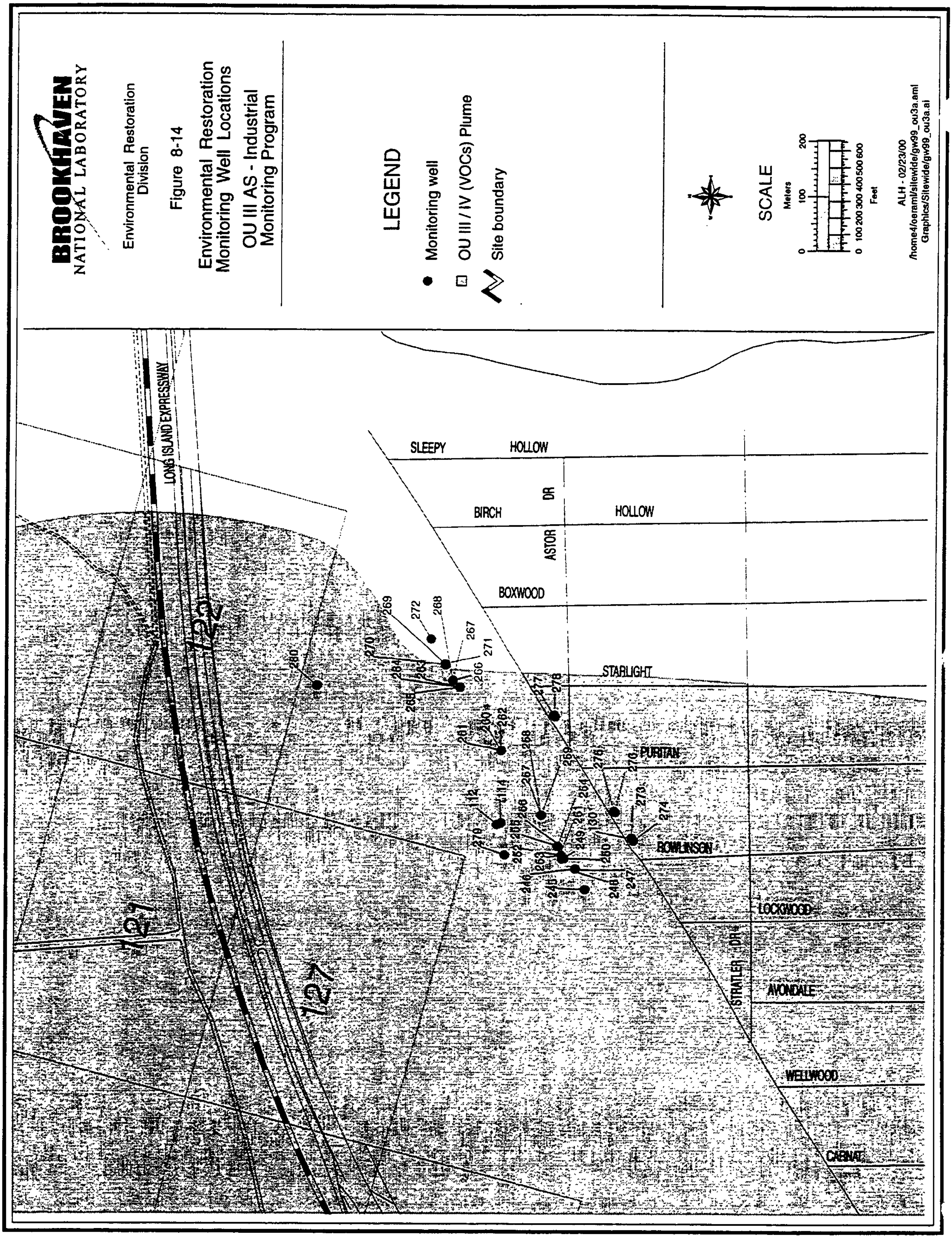
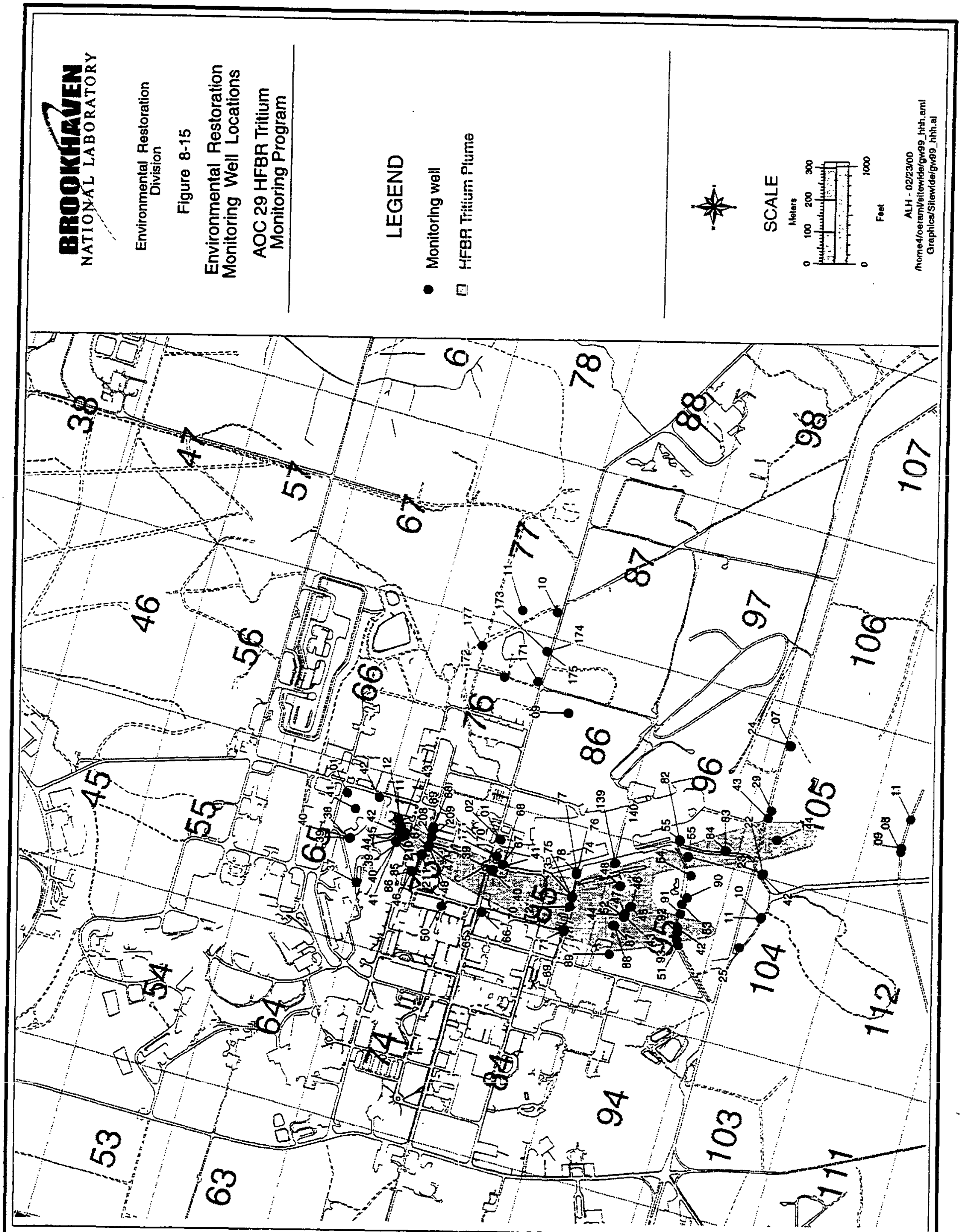
161
16
163
17
114


BROOKHAVEN
NATIONAL LABORATORY
Environmental Restoration
Division
Figure 8-12
Environmental Restoration
Monitoring Well Locations
OU III Boundary
Monitoring Program
LEGEND
Monitoring well
OU III / IV (VOCs) Plume
Site boundary
SCALE
Meters
Feet
ALH - 02/23/00
/home4/ceram/sitewide/gw99_ou3b.aml
Graphics/Sitewide/gw99_ou3b.ai
OU III Recharge Basin
97
106
96
105
95
104
113
112
120
103
111
119
126
127
130
125
129
102
110
118
124
8
131


BROOKHAVEN NATIONAL LABORATORY
Environmental Restoration Division
Figure 8-13
Environmental Restoration Monitoring Well Locations OU III Offsite Monitoring Program
LEGEND
Monitoring well
OU III / IV (VOCs) Plume
SCALE
Meters
0
100
200
300
Feet
0
1000
ALH - 02/23/00
/home4/oeraml/sitewide/gw99_ou3o.aml
Graphics/Sitewide/gw99_ou3o.ai
107
104
106
103
50
101
102
144
143
98
97
99
41
40
53
52
51
21
22
23
WALDORF
ROWLINSON
LOCKWOOD
AVONDALE
WELLWOOD
CARNATION
FREESTATE
STRATLER
CRESTWOOD
GLEN
ISLAND
FLOYD
WILLIAM
PKWY
REVILO
RD
AUBORN
WESTEND
HELENE
AVE
MOOLE
RICHES
DECATOR
HILL
BELMONT
PATTON
FLOWER
NORWOOD
DR


BROOKHAVEN
NATIONAL LABORATORY
Environmental Restoration Division
Figure 8-14
Environmental Restoration Monitoring Well Locations
OU III AS - Industrial Monitoring Program
LEGEND
Monitoring well
OU III / IV (VOCs) Plume
Site boundary
SCALE
Meters
0
100
200
0 100 200 300 400 500 600
Feet
ALH - 02/23/00
/home4/oeraml/sitewide/gw99_ou3a.aml
Graphics/Sitewide/gw99_ou3a.ai
LONG ISLAND EXPRESSWAY
SLEEPY
HOLLOW
BIRCH
HOLLOW
DR
ASTOR
BOXWOOD
STARLIGHT
PURITAN
ROWLINSON
LOCKWOOD
STRATLER DR
AVONDALE
WELLWOOD
CARNAT
280
269
272
268
267
270
271
264
263
265
266
277
278
261
260
262
268
259
276
270
267
112
266
264
261
301
273
274
270
252
263
249
250
246
240
248
247


BROOKHAVEN
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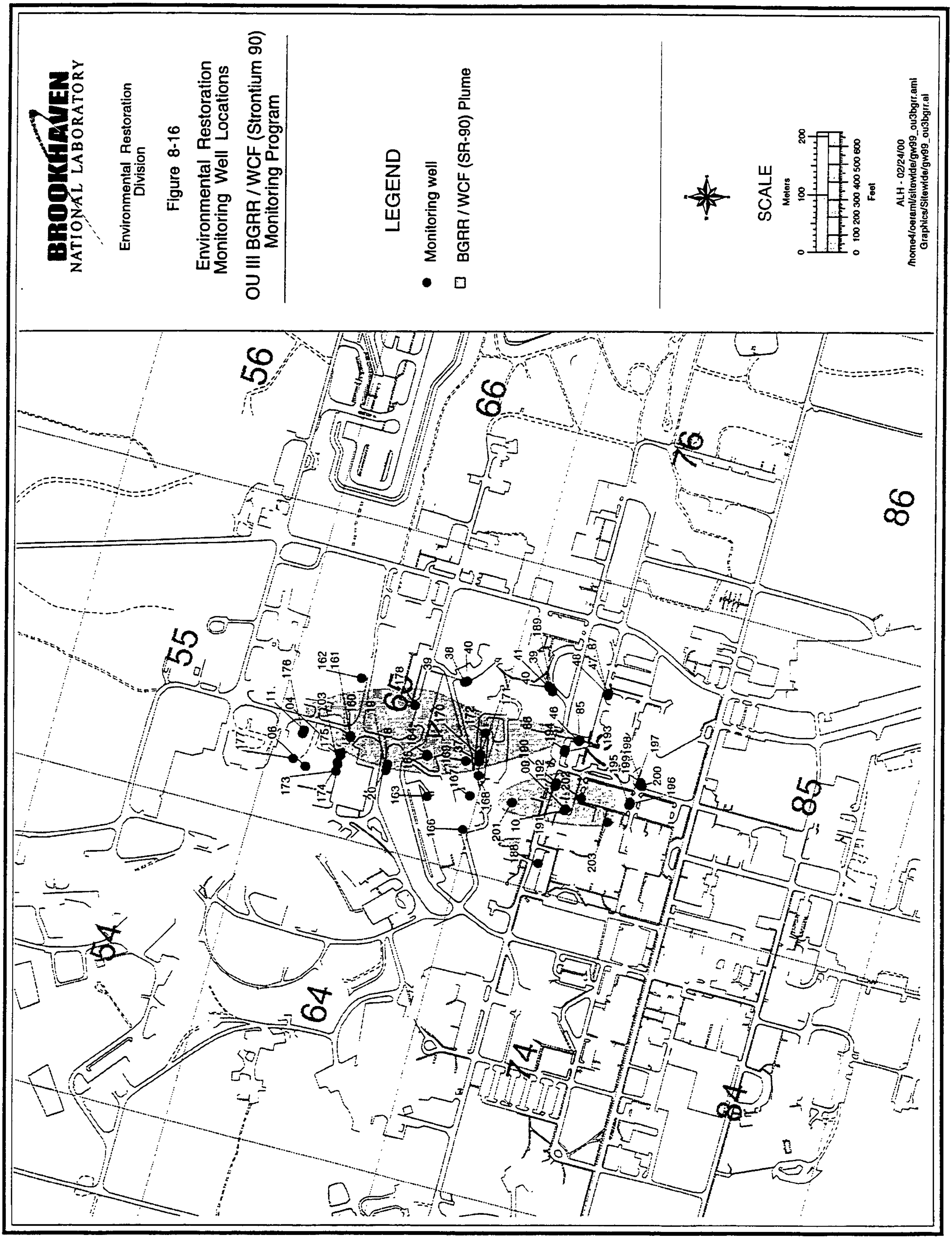
Environmental Restoration
Division
Figure 8-15
Environmental Restoration
Monitoring Well Locations
AOC 29 HFBR Tritium
Monitoring Program
LEGEND
Monitoring well
HFBR Tritium Plume
SCALE
Meters
0 100 200 300
Feet
0 1000
ALH - 02/23/00
/home4/oeram/sitewide/gw99_hhh.aml
Graphics/Sitewide/gw99_hhh.al



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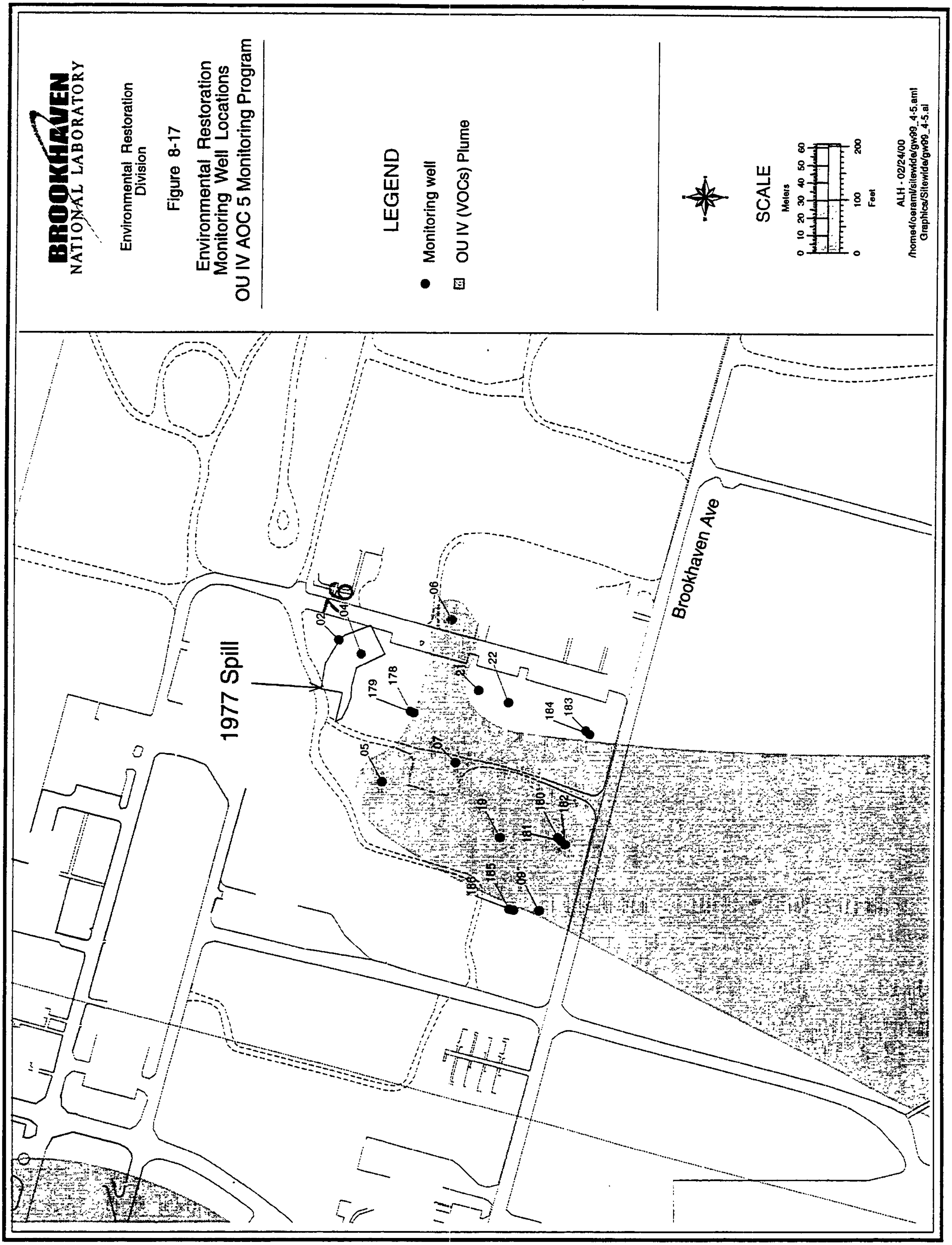
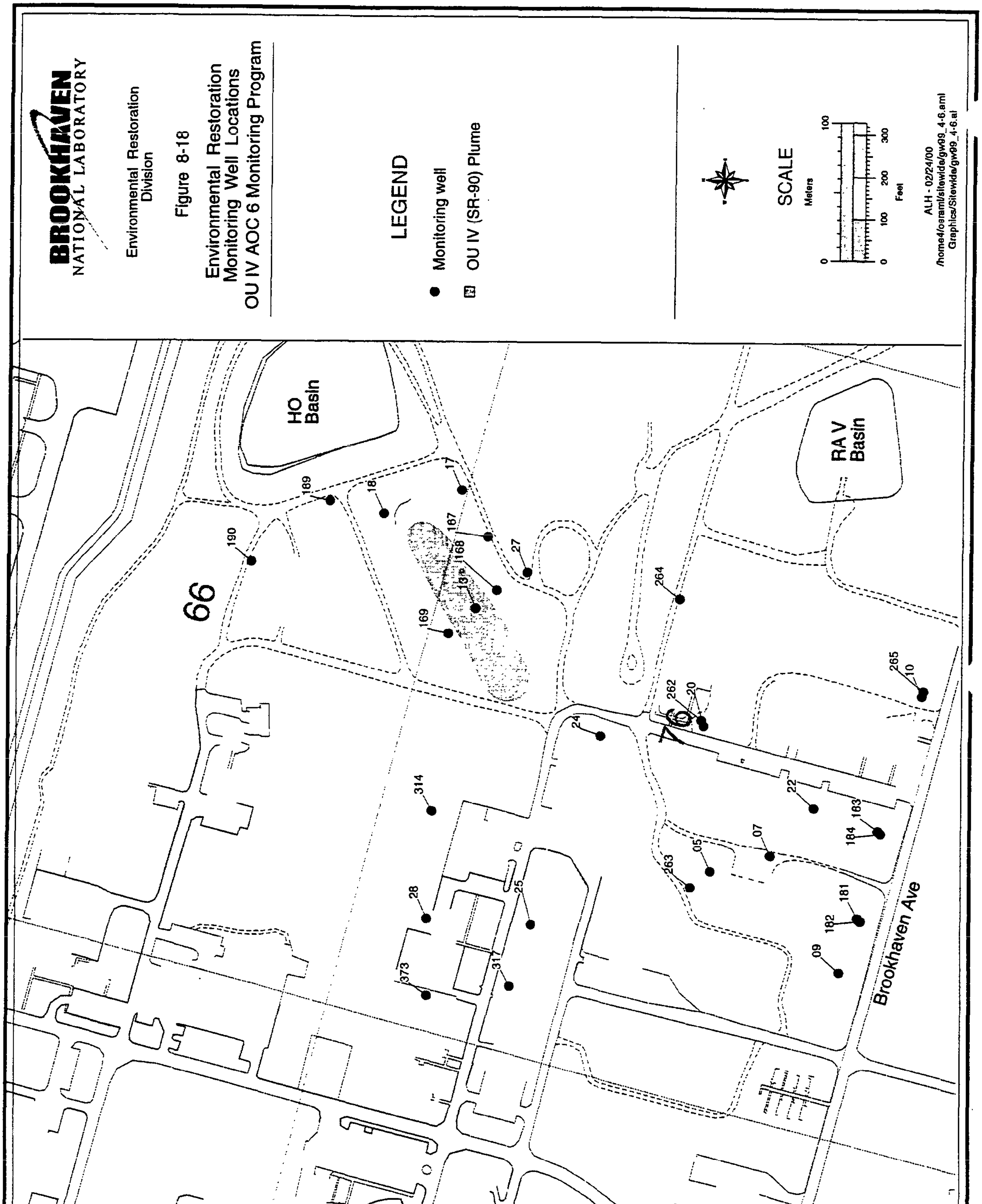
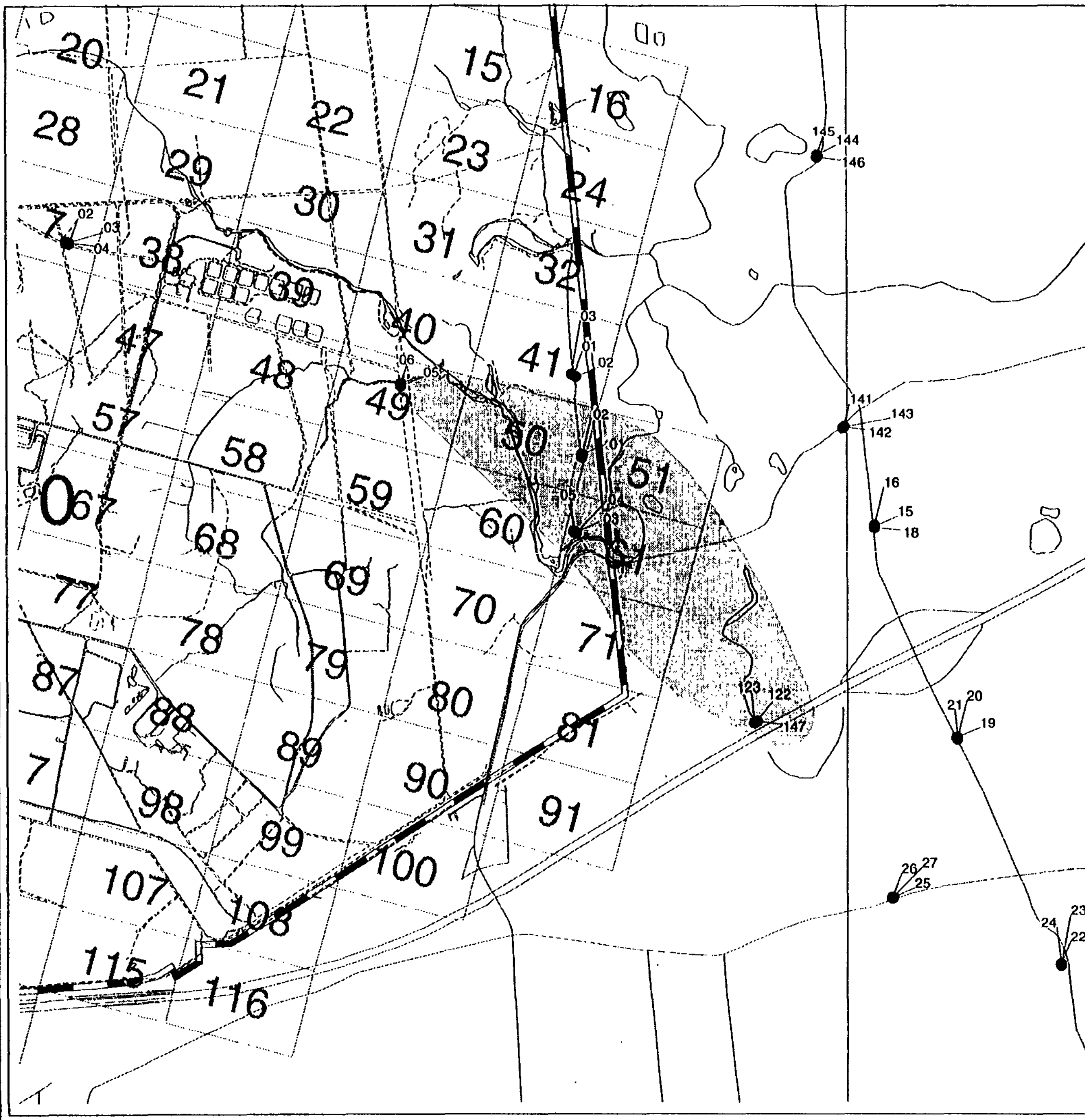
Environmental Restoration
Division
Figure 8-16
Environmental Restoration
Monitoring Well Locations
OU III BGRR / WCF (Strontium 90)
Monitoring Program
LEGEND
Monitoring well
BGRR / WCF (SR-90) Plume
SCALE
Meters
0 100 200
0 100 200 300 400 500 600
Feet
ALH - 02/24/00
/home4/oerami/sitewide/gw99_ou3bgrr.aml
Graphics/Sitewide/gw99_ou3bgrr.ai
56
66
76
86
55
65
75
85
54
64
74
84


BROOKHAVEN NATIONAL LABORATORY
Environmental Restoration Division
Figure 8-17
Environmental Restoration Monitoring Well Locations OU IV AOC 5 Monitoring Program
LEGEND
Monitoring well
OU IV (VOCs) Plume
SCALE
Meters
0 10 20 30 40 50 60
0 100 200
Feet
ALH - 02/24/00
/home4/oeraml/sitewide/gw99_4-5.aml
Graphics/Sitewide/gw99_4-5.al
1977 Spill
Brookhaven Ave
02
04
06
21
22
178
179
184
183
05
07
19
180
182
181
186
185
09


BROOKHAVEN
NATIONAL LABORATORY
Environmental Restoration Division
Figure 8-18
Environmental Restoration Monitoring Well Locations
OU IV AOC 6 Monitoring Program
LEGEND
Monitoring well
OU IV (SR-90) Plume
SCALE
Meters
0 100
Feet
0 100 200 300
ALH - 02/24/00
HO Basin
RA V Basin
66
Brookhaven Ave
189
190
18
17
167
168
169
27
264
262
20
265
10
24
314
22
163
184
07
05
263
28
25
181
182
09
373
317



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Environmental Restoration Division

Figure 8-19

Environmental Restoration Monitoring Well Locations
OU V Monitoring Program

LEGEND

- ● Monitoring well
- OU V STP (VOCs) Plume
- Site boundary

SCALE

Meters
0 100 200 300 400 500 600 700

0 1000 2000
Feet

ALH - 02/24/00
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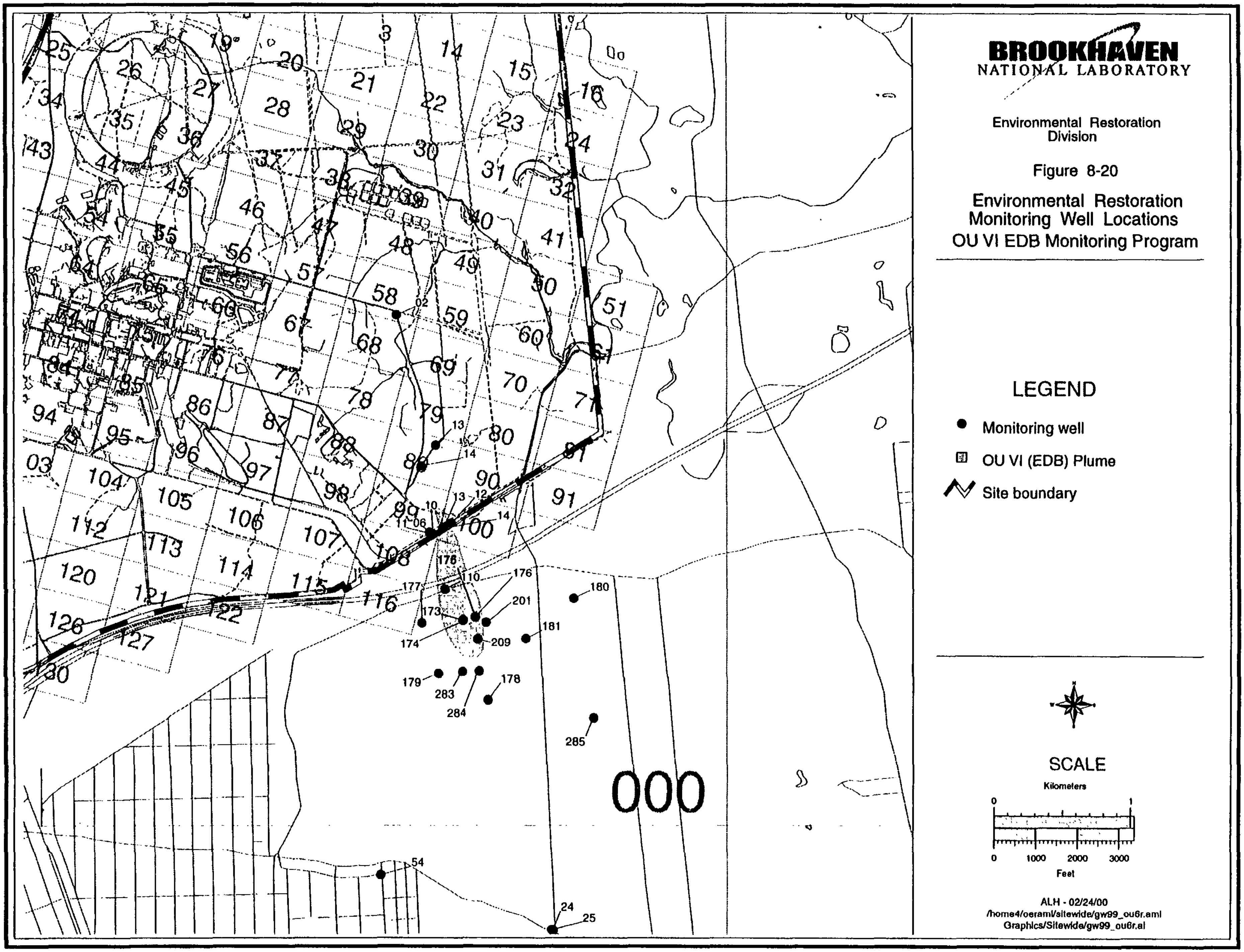
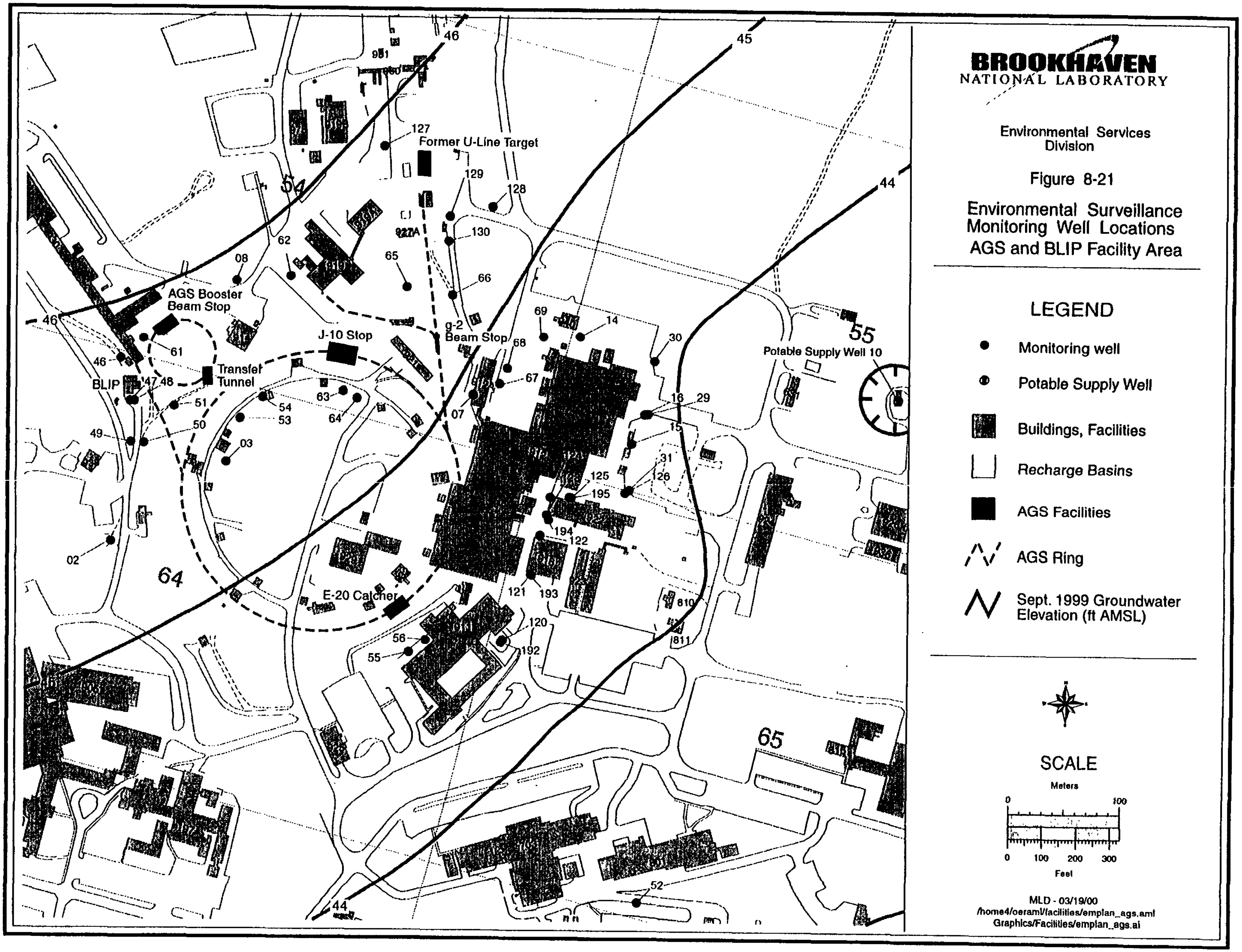
Graphics/Sitewide/gw99_ou5.ai


BROOKHAVEN
NATIONAL LABORATORY
Environmental Restoration Division
Figure 8-20
Environmental Restoration Monitoring Well Locations
OU VI EDB Monitoring Program
LEGEND
Monitoring well
OU VI (EDB) Plume
Site boundary
SCALE
Kilometers
0
1
0
1000
2000
3000
Feet
ALH - 02/24/00
/home4/oeraml/sitewide/gw99_ou6r.aml
Graphics/Sitewide/gw99_ou6r.ai
000
180
176
201
181
177
173
174
209
179
283
284
178
285
54
24
25


BROOKHAVEN NATIONAL LABORATORY
Environmental Services Division
Figure 8-21
Environmental Surveillance Monitoring Well Locations AGS and BLIP Facility Area
LEGEND
Monitoring well
Potable Supply Well
Buildings, Facilities
Recharge Basins
AGS Facilities
AGS Ring
Sept. 1999 Groundwater Elevation (ft AMSL)
SCALE
Meters
0
100
0
100
200
300
Feet
MLD - 03/19/00
/home4/oeraml/facilities/emplan_ags.aml
Graphics/Facilities/emplan_ags.ai
Former U-Line Target
AGS Booster Beam Stop
J-10 Stop
g-2 Beam Stop
Transfer Tunnel
BLIP
E-20 Catcher
Potable Supply Well 10
46
45
44
54
55
64
65
127
129
128
130
927A
62
08
65
66
69
14
30
61
68
67
07
16
29
15
31
126
125
195
194
122
121
193
810
811
120
192
56
55
54
53
63
64
51
50
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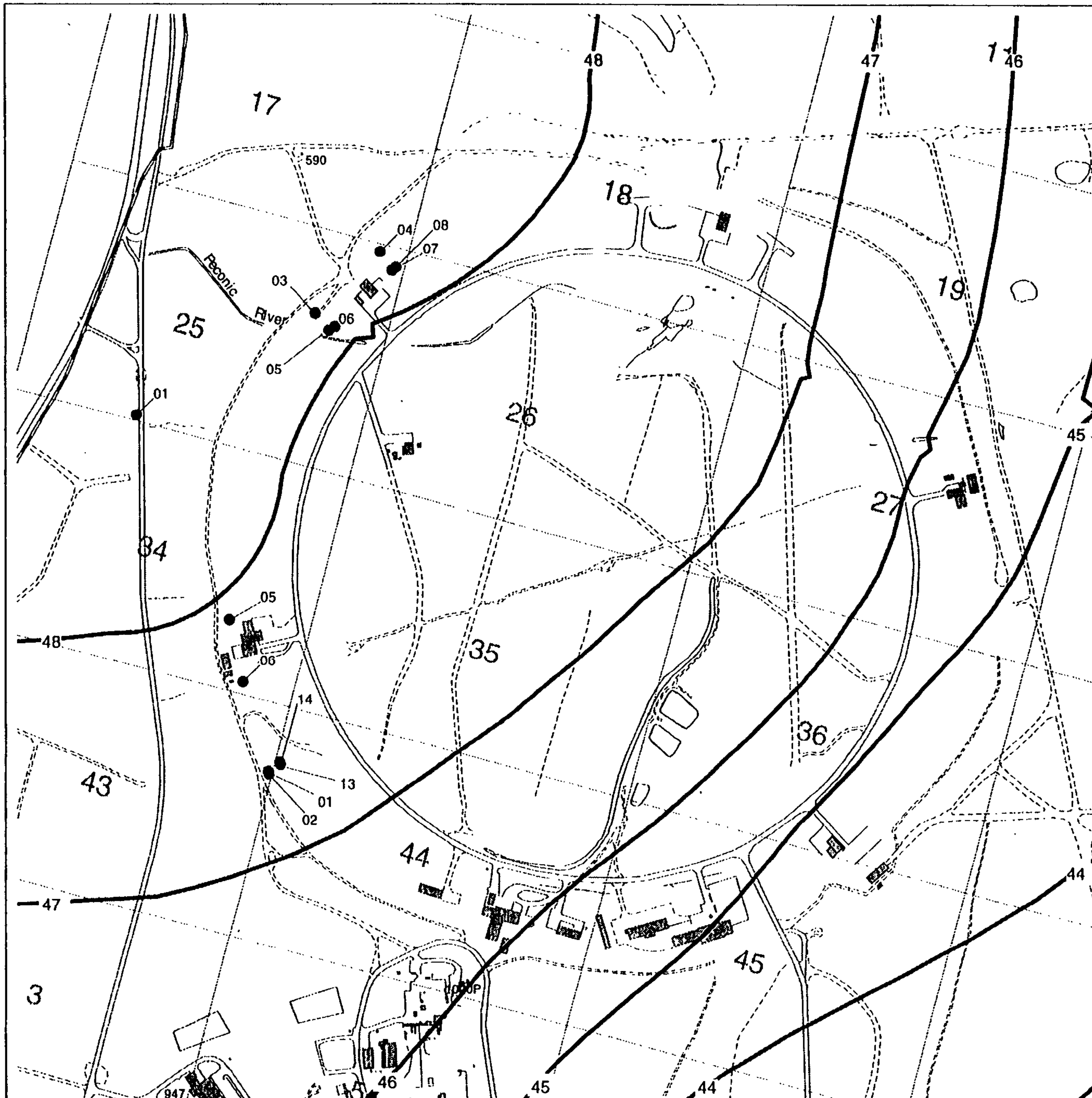
03
47
48
02
52



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Environmental Services Division

Figure 8-22

Environmental Surveillance Monitoring Well Locations RHIC Facility Area

LEGEND

- ● Monitoring well
- Buildings, Facilities
- Recharge Basins
- Site Boundary
- Sept. 1999 Groundwater Elevation (ft AMSL)

SCALE

Meters: 0 100 200

Feet: 0 100 200 300 400 500 600

MLD - 03/19/00
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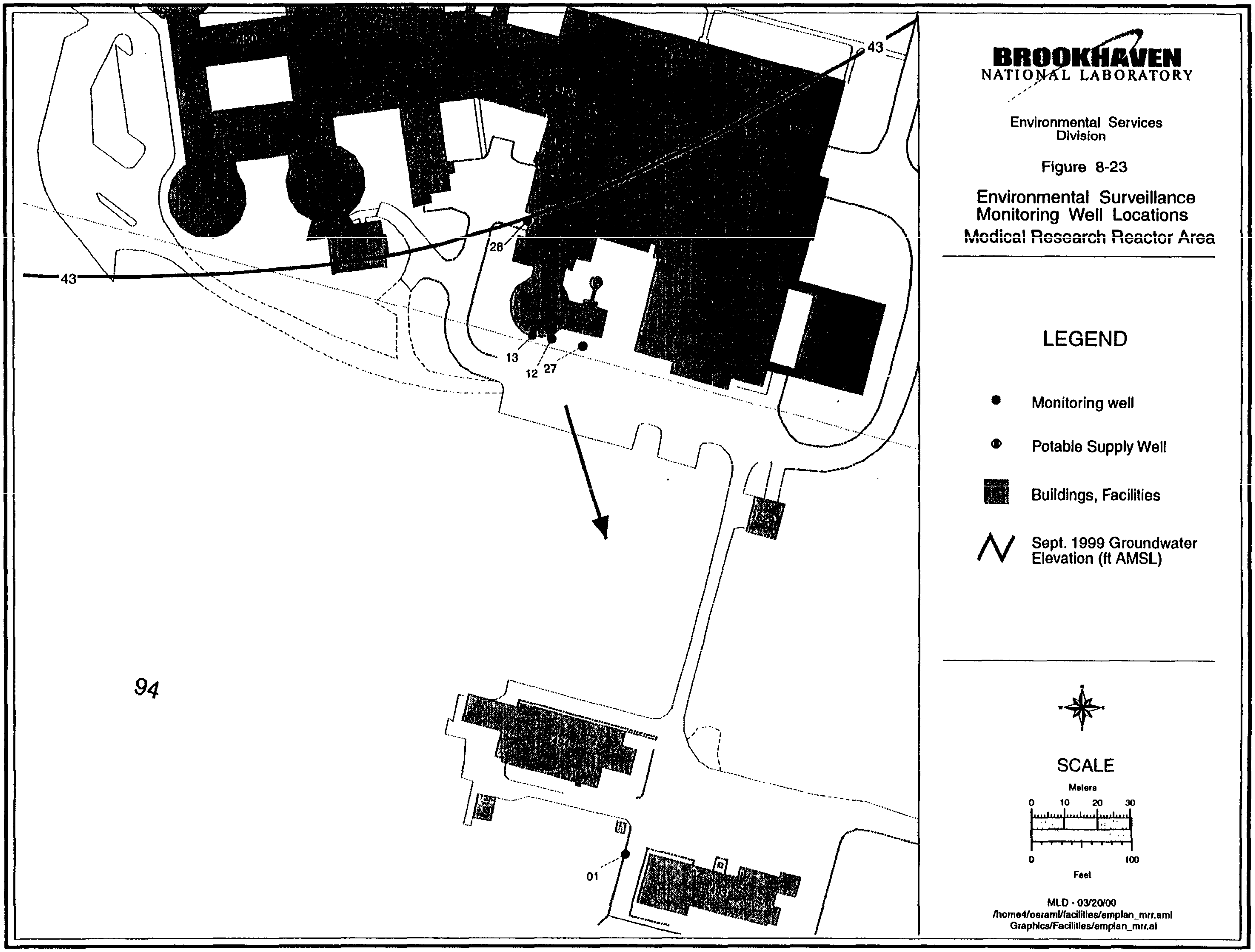
Graphics/Facilities/emplan_rhic.ai


43
43
28
13
12
27
94
01
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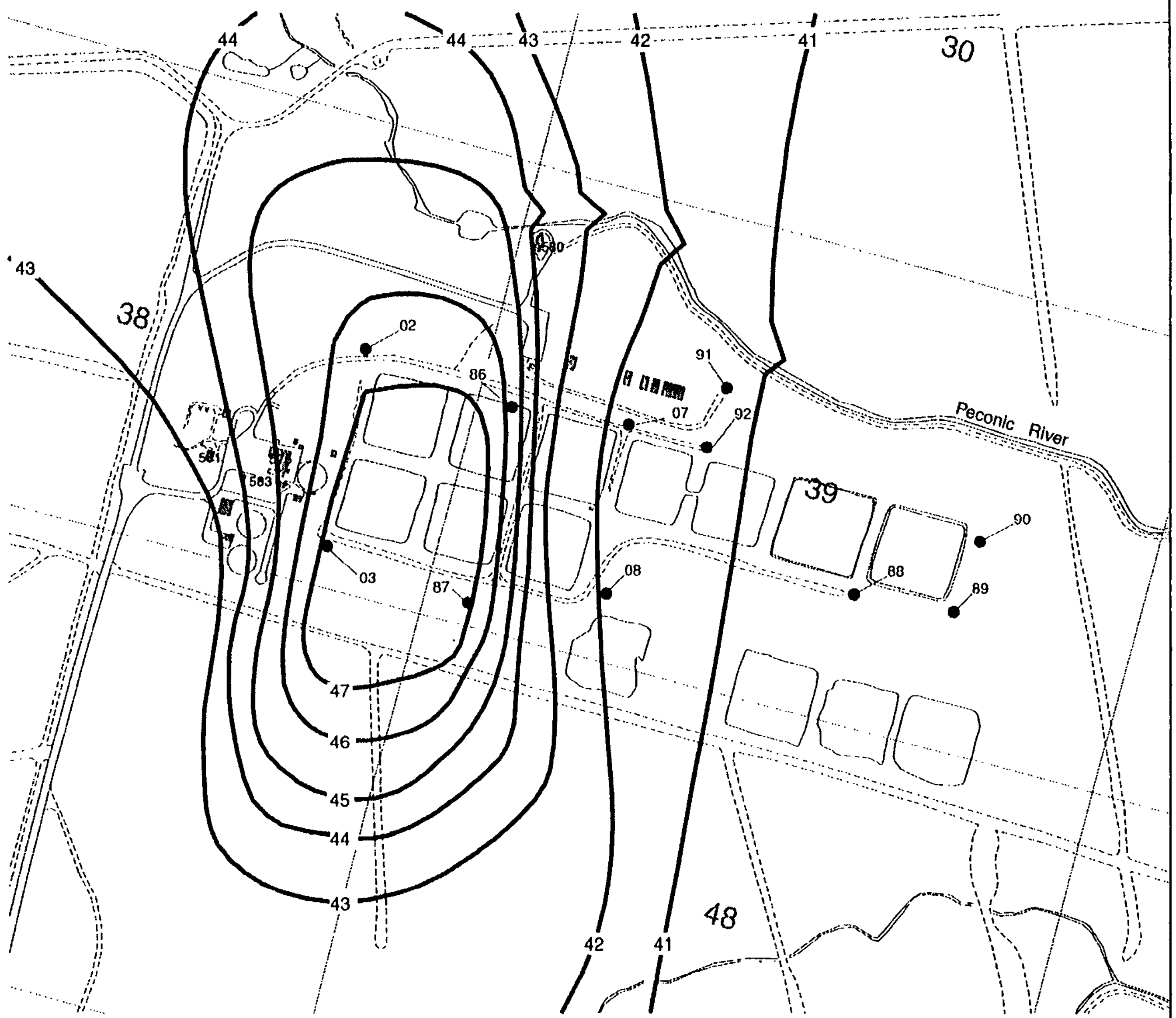
Environmental Services Division
Figure 8-23
Environmental Surveillance Monitoring Well Locations
Medical Research Reactor Area
LEGEND
Monitoring well
Potable Supply Well
Buildings, Facilities
Sept. 1999 Groundwater Elevation (ft AMSL)
SCALE
Meters
0 10 20 30
0 100
Feet
MLD - 03/20/00
/home4/osraml/facilities/emplan_mrr.aml
Graphics/Facilities/emplan_mrr.ai



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Environmental Services Division

Figure 8-24

Environmental Surveillance Monitoring Well Locations

Sewage Treatment Plant and Live Fire Range Area

LEGEND

- Monitoring well
- Buildings, Facilities
- Recharge Basins
- Sept. 1999 Groundwater Elevation (ft AMSL)

SCALE

Meters 0 100

0 100 200 300 Feet

MLD - 03/29/00
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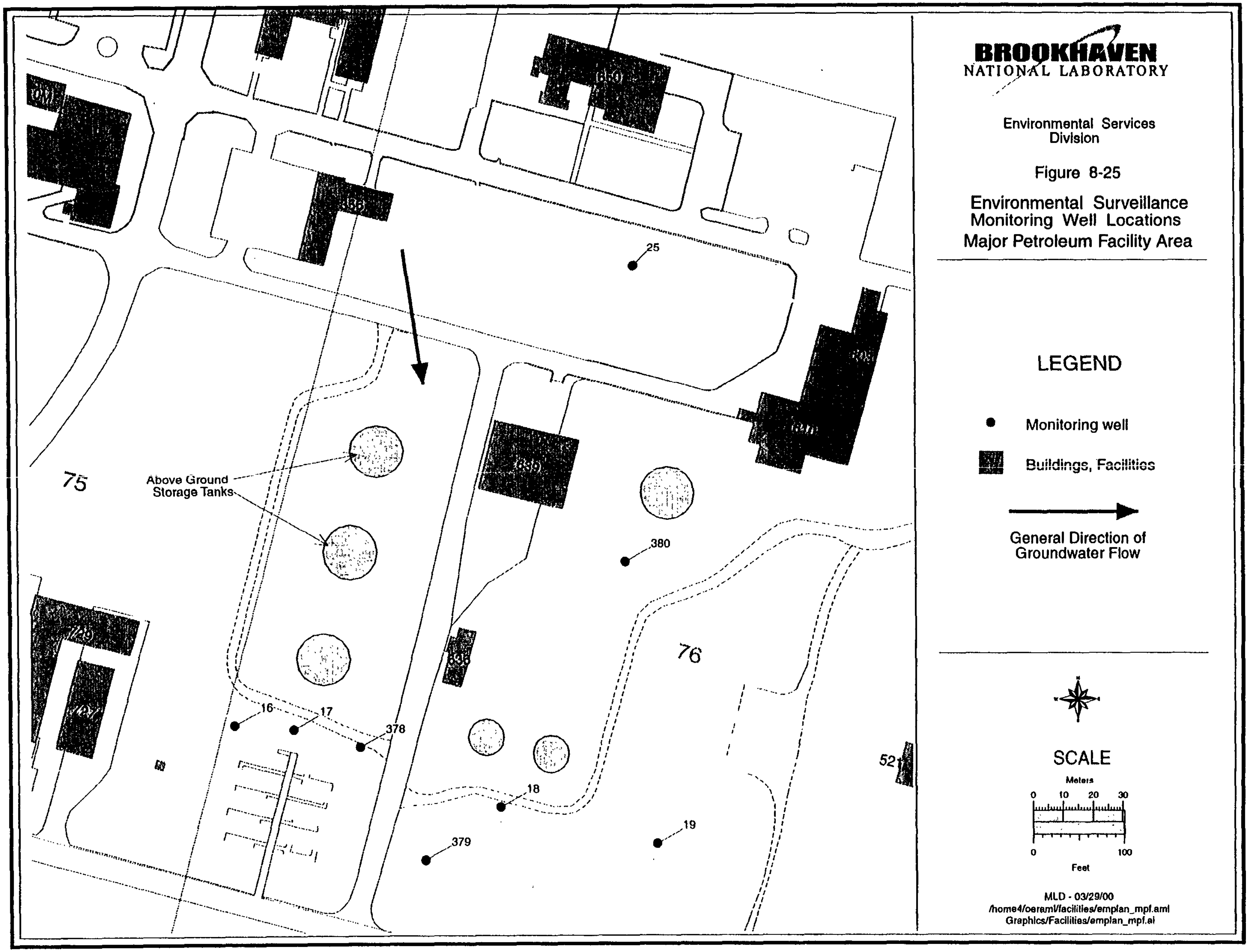
Graphics/Facilities/emplan_stp-lfr.ai



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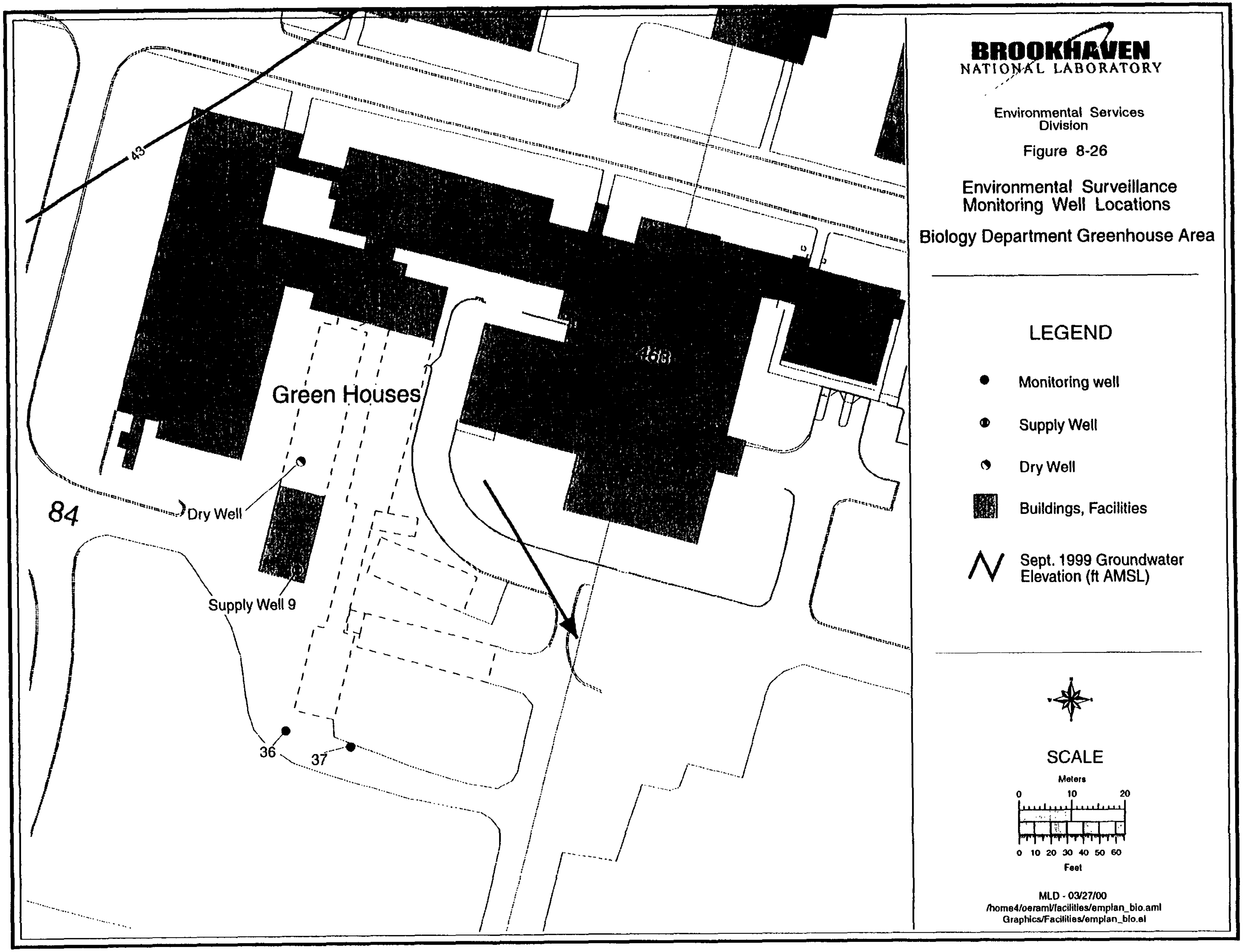
Environmental Services Division
Figure 8-25
Environmental Surveillance Monitoring Well Locations Major Petroleum Facility Area
LEGEND
Monitoring well
Buildings, Facilities
General Direction of Groundwater Flow
SCALE
Meters
0 10 20 30
0 100
Feet
MLD - 03/29/00
/home4/oeraml/facilities/emplan_mpf.aml
Graphics/Facilities/emplan_mpf.ai
Above Ground Storage Tanks
75
76
25
380
16
17
378
18
379
19
521



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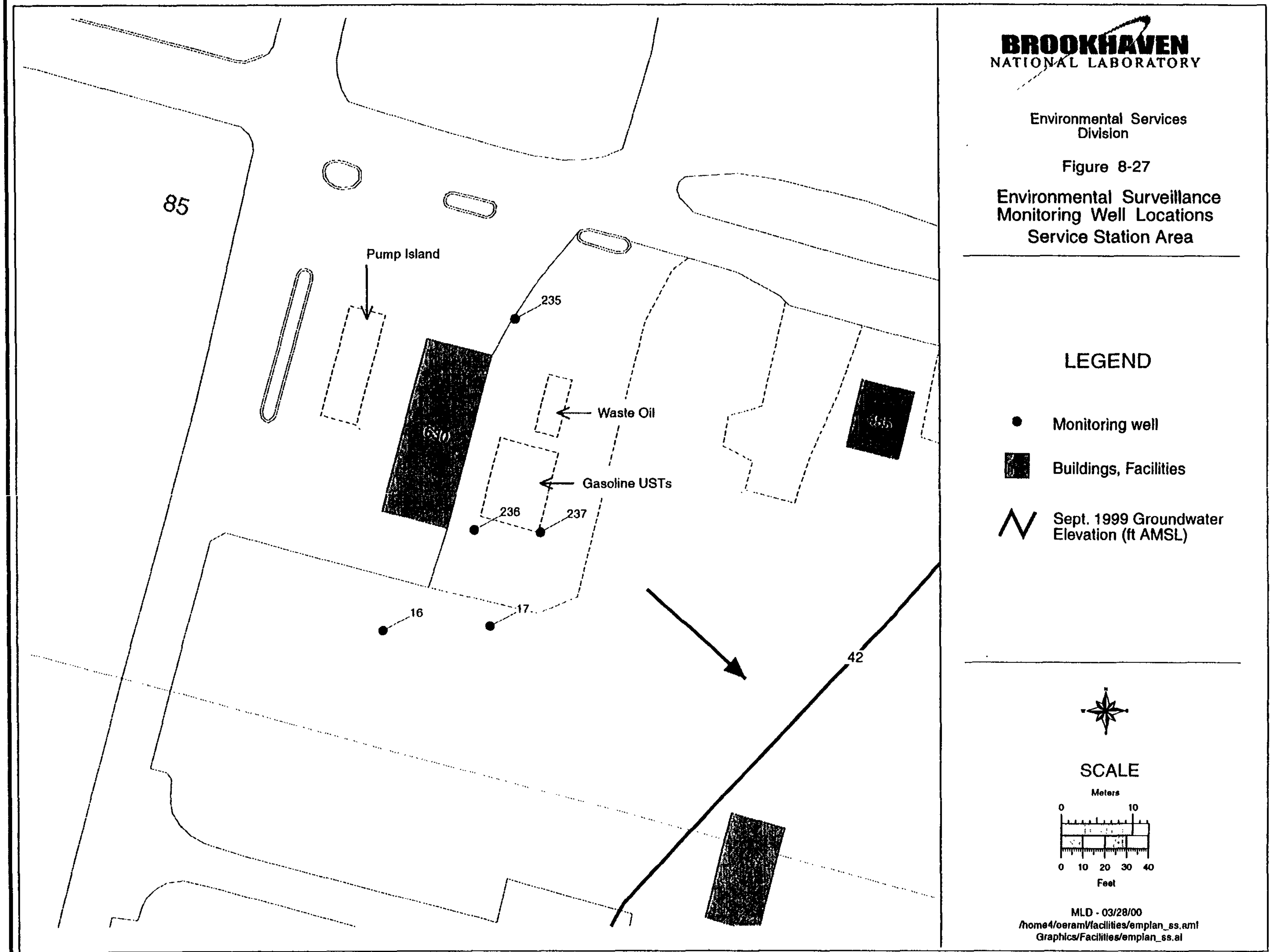
NATIONAL LABORATORY
Environmental Services Division
Figure 8-26
Environmental Surveillance Monitoring Well Locations
Biology Department Greenhouse Area
LEGEND
Monitoring well
Supply Well
Dry Well
Buildings, Facilities
Sept. 1999 Groundwater Elevation (ft AMSL)
SCALE
Meters
0
10
20
0 10 20 30 40 50 60
Feet
MLD - 03/27/00
/home4/oeraml/facilities/emplan_bio.aml
Graphics/Facilities/emplan_bio.el
43
Green Houses
84
Dry Well
Supply Well 9
36
37



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Environmental Services Division

Figure 8-27

Environmental Surveillance Monitoring Well Locations Service Station Area

MLD - 03/28/00
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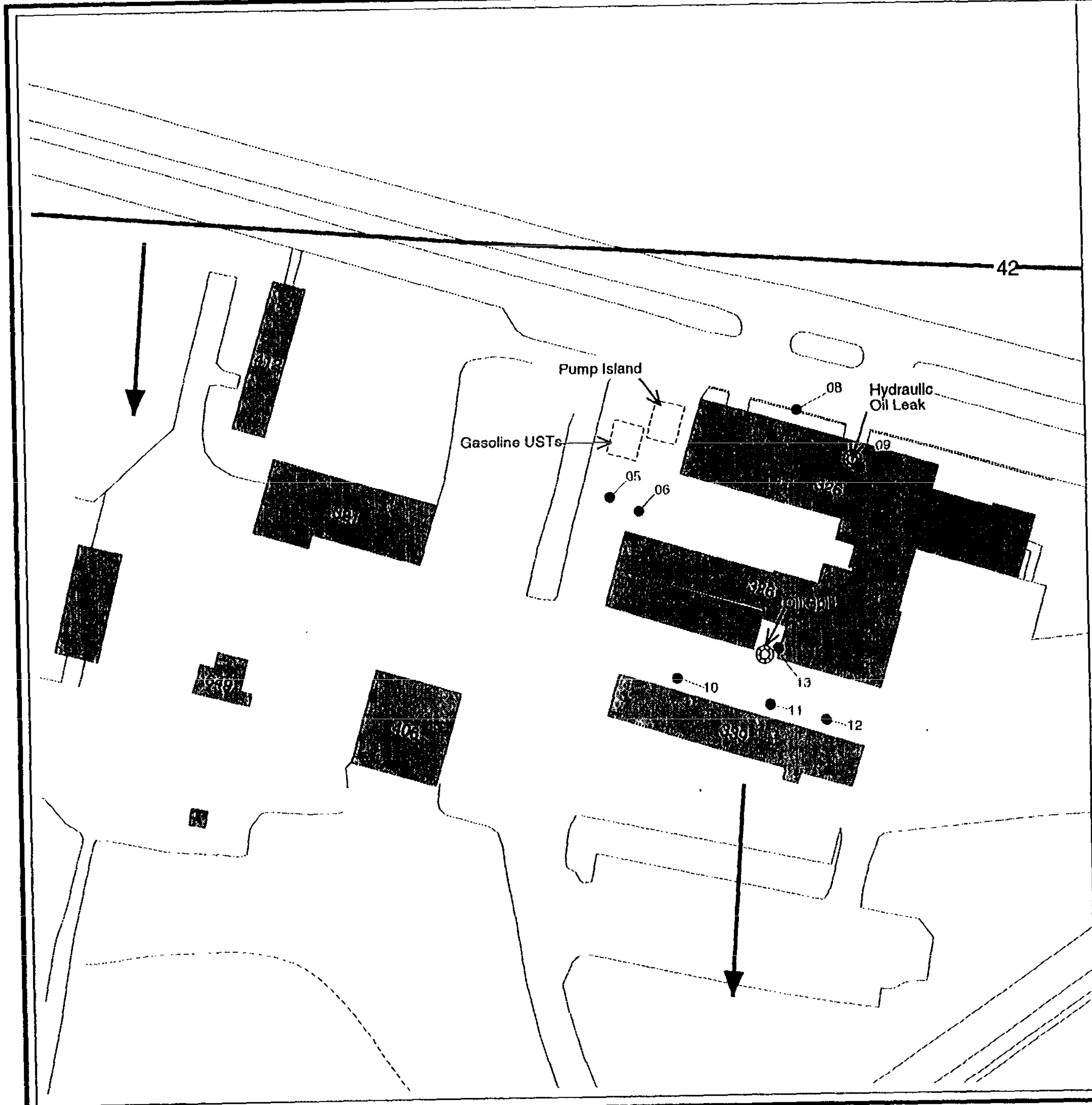
Graphics/Facilities/emplan_ss.ai



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Environmental Services Division

Figure 8-28

Environmental Surveillance Monitoring Well Locations Motor Pool Area

LEGEND

- Monitoring well
- Buildings, Facilities
- Sept. 1999 Groundwater Elevation (ft AMSL)

SCALE

Meters 0 10 20

0 10 20 30 40 50 60 Feet

MLD - 03/28/00
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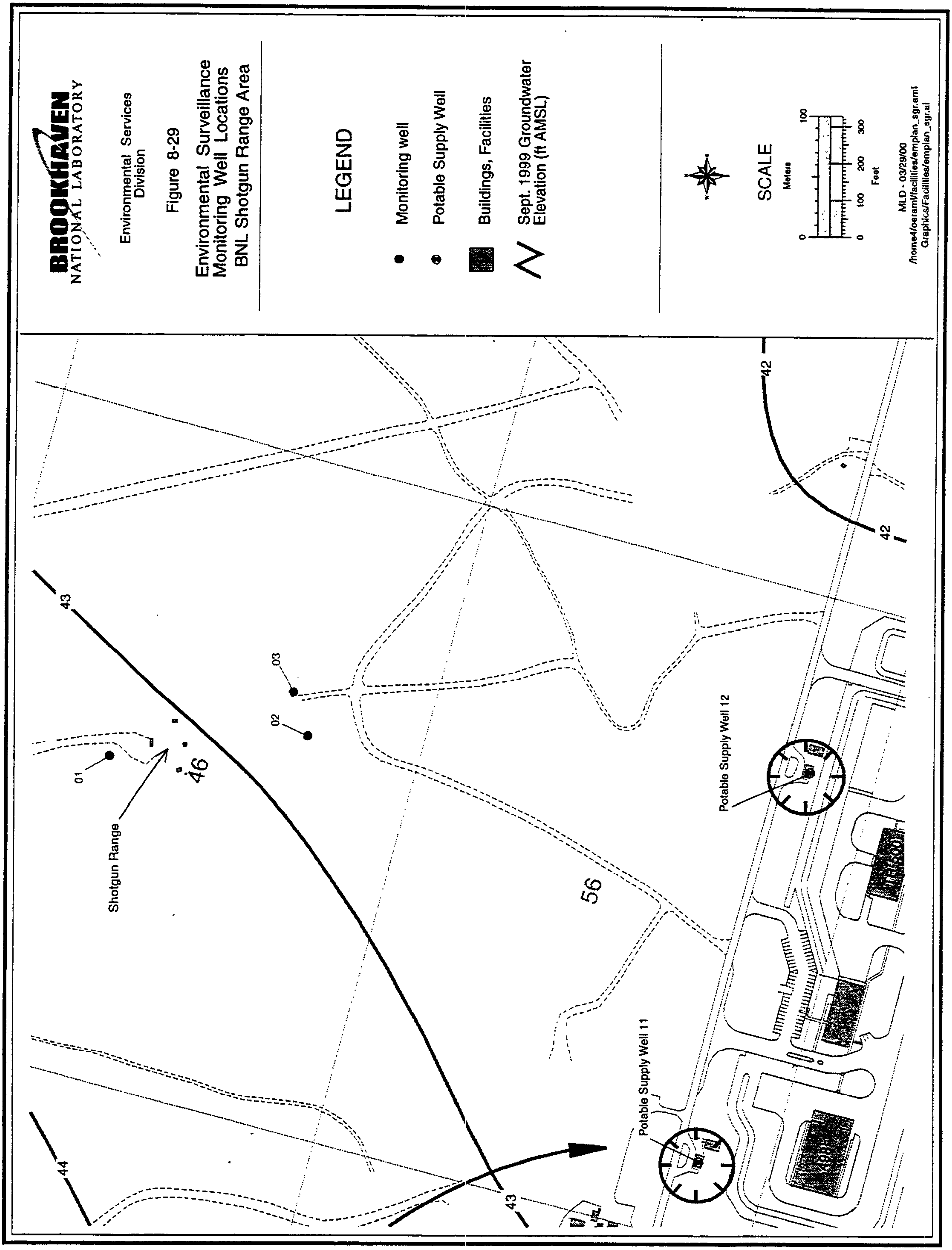
Graphics/Facilities/emplan_mtp.ai


BROOKHAVEN
NATIONAL LABORATORY
Environmental Services
Division
Figure 8-29
Environmental Surveillance
Monitoring Well Locations
BNL Shotgun Range Area
LEGEND
Monitoring well
Potable Supply Well
Buildings, Facilities
Sept. 1999 Groundwater
Elevation (ft AMSL)
SCALE
Meters
0
100
Feet
0
100
200
300
MLD - 03/29/00
/home4/oeraml/facilities/emplan_sgr.aml
Graphics/Facilities/emplan_sgr.ai
Shotgun Range
01
02
03
46
56
43
44
42
Potable Supply Well 12
Potable Supply Well 11

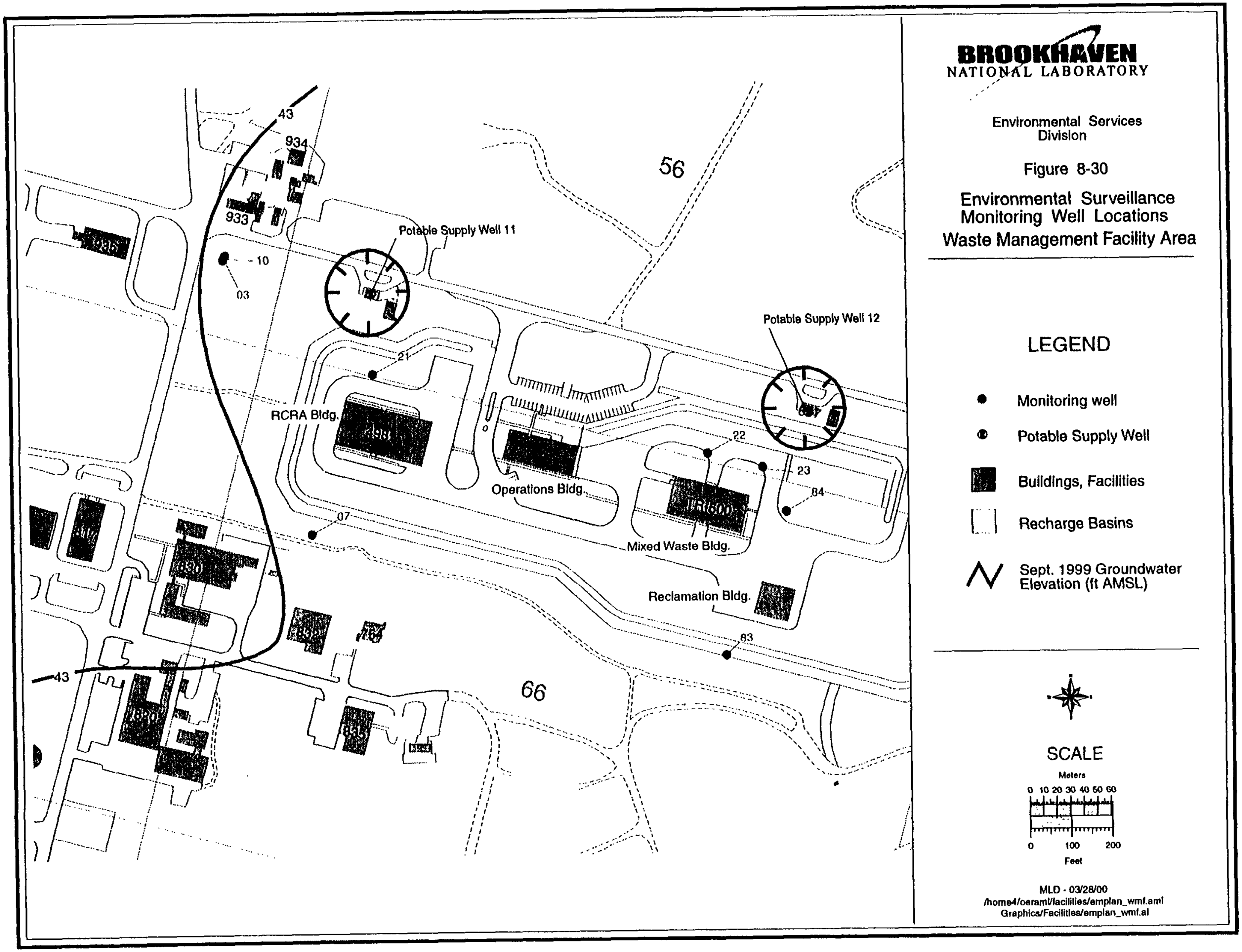


Figure 8-30
Environmental Surveillance Monitoring Well Locations Waste Management Facility Area

9 POTABLE WATER MONITORING

9.1 Introduction

Brookhaven National Laboratory (BNL) maintains six groundwater production wells for the distribution of potable water to the BNL community. There are an additional five groundwater wells used to supply cooling water to various laboratory operations. There are two components to the potable water monitoring program: activities conducted to demonstrate compliance with regulatory requirements and activities conducted as part of the Environmental Monitoring Program (EMP).

9.2 Rationale and Design Criteria

9.2.1 Drivers

The Safe Drinking Water Act (SDWA) establishes national standards for levels of contaminants in drinking water and a program for the protection of sole source aquifers. SDWA requirements are implemented at the state level by the New York State Department of Health (NYSDOH) and locally by the Suffolk County Department of Health Services (SCDHS). The SCDHS specifies analytical parameters and sample collection source and frequency. Potable water system monitoring requirements are contained in the New York State Sanitary Code [10 NYCRR Part 5]. Since BNL distributes domestic water to more than 25 users, the potable water system must meet the performance and monitoring requirements specified by the SDWA and corresponding state regulations. These requirements include specific chemical and radiological monitoring of the supply wells and distribution system, and the enforcement of a strict cross connection control program.

9.2.2 Monitoring Objectives

Monitoring of the potable water system under the EMP is conducted as both a cross check of the compliance monitoring program and to enhance the users' confidence in the potable water system. Sampling and analysis under this program includes assessment of the supply wells and distribution system at the point of consumption.

The objective of the potable water compliance monitoring program is to ensure that the concentrations of regulated contaminants present in the domestic water system are less than the maximum contaminant levels specified by regulation. To ensure that BNL's potable water system complies with SDWA requirements, a potable water system sampling and analysis plan [Chaloupka 2000] was prepared and approved by the SCDHS. This plan includes monitoring at the supply wellheads to ensure that any potential groundwater contamination does not adversely affect the potable water supply. In addition, bacteriology analysis of samples collected at the point of consumption is conducted to ensure the efficient disinfection of the delivery system and the effectiveness of the water treatment system.

The objective of the environmental monitoring program is to provide routine analysis of the domestic water system both at the well and at the point of consumption. The potable water system is sampled under the BNL environmental monitoring program to verify compliance program results and provide additional data to assure the BNL community that the domestic water system remains a viable and high quality potable water source.

9.2.3 Data Quality Objectives

Analytical data quality is assured through the quality assurance programs implemented at both the onsite Analytical Services Laboratory (ASL) and the contractor laboratories. Additionally, representative blanks, and duplicate samples. A full description of the quality assurance program elements is contained in Chapter 12.

9.3 Extent and Frequency of Monitoring

9.3.1 Criteria for Selecting Sample Collection Locations

In accordance with SDWA requirements, potable water samples are collected at the wellhead, post treatment, and from the distribution system. The specific location from which each sample is collected is contingent upon the type of analysis, method of water treatment, and the purpose of the sample (i.e., to assess groundwater quality or impacts of distribution system piping). To assess source water quality, water samples are collected typically at the wellhead. Analytes assessed at the wellhead include volatile organic compounds (VOCs), pesticides and synthetic organic chemicals, inorganics, and bacteriology. To assess the efficiency of water treatment systems, samples are collected immediately post treatment for VOCs and/or inorganic analysis. To ensure that the potable water is not corrosive to the BNL distribution system and that the piping system materials are sound, asbestos, trihalomethane, and inorganic analyses are conducted on water samples collected at the point of consumption.

9.3.2 Sampling Frequency

9.3.2.1 Compliance Monitoring

The sample collection frequency for the compliance program is dictated by regulatory requirement. Sample frequency varies from daily to quarterly and is analyte and location dependent, as specified in the Potable Water Sampling Plan [BNL 2000].

9.3.2.2 Required versus Actual Compliance Monitoring

The BNL compliance monitoring program exceeds the minimum monitoring requirements specified by regulations. Specifically, bacteriology analyses are performed at additional sites to ensure effective and efficient disinfection of the domestic water system. Additionally, water quality (i.e., pH, conductivity, and temperature) is recorded several times per week. Potable water samples are analyzed on a monthly basis for gross alpha, gross beta, gamma, and tritium; however, these parameters are reported quarterly as required.

9.3.2.3 Surveillance Monitoring

Monitoring under the surveillance program includes analysis of well water samples for gross alpha, gross beta, gamma, and tritium eight times per year; and analysis of both treated and untreated water samples for VOCs, metals, and anions on a quarterly basis. Additionally, water samples are collected on an "as requested" basis from points of consumption to assess water quality delivered to facilities.

9.4 Analytical Methodologies and Laboratory Procedures

Two types of laboratories are utilized for the analysis of potable water samples. Samples collected and analyzed for compliance purposes are typically performed by offsite, independent, contracted laboratories. Analysis of samples used for environmental surveillance purposes are generally performed onsite by the BNL ASL. All contracted laboratories are fully certified by the NYSDOH for the analysis of potable water samples.

In accordance with state regulations, analysis of liquid effluents used to document regulatory compliance is performed according to the U.S. Environmental Protection Agency (EPA) standard methods of analysis

In accordance with state regulations, analysis of liquid effluents used to document regulatory compliance is performed according to the U.S. Environmental Protection Agency (EPA) standard methods of analysis [40 CFR 136]. Methodologies are matrix and parameter dependent. Procedures for the analysis of samples are maintained and documented by the analytical laboratory.

The onsite ASL performs analysis of environmental surveillance samples. When practicable, analysis is performed using EPA standard methods of analysis. Any deviation from these methods is documented in the analytical procedures maintained by the ASL. Chapter 12 contains a description of the analytical methods used for onsite analyses. The ASL also participates in both DOE and EPA sponsored proficiency evaluation programs. The results of these evaluations are published annually in BNL's Site Environmental Report (SER).

9.5 References

10 NYCRR Part 5. "New York State Sanitary Code." *New York Codes, Rules and Regulations.*

40 CFR 136. 1999. U.S. Environmental Protection Agency. "Test procedures for the analysis of pollutants under the Clean Water Act." *U.S. Code of Federal Regulations.*

BNL. 2000. *Potable Water Sampling Plan.* Brookhaven National Laboratory, Upton, New York. January 2000.

Chaloupka, W. 2000. *Brookhaven National Laboratory 2000 Potable Water Sampling Plan.* Brookhaven National Laboratory, Upton, New York. January 2000.

Safe Drinking Water Act (SDWA). 1974. Public Laws 92-523 and 99-339, as amended, 42 USC 300f et seq.

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10 FLORA, FAUNA, PRECIPITATION, AND SOIL MONITORING

10.1 Introduction

Ingestion is one of the pathways by which exposure to radiological and nonradiological components to the general public may occur. Therefore, sampling and analysis of vegetation and fauna is a valuable source of data for estimating bioaccumulation and the projection of dose via the ingestion pathway. An analysis of precipitation, soil, and sediment provides an integrating medium that can account for contaminants released to the atmosphere and surface water.

10.2 Rationale and Design Criteria

10.2.1 Drivers

Using this basis, and in accordance with the recommendations of the U.S. Department of Energy's (DOE) *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* [DOE/EH-0173T 1991], a program to sample vegetation, fauna, precipitation, and soil/sediment has been established at Brookhaven National Laboratory (BNL). Although no specific guidance is given for nonradiological parameters, a program has also been established to analyze these same samples for nonrad parameters, such as metals, pesticides, and polychlorinated biphenyls (PCBs).

DOE/EH-0173T provides guidance on surveillance monitoring to determine if radionuclides released to the environment are behaving in the environment as expected. The same philosophy is applied in the determination of the impact of nonradiological releases to the environment as a result of the operations of BNL facilities.

Surveillance monitoring is also performed when there is a high level of public interest or concern, or where best management practices indicate monitoring is appropriate. It is assumed that the material being measured and compared to some risk-based standard is well mixed in the particular environmental media being characterized, and that any concentration present represents what might be ingested by humans.

10.2.2 Monitoring Objectives

The objectives of the flora, fauna, and soil monitoring program are to:

- Establish a baseline of data for each media onsite for trend analysis,
- Determine onsite impact, if any, of BNL operations on these media,
- Determine offsite impact, if any, of BNL operations on the these media,
- Establish a baseline of data for each media using offsite controls, and
- Provide supporting data for the air and water sampling program,

These objectives are achieved by the implementation of a routine monitoring program, where practical, for flora, fauna, precipitation, and soil/sediment. This program includes the collection of both onsite and offsite soil/sediment samples, flora samples, fauna samples, and precipitation samples. To determine potential impacts, onsite and offsite data are compared, and BNL data are compared with data from other agencies. Data collected from the sampling and analysis of the flora, fauna, and soil/sediment monitoring program provide information to determine the impact of BNL operations on the environment.

10.2.3 Potential Sources and Contaminants

Sources and pathways are described in Chapter 3, "Emission/Effluent Sources and Pathways."

10.2.4 Collection Methods and Procedures

Each medium has a set of Standard Operating Procedures (SOPs) for sample collection. Detailed procedures may be found in the Environmental Services Division (ESD) Standard Operating Procedures [BNL 1999].

10.3 Extent and Frequency of Monitoring

10.3.1 Soil/Sediment

10.3.1.1 Criteria for Selecting Soil Sample Locations

The selection of soil monitoring locations is based on:

- Areas of known contamination,
- Areas near air, water, and vegetation sampling locations to compliment these programs, and
- Areas in the principal downwind direction of the prevailing winds.

Surface soil surveillance is considered a direct measure of environmental impact because, over time, contaminants from air emissions and water discharges can accumulate in soil/sediment. As a result, soil monitoring can be used to characterize both short term and cumulative effects (trends) of BNL operations and to complement the air and surface water surveillance programs. Air and surface water surveillance are, for the most part, designed to measure transient (short term) conditions. Data from the soil surveillance program can potentially validate results from the air and surface water programs. Long term data from the soil program allow small effects that could be missed by short term measurements to be documented as cumulative effects over a longer period. Although there are no contamination concentration guidelines for soil, as there are for water and air, onsite soil monitoring is performed on a routine basis biennially and covers areas of known or suspected contamination and background areas. In the case of remediation, however, cleanup guidance is issued under the Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) and the DOE's RESRAD (Residual Radioactive Material) software program.

The soil sampling locations (See Figure 10-1 and Appendix B) correspond to similar areas of influence or monitor effects from similar operations, i.e., water discharge monitoring at the Sewage Treatment Plant (STP). In 1992, IT Corporation was contracted to develop a sitewide soil and vegetation sampling plan for BNL [ITC 1992]. In addition, onsite remediation efforts require the development of specific soil sampling programs with the required sampling protocols and data quality objectives (DQO). A sitewide soil contamination profile has been generated from data collected over the past six years. In 1996, the IT Corporation Plan was used to develop an updated soil and vegetation sampling plan. Twenty five locations were selected and soil and vegetation samples (in the same area as the soil sample) were collected. Onsite sampling data will be acquired from the Environmental Restoration (ER) programs.

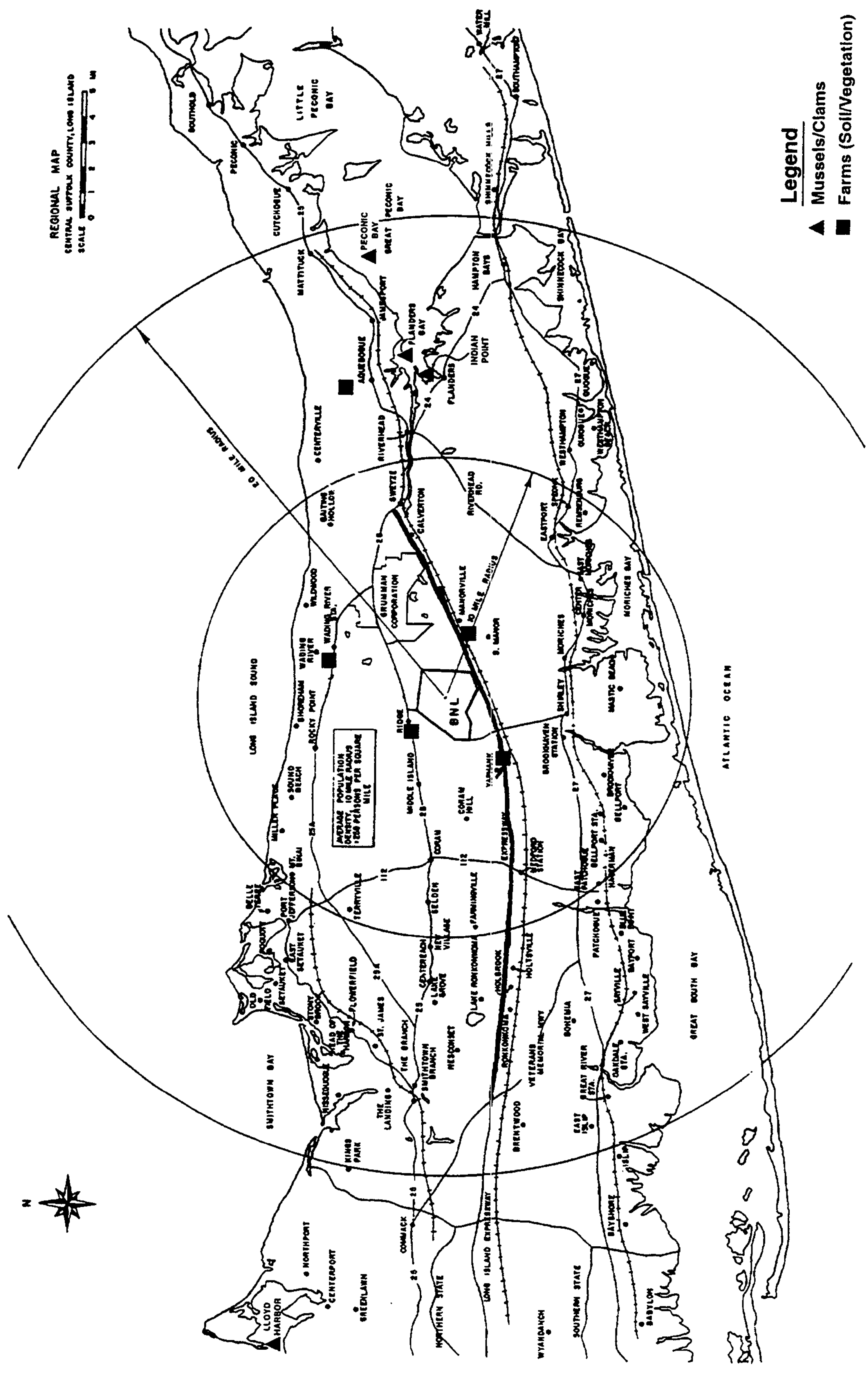

Figure 10-1. Soil, Vegetation and Aquatic Fauna Sampling Location

Offsite soil monitoring consists of four stations based on the projected Wind Rose (see Chapter 2) for the BNL site. The sites selected were local farms. An additional site located 16 miles from the center of the BNL site serves as the control site. A review of current historical data (1994-1998) indicates that BNL generated radionuclides were conspicuously absent. The offsite soil sampling program will be completed during calendar year (CY) 2000.

10.3.1.2 Criteria for Selecting Sediment Sample Locations

The location of sediment monitoring locations is based on:

- Areas of known contamination,
- Areas of sediment deposition,
- Areas downstream of known contamination,
- Areas of sediment erosion, and
- Areas corresponding to actions taken under Operating Unit (OU) V.

Sediment sampling provides an opportunity to acquire data that may help determine whether historic releases of contaminants to a water body have occurred. Data may also be used in the determination of contaminant dynamics within the aquatic body, since sediments could act as a reservoir that could contribute to the presence of contaminants in the aquatic system even if the source were mitigated. Data may also provide information on long term buildup of undissolved contaminants or long term accumulation rates, and to estimate environmental contaminant inventories. The accumulation of contaminants in the sediment can lead to exposure of humans through ingestion of aquatic species, through sediment resuspension into drinking water supplies, or as an external source if the contaminant can be absorbed through the skin. For BNL, the possibility of sediment resuspension impacting on drinking water supplies does not apply, as groundwater is the source of drinking water in Long Island.

The Peconic River has been the key sampling location for sediment sampling (see Appendix B). Annual releases of contaminants to the Peconic River (see *BNL Site Environmental Reports* [SERs]) provide the rationale for sediment sampling and also the determination of the specific analytes that need to be analyzed. No set sediment sampling locations are maintained because the sampling locations are based on areas downstream of known contamination as well as erosional and depositional areas, which may vary from year to year. The frequency, based on data review over the past ten years, has indicated that the sampling be done once a year. The sampling is conducted by collecting the top six inches, and then fractionating the sample into two-inch increments. Data from samples collected beyond six inches are derived from ER programs conducted in the same region/location. Sediment sampling has not been performed in the recharge basins. An evaluation of the data derived from analyses of discharges to the recharge basin indicated that the concentration of contaminants of interest were at or below the level of detection, suggesting that sediment sampling of the recharge basins be done biennially. This sampling will be initiated in CY 2000.

10.3.2 Criteria for Selecting Terrestrial Fauna Sample Locations

The fauna monitoring program complements soil and vegetation sampling for use in characterization, and may also help in determining the long term effectiveness of remediation. Monitoring between 1986 and

1998 [BNL SERs 1986 to 1998] has provided baseline and trend data. In addition, a baseline exists from a sitewide fauna sampling program that was conducted in 1992 and reported in the SER for 1992. Selection of fauna monitoring locations is determined by:

- Deer sampling onsite – random accidental death,
- Deer sampling offsite – coordinated with New York State Department of Environmental Conservation (NYSDEC) hunting check station,
- Small mammals – areas near existing air and water monitoring stations, and random areas throughout the BNL site, and
- Waterfowl (goose) fecal matter – random locations, comparative vegetation from random lawn locations.

Surveillance of fauna provides a measure of environmental impact from contaminants, since some contaminants may accumulate in the tissue of animals that consume contaminated vegetation, come into contact with contaminated soils, or drink contaminated water. Deer are representative herbivores that come in direct contact with both primary (water and soil) and secondary (plants) environmental media. They were selected for monitoring because they represent the most direct terrestrial pathway from soil/vegetation to humans. Deer hunting is permitted around the site perimeter and beyond, but not onsite. The potential exists for deer consuming vegetation onsite to move offsite and be harvested by hunters. Historical surveillance data for deer onsite and offsite has indicated that the levels of cesium-137 in deer harvested onsite are above those observed elsewhere on Long Island. Radiological studies of the site have indicated that there are areas where the residual radionuclide contamination of soil exceeds background values.

Implementation of a supplemental small mammal sampling program for mice, woodchuck, and squirrels was investigated from a number of perspectives, including availability, ease of trapping, sample volume required for analysis, etc. Based on the above, it is proposed to initiate the sampling of squirrels and woodchucks. These animals have a diet very similar to deer and thus may show similar contaminant uptake as that seen in the deer population and may provide supporting information. This would occur in the spring of CY 2000.

Implementation of a program to determine presence and uptake of radionuclides (e.g., cesium-137) in Canada goose (*Branta canadensis*) will be initiated during CY 2000. Random samples of goose fecal matter will be collected and analyzed for radionuclides known to be present in vegetation at BNL. Random samples of lawn vegetation (the primary food of geese) will also be sampled and analyzed for comparison. Differences in analytical data are expected to provide an indication of the rate of uptake of various radionuclides.

Sampling locations for fauna monitoring (See Appendix B) must coincide with locations where animals are abundant and, therefore, may not coincide with locations for other media. However, sampling locations are selected, where possible, to represent the same areas of influence as for air and water sampling. The current fauna monitoring program covers only deer. The onsite locations are opportunistic and depend on road kills, whereas the offsite sampling program is through the NYSDEC hunting program. The onsite sampling, which is currently restricted to road kills, has no specific time set aside for sampling. Samples from the offsite faunal program are obtained from hunters who donate samples at the NYSDEC check stations or from the NYSDEC's Officers assigned to conduct sampling. The offsite sampling program obtains samples from within one mile of the site. Samples obtained from deer taken within one mile of BNL are considered as if they were from onsite, as deer are generally stay within one mile of their established territory. Control samples are taken from locations far removed from the influence of the site. Sampling conducted by NYSDEC is restricted to the hunting season (November through December). The number of samples collected is also determined by the NYSDEC's ability to assist BNL in obtaining the samples from the hunters.

A recent statistical analysis [Bond and Casey 1998] indicated that offsite sampling within one mile of the site would require a minimum of 40 deer samples to be defensible from a statistical standpoint. Onsite sampling could produce statistically defensible results with 20 deer samples. In an analysis performed by New York State Department of Health [NYSDOH 1998] on the adequacy of sample size, it was concluded that 25 samples would satisfy the sample size requirement. Therefore, the annual target sample requirements for this program is set at 40 offsite samples and 25 onsite samples.

10.3.3 Criteria for Selecting Terrestrial Flora Samples

Site selection for terrestrial flora samples is based on:

- Direction of prevailing winds (sites selected downwind),
- Availability of agriculturally grown crops,
- Availability of crops grown onsite,
- Availability of aquatic vegetation onsite, and
- Availability of aquatic vegetation offsite.

Vegetation surveillance is considered a direct measure of environmental effect because vegetation may take up contaminants from water and soil that have been deposited by air and water transport mechanisms. Such accumulation allows the flora monitoring program to characterize both short term and cumulative effects (trends) of BNL operations as well as complement the air, surface water, and soil surveillance programs. Air and surface water surveillance are, for the most part, designed to measure transient conditions. Data from the flora surveillance program may validate short term conditions measured in the air and surface water and long term results from the soil surveillance program. Surveillance of flora is coordinated with the Suffolk County Department of Health Services (SCDHS).

The flora surveillance program includes onsite, offsite, and control locations (Figure 10-1). The IT Corporation soil/vegetation plan was used to select onsite locations so that vegetation sampling would correspond with the soil sampling program. Additionally, the sitewide ER program has also developed an extensive database that includes documentation of radionuclides and nonradiological contaminants in onsite vegetation. Data used in the SER is currently based on information gathered from ER programs, which includes adequate sampling and analysis of vegetation. The offsite vegetation program matches the offsite soil sampling program in frequency of collection (annually) and analysis (gamma). Vegetation samples from the four farms located in the primary Wind Rose direction are sampled by ESD in cooperation with SCDHS. A farm located about 16 miles away from BNL is used as a control location. Samples collected include seasonal local vegetables and fruits.

In order to evaluate the impact on garden vegetables grown onsite, a plot of land situated in the apartment housing area (located in the southwest corner of the site) will be cultivated and planted with locally grown vegetables such as tomatoes, corn and beans, and harvested for gamma analysis. These samples will serve as a basis for comparison with vegetables grown offsite.

10.3.4 Criteria for Selecting Aquatic Fauna Sample Locations

Aquatic fauna sampling locations are based on:

- Presence of suitable aquatic habitat for availability of samples,
- Ability to access potential sampling locations,
- Presence/absence of known contaminants in water/sediment,
- Correspondence with surface water/sediment sampling locations, and
- Aquatic habitats unaffected by BNL activities (control locations).

Surveillance of aquatic fauna measures environmental impact from contaminants, since some contaminants may accumulate in the tissue of aquatic animals that are exposed to contaminated water, vegetation, or sediment, or through consumption of contaminated fauna (prey). Fish and mussels were selected for monitoring because they represent the most direct aquatic pathway from liquid discharges to humans. Though fishing for human consumption is not permitted onsite, the potential exists that discharges into the Peconic River from the STP could expose offsite fish and mussels to contamination. Historical surveillance data on fish, both onsite and offsite, indicate that the levels of certain radionuclides are above those observed elsewhere on Long Island. Radiological monitoring of the effluent discharged to the Peconic River from the STP (See Figure 7-2) indicates that the effluent contains very low levels of radionuclides, such as tritium, cesium-137, and strontium-90, at levels that exceed background values. Numerous studies indicate that fish and mussels reflect the presence of contaminants in the waters that they inhabit. Analysis of fish and mussel samples obtained in control locations have confirmed the absence of BNL generated contaminants.

The current aquatic fauna monitoring program is dictated by the discharge of the STP effluent into the Peconic River (See Appendix B). The river downstream of the BNL site is used for recreational purposes and for fishing (sport or for consumption). Sampling in the river is done in cooperation with the NYSDEC (Stony Brook) and is also done in conjunction with the requirement of the NYSDOH, who also samples the river for surveillance. Figure 10-2 shows the aquatic faunal sampling locations. From the Peconic River, fish are sampled at the BNL site (STP Outfall), Donahue's Pond, and Forge Pond. Fresh water mussels are sampled at Forge Pond. Two sites are used as background: (1) Swan Pond (water from this pond flows into the river, however, there are occasions where the fish are known to enter this pond from the river), and (2) Carmans river (located to the south of BNL). These sites are not influenced by BNL operations. However, the potential exists for groundwater from the southern boundary of the BNL site to move towards the Carmans River. NYSDEC has occasionally sampled ponds and lakes on Long Island, and samples from these locations have been used to represent background locations.

Some environmental groups have expressed concern that the STP effluent discharged to the Peconic River could impact the shellfish population at the mouth of the river and in the adjoining bays (Peconic and Flanders). This has prompted sampling of clams and mussels from the Peconic and Flanders bays. The background location for this sampling is Lloyd Harbor, which is located west of the BNL site and in the Long Island Sound (Figure 10-2). The sampling frequency is annual.

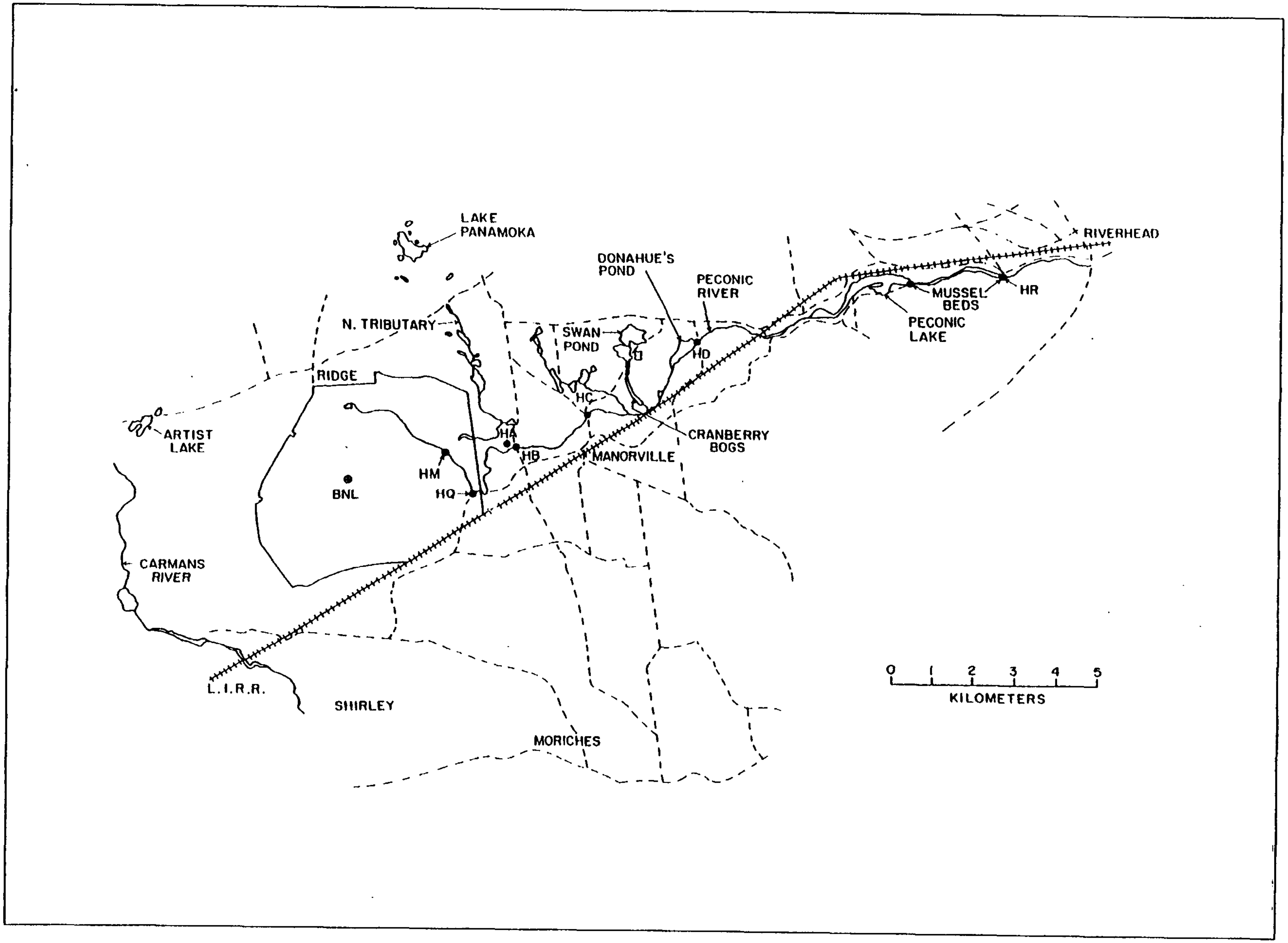

Figure 10-2. Peconic River Aquatic Faunal Sampling Stations

10.3.5 Collection of Precipitation Samples

Precipitation monitoring is performed to determine if releases of radioactive elements from routine operations at BNL have impacted precipitation, to monitor worldwide fallout from nuclear testing, and to determine natural radioactivity levels from the stratosphere/troposphere during rain events.

The precipitation samplers consist of a pot type collector with a surface area of 0.33 square meters. The collector remains open, collecting both precipitation during rain events and dry deposition.

There are currently two sampling stations in use, one located at the STP (Station S5) and one near the onsite laundry facility (Station P4).. This latter location was selected to represent BNL housing and the Childcare Center. Theses sampling locations are shown in Figure 5-1.

Each quarter, a single one-month composite sample is collected and submitted to the Analytical Services Laboratory (ASL) for analysis. The samples are analyzed for gross alpha, gross beta, tritium, and gamma activity.

10.4 Collection of Quality Control Samples

Technical activities used to ensure quality include collection of quality control samples. Ten percent of soil, sediment, and vegetation samples are homogenized in the ASL and split into two aliquots, which are treated as individual samples.

Since fish samples are collected to represent different trophic levels, splitting of samples depends on the number of fish in a species that are caught. Every attempt is made to submit duplicate samples to the ASL. When possible, the sample is homogenized in the laboratory and two aliquots are prepared. The aliquots are treated as individual samples. In some cases, when tissue analysis is required, it may not be possible to split samples.

Since shellfish samples are too small to be analyzed individually, a composite is made of all shellfish from one location. The composite is homogenized and split into two aliquots for submission to the ASL as individual samples. Depending on the number of stations sampled, one out of ten stations (or a portion thereof) is used to generate split samples.

Terrestrial fauna samples are also homogenized and split into two aliquots when possible, depending on the size of the sample. These split samples are then submitted to the ASL.

10.4.1 Analytes

Terrestrial and aquatic environmental samples will be analyzed for the parameters listed in Appendix B.

10.5 Procedures for Laboratory Analysis

See Appendix C, Instrumentation and Analytical Methods, for laboratory analytical procedures.

10.6 References

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11 DIRECT RADIATION MONITORING

11.1 Introduction

Brookhaven National Laboratory (BNL) measures environmental background radiation through a network of onsite and offsite dosimeter units. These units, called thermoluminescent dosimeters (TLDs), measure gamma radiation originating from cosmic and terrestrial sources as well as any contribution from Laboratory operations.

11.2 Rationale and Design Criteria

11.2.1 Drivers

In accordance with U.S. Department of Energy (DOE) Orders 5400.1 [1998] and 5400.5 [1990], BNL monitors direct radiation to establish background levels and to determine public doses resulting from its operations. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* [DOE/EH-0173T 1991] recommends using TLDs to monitor direct gamma radiation in the environment.

11.2.2 Monitoring Objectives

The primary purpose of direct radiation monitoring is to measure radiation doses and evaluate the maximum dose to the public, if any, from direct gamma radiation originating from BNL sources. The objectives of external radiation monitoring are the following:

- Obtain external exposure measurements at locations of potential public access to verify that doses to the public through all pathways from Laboratory operations remain low relative to standards.
- Obtain radiation exposure data near specific facilities or waste sites to assess the integrated effects of individual operations.
- Obtain measurements at the site perimeter and in nearby communities to provide public assurance that the degree of external radiation exposure from site operations is known.
- Measure onsite and offsite external radiation exposure to assess the environmental effects and doses from unexpected releases.

11.2.3 Potential Sources and Contaminants

External radiation exposure can be produced by various sources on and around the BNL site. The environmental pathways through air and surface water can transport radionuclides from emission or effluent sources (point or diffuse) to locations near the public and other biota. Many of these released radionuclides produce penetrating particles and photons (i.e., beta and gamma radiation) during decay processes in media external to an organism. These media include air, surface water, soil, sediment, and vegetation. Several actual or potential sources could lead to external radiation exposure of the public or onsite biota from radiation or radioactive materials. These sources include routine facility emissions and effluents, radiation generating facilities and equipment, environmental restoration sites, and onsite vehicle transport of sources or wastes. Emission and effluent sources and pathways are discussed in detail in Chapter 3.

11.2.4 Measurement Methods and Procedures

Penetrating radiation is measured using radiation dosimeters. The dosimeters measure the total amount of penetrating radiation, both natural background and man made radiation, near a particular location. At BNL, TLDs are used to monitor direct gamma radiation.

The principle of operation for TLDs is the following. When certain crystals in the physical matrix of the TLD are exposed to gamma radiation, impurities in the crystals form low-temperature trapping sites for electrons excited to higher energy states. The electrons remain in a high energy state at normal ambient temperatures. In the analytical laboratory, the TLD is processed in a three phase process. First, the TLD is heated, causing the electrons to be released from the trapping sites. When the electrons drop to a lower energy state, photons are emitted. Second, the photons are measured with a photomultiplier tube with the light intensity being proportional to the original absorbed dose of radiation. The light intensity measurement is recorded. Third, after the TLD is read, it is heated and read again. The second reading should be near zero, indicating that all of the gamma-radiation-induced stored energy has been released (and therefore measured). This second heat treatment is referred to as annealing and verifies that the TLD is ready for reuse in the field.

The quantity of energy deposited by radiation in the TLD detector material is converted to dose equivalent in millirem (mrem) by calibrating the dosimeter reader to read the absorbed dose and then applying a quality factor for a beta/gamma radiation field. The accuracy of radiation measurements made with TLDs is evaluated by comparing the performance of dosimeters exposed to known radiation exposures. These quality control TLDs are irradiated with National Institute of Standards and Technology (NIST) traceable standards. The environmental radiation monitor in use at BNL is the Harshaw 8807 Thermoluminescent Dosimeter.

11.3 Extent and Frequency of Monitoring

External radiation exposures are measured with consideration for the types and levels of exposure expected from the various pathway transport media and other direct radiation sources. Some of the critical environmental media or sources causing potential external radiation exposure are airborne cloud passage and exposure to contaminated surface water, vegetation, or soil. Most of the types of radiation causing external exposures are gamma photons and beta particles. External neutron and alpha particle exposures to the public have negligible potential. Historical data support the approach of designing the measurement methods mainly for photon sources, but pure beta emitters can exist in the environment unaccompanied by gamma emitters (e.g., strontium).

External radiation sampling locations are selected to accomplish the surveillance objectives. Several sources of information are used to help determine the potential for detecting increased exposures to the public. Some important factors that influence the determination of sampling locations are the radiation source characteristics, meteorology, geography, hydrology, sedimentation, population distribution, and recreational activities or lifestyles. There is a continual need for emergency preparedness dosimetry, confirmation of emission controls and dose modeling, and background monitoring for public assurance. The fulfillment of these needs requires placement in strategic offsite locations that are generally upwind for the background location(s) and in population centers located within prevailing wind directions. Because of the size of the BNL site, maximum predicted concentrations from airborne emissions are typically onsite, and sampling at these locations continues although the data do not indicate public exposures.

Sampling frequencies are determined based on the potential for detecting elevated external radiation levels and for public exposure. Sampling frequencies for onsite TLDs may require adjustments that reflect changes such as potential for elevated exposure rates due to modifications in operations or transportation of radiation sources. If intermittent or sporadic operations have significant potential for elevating environmental exposures, survey frequencies are adjusted. The normal exchange frequency for all TLDs is on a quarterly basis, determined as the approximate exposure time needed to generate statistically confident results above the limit of detection.

11.3.1 TLD Locations

There are a total of 24 onsite locations (Figure 11-1) that have TLDs in place, as well as 21 offsite locations (Figure 11-2) that are also monitored. The offsite measurements provide background comparison values and are used to determine whether BNL operations have had an impact on the ambient radiation levels of the surrounding area.

Under the Environmental Restoration Program, a network of 16 additional TLDs was installed to monitor gamma radiation exposure levels inside the fenced area of the Building 650 Sump Outfall (Figure 11-3). The Sump Outfall (Operable Unit [OU] IV, Area of Concern [AOC] 6) is a source of localized radiological soil and groundwater contamination which is being remediated. Radionuclides identified in the soil in this area include strontium-90, cesium-137, and isotopes of europium and plutonium. Four fence perimeter dosimeters were also installed, as well as two background dosimeters located onsite in an area not influenced by AOC 6 or other site radiation sources. In 1998, five locations were added to this TLD network: C5, D5, E3, E4, and E5. These TLDs were added when elevated readings from dosimeters D2 through D5 indicated that radionuclides related to the Building 650 Sump Outfall were probably also located to the southeast, just beyond the existing network. The new stations were installed to monitor this area, although previous soil sampling and fence dosimeters show that radionuclides related to Building 650 are localized within the fenced area.

11.4 Procedures for Laboratory Analysis

The 8807 TLDs are exchanged and processed quarterly. In case of an accident where a rise in background is suspected, the detectors may be immediately retrieved and processed. TLDs are read and annealed by the personnel monitoring group within BNL's radiological control program.

The 8807 monitors are calibrated annually at Pacific Northwest National Laboratory utilizing sources traceable to NIST. Each quarter the environmental TLDs are read using Harshaw TLD readers, which are calibrated using NIST traceable radiation sources.

All measured doses at BNL monitoring locations are compared to both recent and historical background measurements to determine the contribution, if any, from BNL operations. All data are reported as total doses (Effective Dose Equivalent [EDE] in mrem), including those from both background and BNL sources.

When a TLD is missing, the annual dose is calculated as four times the average quarterly dose determined from available data. TLDs that are wet, damaged, or found on the ground are not accepted for use in monitoring analyses. The annual *Site Environmental Report* (SER) discusses which TLDs were reported as missing or damaged.

11.5 Quality Assurance

BNL's personnel dosimetry program participates in the DOE Laboratory Accreditation Program (DOELAP) every two years, and must meet specified interlaboratory comparison performance goals, as

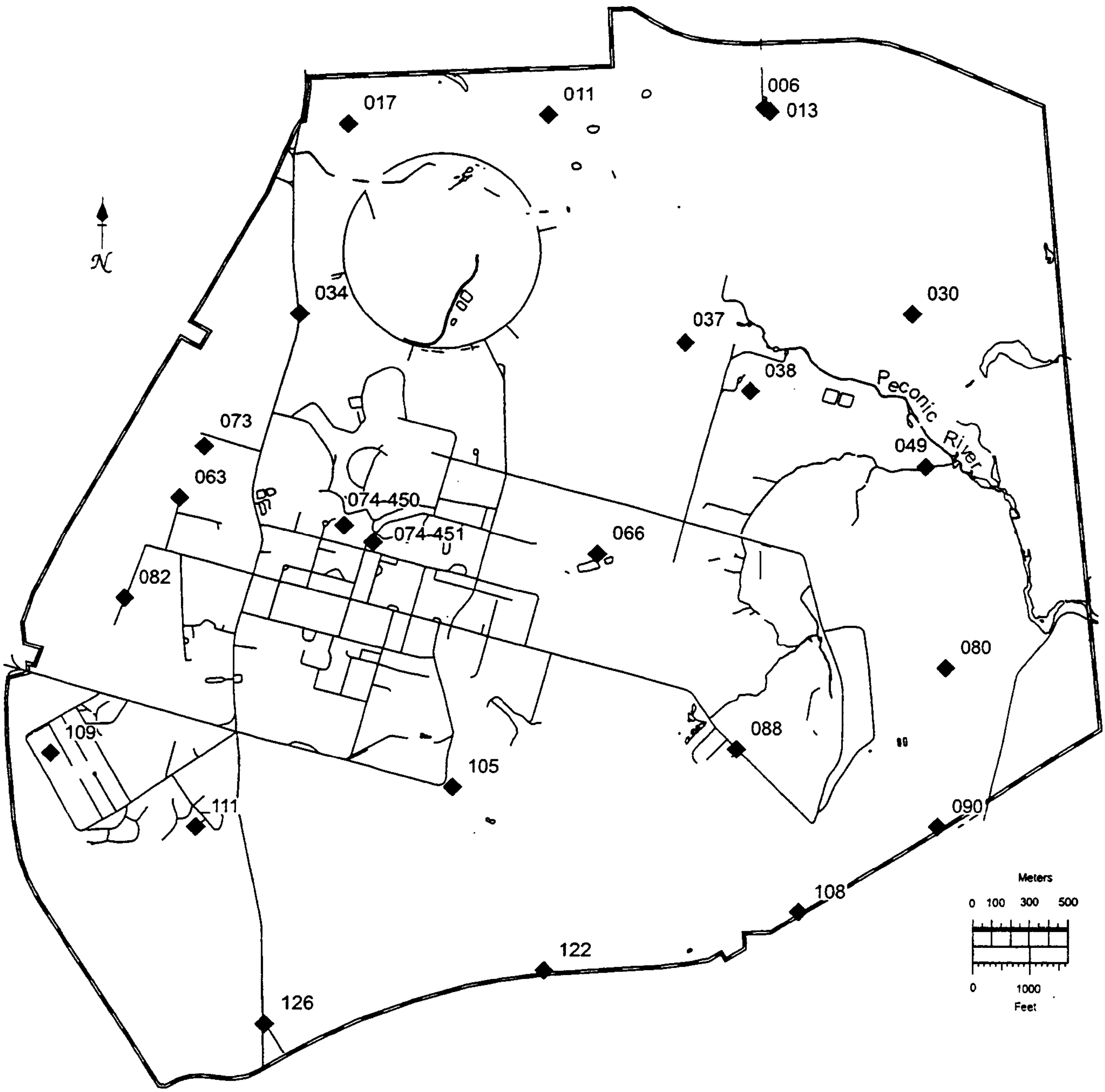

Figure 11-1. Onsite TLD Locations

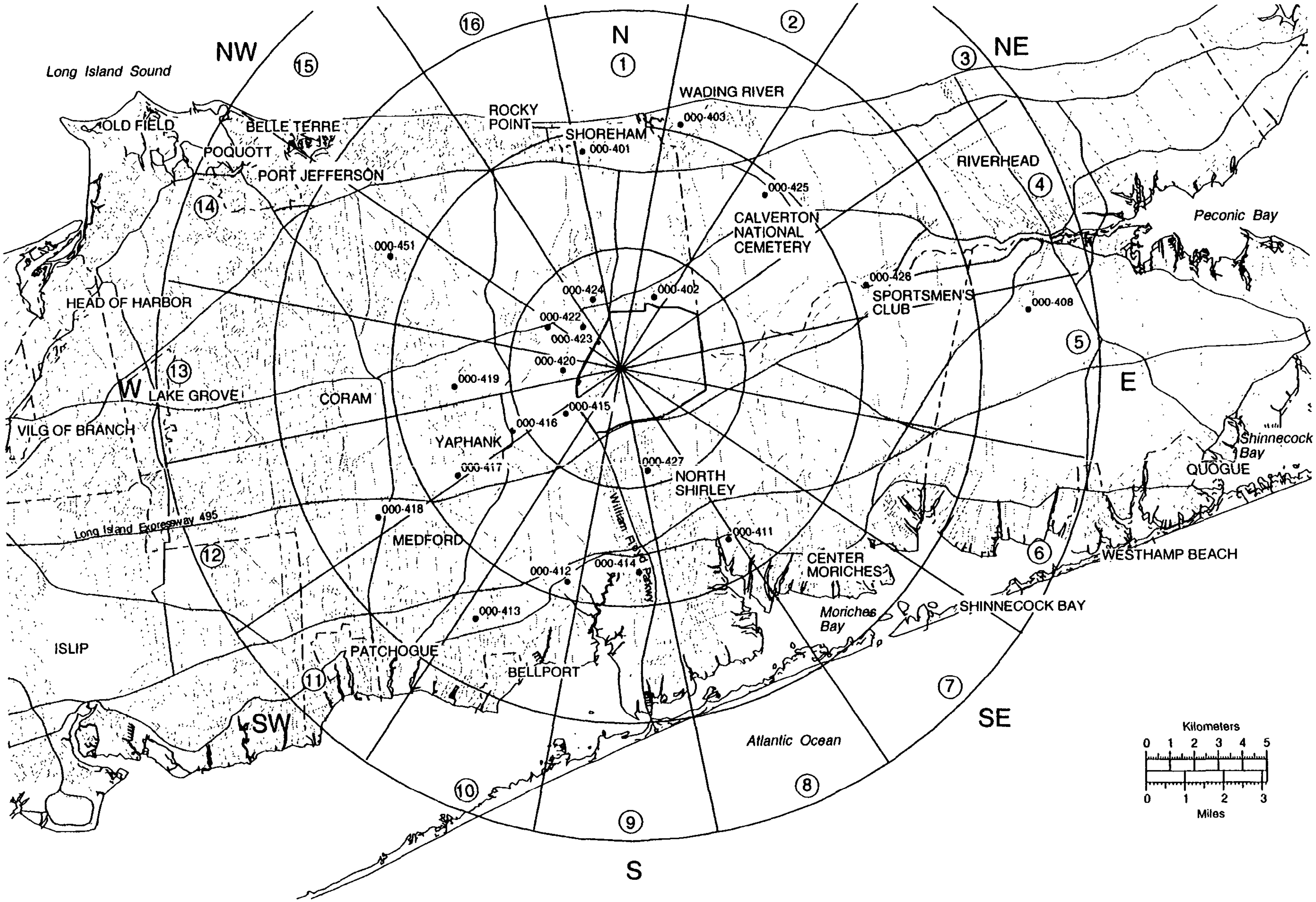

Figure 11-2. Offsite TLD Locations

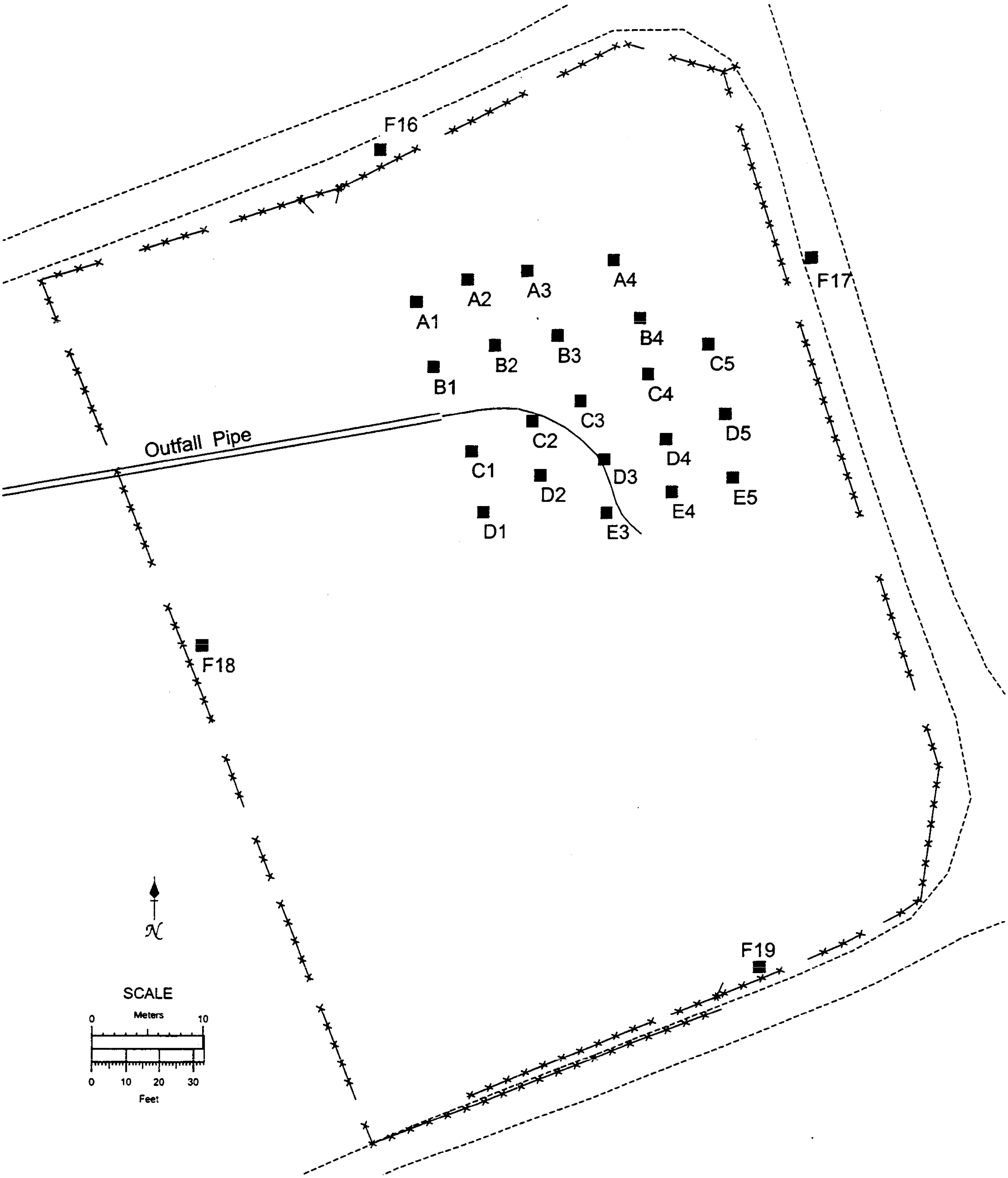

Figure 11-3. Building 650 Sump Outfall TLD Network

well as pass an onsite assessment. The TLD program at BNL is DOELAP-accredited for use of TLD dosimeters for personnel radiation monitoring purposes. Although no comparable DOE program exists for environmental monitoring, BNL has participated in the field testing of a proposed comparable program and has incorporated the key features into the BNL environmental monitoring program.

The most important quality control features in this program are the calibration, maintenance, and audits of the TLD reading/recording system; anomalous data evaluation; personnel training; and procedures and records maintenance. Routine quality control of the TLD process cycle is achieved by the quality control program within the personnel monitoring group. The quality control program provides a measure of the quality of the complete TLD processing cycle. Intercomparison studies are conducted to determine and document TLD processing performance.

Anomalous TLD results are evaluated promptly to confirm or dismiss unusual results. Investigation into an anomalous result includes, as necessary, verification of the quality of the result (sampling and analytical aspects); questioning staff at facilities near the location with anomalous results about unusual situations; reviewing nearby air sampling results; and following up with immediate portable instrument measurements and/or gamma spectroscopy.

The TLDs are handled in transport with consideration for keeping them unexposed to significant external radiation fields that would generate false positive data. Comments describing any unusual handling of TLDs or any findings that may affect TLD results are recorded in the field notebook. Sample collection and handling procedures are documented in Standard Operating Procedure (SOP) EM-SOP-502, *Placement and Collection of Thermoluminescent Dosimeters* [BNL 1999].

11.6 References

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12 QUALITY ASSURANCE

12.1 Introduction

Quality is an integral part of every function at Brookhaven National Laboratory (BNL). A program is in place to ensure that all environmental monitoring data meet appropriate Quality Assurance (QA) requirements. Some environmental samples at BNL are analyzed by an onsite laboratory, the Analytical Services Laboratory (ASL). BNL also procures and maintains contracts with offsite laboratories: General Engineering Lab (GEL) for radiological analytes, H2M Lab for nonradiological analytes, and Chemtex Lab for select nonradiological analytes. All analytical laboratories are New York State certified for specific parameters, and are subject to audits.

12.2 BNL Quality Assurance Program

Responsibility for quality at BNL starts with BNL's Director and extends down through the entire organization. The BNL quality management (QM) system coordinates and evaluates QA implementation at BNL, and provides professional assistance to the Departments and Divisions. The objectives of BNL's environmental monitoring QA Program are to ensure proper planning, organization, direction, control, and support in order to achieve the objectives of the environmental program. Overall performance is reviewed and evaluated using a rigorous assessment process. This QA program was developed to ensure compliance with requirements in U.S. Department of Energy (DOE) Orders O 414.1 [1998], *Quality Assurance*, and 5400.1 [1988], *General Environmental Protection Program.*

12.3 Scope of the Program

BNL has adopted or adapted program elements specified in DOE Order 414.1 as well as the additional environmental QA requirements of DOE Order 5400.1 into sampling, analysis, and data handling activities. QA practices and procedures are documented in manuals and Standard Operating Procedures (SOPs) (e.g., sample collection, radiation measurements, chain-of-custody, and analytical chemistry).

BNL ensures that environmental media are sampled and analyzed in a way that provides representative, defensible data. The QA program supports this activity by incorporating QA elements such as field sampling designs, documented procedures, chain-of-custody, a calibration/standardization program, acceptance criteria, statistical data analyses, software QA, and data processing systems in the environmental surveillance and effluent monitoring programs. The offsite contractor laboratories that perform radiological and chemical analyses for BNL are also required to incorporate QA elements into their operation.

Routine Quality Control (QC) procedures followed by the ASL include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. These procedures are documented in the ASL Quality Assurance Project Plan (QAPP) [BNL 1999a]. The ASL and the three contractor laboratories participate in several national and state performance evaluation testing programs. Results of the performance evaluation tests provide information on the quality of a laboratory's results and allow comparisons to be made between laboratories.

In addition, BNL has established a program of internal and external audits to verify the effectiveness of the environmental sampling, analysis, and database activities. Contractor laboratories are subject to audits by BNL personnel as well as the New York State Department of Health (NYSDOH). The BNL Environmental Monitoring Program (EMP) is subject to periodic audits by the BNL Quality Management Office, DOE Brookhaven Group Office, DOE Chicago Operations, the U.S. Environmental

Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), and other independent groups.

12.4 Environmental Monitoring Program Quality Assurance

In addition to the aforementioned programs, the BNL groundwater monitoring program QAPP [BNL 1999b] describes the QA program and the QC requirements followed for groundwater monitoring activities. The plan defines the project organization structure, documentation requirements, sample custody requirements, acceptance criteria, auditing functions, corrective action provisions, and guidance on the collection of QA/QC samples. The QAPP was developed using the guidance provided in the document EPA QA/R-5, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* [EPA 1998]. This plan is currently being revised to address all environmental monitoring activities and will become the governing document for all BNL EMP quality assurance practices once implemented. The EMP QAPP will be finalized in calendar year (CY) 2000.

12.5 Sample Collection

All sample collection is completed by trained technicians according to SOPs, under the direction of subject matter experts. These procedures are developed from information in the media-specific Data Quality Objectives (DQOs). Logbooks are used by each media specific sampling program to document the collection of each sample. Chain-of-custody procedures are used to ensure that each sample is properly handled and controlled until it is received by the laboratory, at which time the laboratory initiates an internal chain-of-custody procedure.

12.6 Data Validation

For in-house analyses, SOPs have been established to calibrate instruments, analyze samples, and check quality control. Quality control checks performed include analysis of blanks or background concentrations, use of Amersham or National Institute for Standards and Technology (NIST) traceable standards, and analysis of reference standards, spiked samples, and duplicate samples. The laboratory supervisor and/or QA officer reviews all analytical and quality control results before the data are reported and incorporated into the emvironmental management database.

Data packages received from contractor laboratories are reviewed at BNL by subject matter experts in either radiological analyses or analytical chemistry to ensure compliance with contract specifications before the data are accepted and entered into the environmental management database. In addition, data packages are examined to ensure that samples do not exceed holding times, that there are no poor recoveries, that the proper sampling method was used, and that field blanks were less than the Minimum Detection Limits (MDL). Nonradiological data analyzed offsite are verified and validated using EPA contract laboratory protocol guidelines [EPA 1990, 1996]. Radiological packages are verified and validated using both BNL and DOE guidance documents [BNL 1997; DOE 1994; DOE 1977].

12.7 Data Quality Assessment

The EPA defines data quality assessment as "the scientific and statistical evaluation of data to determine if data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use" [EPA 1996]. The respective subject matter expert reviews each set of data provided by the analytical laboratory after data validation. Initially, the subject matter expert verifies the values in the electronic database compared with the hard copy of the results provided by the analytical lab. The results are subsequently compared to historical results, duplicate samples, and control samples.

12.8 References

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Acronyms

AGS	Alternating Gradient Synchrotron
ALARA	As Low As Reasonably Achievable
amu	Atomic Mass Unit
ANSI	American National Standards Institute
AOC	Area of Concern
ASL	Analytical Services Laboratory
AS/SVE	Air Sparging/Soil Vapor Extraction
BERA	Brookhaven Employees Recreation Association
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven Linac Isotope Producer
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
BOD	Biological Oxygen Demand
BSA	Brookhaven Science Associates
BTEX	Benzene, toluene, ethylbenzene, and xylene
C-A	Collider Accelerator
CAA	Clean Air Act
CASIM	Cascade Simulation
CCWP	Central Chilled Water Plant
CEM	Continuous Emissions Monitoring
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
CFR	Code of Federal Regulations
CO_2	Carbon Dioxide
COC	Contaminant (or Chemical) of Concern
CSF	Central Steam Facility
CWA	Clean Water Act
CY	Calendar Year
D_2O	Deuterium; Heavy Water
DCA	1,1-Dichloroethane
DCE	1,1-Dichloroethylene
DCG	Derived Concentration Guide
DOE	Department of Energy
DOELAP	Department of Energy Laboratory Accreditation Program
DQO	Data Quality Objective
EDB	Ethylene dibromide
EDE	Effective Dose Equivalent
EM	Environmental Monitoring
EMIS	Environmental Management Information System
EML	Environment Measurements Laboratory
EMP	Environmental Monitoring Plan/Program
ER	Environmental Restoration
EPA	Environmental Protection Agency
ES	Environmental Surveillance
ESD	Environmental Services Division

FFA	Federal Facilities Agreement
FY	Fiscal Year
GEL	General Engineering Lab
GIS	Geographic Information System
HAP	Hazardous Air Pollutant
HEPA	High Efficiency Particulate Air
HFBR	High Flux Beam Reactor
HITL	Heavy Ion Transfer Line
HTO	Tritiated Water Vapor
HWMF	Hazardous Waste Management Facility
IAG	Interagency Agreement
LIE	Long Island Expressway
LINAC	Linear Accelerator
MCL	Maximum Concentration Level
MDL	Minimum Detection Limit
MEI	Maximally Exposed Individual
MGD	Million Gallons per Day
MPF	Major Petroleum Facility
MRC	Medical Research Center
MTBE	Methyl tertiary butyl ether
MW	Megawatt
NAAQS	National Ambient Air Quality Standards
ND	Nondetect
NESHAP	National Emission Standards for Hazardous Air Pollutant
NIST	National Institute for Standards and Technology
NOx	Nitrogen Oxides
NPL	National Priorities List
NSLS	National Synchrotron Light Source
NYCRR	New York Code of Rules and Regulations
NYS	New York State
NYSAWQS	New York State Ambient Water Quality Standards
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDWS	New York State Drinking Water Standard
O&M	Operation & Maintenance
OU	Operable Unit
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethylene
PNNL	Pacific Northwest National Laboratory
ppb	Part per billion

QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QC	Quality Control
QM	Quality Management
RA	Removal Action
RACT	Reasonably Achievable Control Technology
RCRA	Resource Conservation and Recovery Act
RESRAD	Residual Radioactive Material
RHIC	Relativistic Heavy Ion Collider
RI/FS	Remedial Investigations/Feasibility Study
ROD	Record of Decision
RTF	Radiation Therapy Facility
SCDHS	Suffolk County Department of Health Services
SDWA	Safe Drinking Water Act
SER	Site Environmental Report
SOP	Standard Operating Procedures
SO_2	Sulfur Dioxide
SPCC	Spill Prevention, Control, and Countermeasures
SPDES	State Pollutant Discharge Elimination System
SPING	Sampler, Particulate, Iodine, and Noble Gas
STEM	Scanning Transmission Electron Microscope
STP	Sewage Treatment Plant
SVOC	Semivolatile Organic Compound
$t_{1/2}$	Half life
TCA	1,1,1-trichloroethane
TCE	Trichloroethylene
TEDA	Triethylene Diamamine
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TSCA	Toxic Substance Control Act
TSDF	Treatment, Storage, and Disposal Facility
TSS	Total Suspended Solids
USC	United States Code
UST	Underground Storage Tank
VOC	Volatile Organic Compound
VUV	Vacuum Ultaviolet
WCF	Waste Concentration Facility
WMF	Waste Management Facility
WSRRSA	Wild, Scenic, and Recreational River Systems Act
WTP	Water Treatment Plant

Glossary of Terms

A

Accuracy - The degree of agreement of a measurement with an accepted reference or true value. It is expressed as the difference between two values, as a percentage of the reference or true value, or as a ratio of the measured value and the reference or true value.

Activation - The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.

Activation products - Radionuclides produced through bombardment with neutrons, protons, or other nuclear particles.

Air Stripping - A process whereby volatile organic chemicals (VOCs) are removed from contaminated water by forcing a stream of air through the water in a vessel. The contaminants are evaporated into the air stream. The air may be further treated before it is released into the atmosphere.

Alpha Radiation - An alpha particle is identical in make up to the nucleus of a helium atom. Alpha particles have a positive charge, and have little or no penetrating power in matter. They are easily stopped by materials such as paper and have a range in air of only an inch or so. Naturally occurring radioactive elements such as radon emit alpha radiation.

Ambient air - The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.

Analyte - A constituent that is being analyzed.

Anion - A negatively charged ion, for example Cl^-.

Aquifer - A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

Area of Concern (AOC) - An area where releases of hazardous substances may have occurred or a location where there has been a release or threat of a release into the environment of a hazardous substance, pollutant, or contaminant (including radionuclides) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). AOCs may include, but need not be limited to, former spill areas, landfills, surface impoundments, waste piles, land treatment units, transfer stations, wastewater treatment units, incinerators, container storage areas, scrapyards ("boneyards"), cesspools, and tanks and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

B

Beta Radiation - Beta radiation is composed of particles which are identical to electrons. Beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha, but may be stopped by materials such as aluminum foil. They have a range in area of a few inches. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

Biochemical (biological) Oxygen Demand (BOD) - A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.

Blank - A control sample that is identical to the sample of interest, except that the analyte of interest is absent.

Blowdown - Water discharged from either a boiler or cooling tower in order to prevent the build-up of inorganic matter within the boiler or tower and to prevent scale formation (i.e., corrosion).

C

Cap - A layer of material, such as clay or a synthetic material, used to prevent rainwater from penetrating and spreading contaminated materials. The surface of the cap is generally mounded or sloped so water will drain off.

Chain-of-Custody - A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

Characterization - Facility or site sampling, monitoring and analysis activities to determine the extent and nature of contamination. Characterization provides the basis of necessary technical information to select an appropriate cleanup alternative.

Code of Federal Regulations (CFR) - A codification of all regulations developed and finalized by federal agencies in the Federal Register.

Composite Sample - A sample of an environmental media that contains a certain number of portions collected over a period of time. The samples may be collected from the same location or different locations. They may or may not be collected at equal time intervals over a predefined period of time (e.g., 24 hours).

Confidence Interval - A numerical range within which the true value of a measurement or calculated value lies. In this report, radiological values are shown with a 95 percent confidence interval, i.e., there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range.

Contamination - Unwanted radioactive and/or hazardous material that is disbursed on or in equipment, structures, objects, soil, or water.

Cooling Water - Water that is used to cool machinery and equipment. Contact cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal. Non-contact cooling water is water used for cooling purposes but has no direct contact with any process material or final product. Process wastewater cooling water is water used for cooling purposes that may have become contaminated through contact with process raw materials or final products.

D

Decontamination - The removal or reduction of radioactive or hazardous contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques to achieve a stated objective or end condition.

Derived Concentration Guide (DCG) – The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year would result in an effective dose equivalent of 100 millirem (1 mSv).

Disposal - Final placement or destruction of waste.

Dosimeter - A portable detection device for measuring the total accumulated exposure to ionizing radiation.

Downgradient - In the direction of groundwater flow from a designated area; analogous to downstream.

E

Effective Dose Equivalent (EDE) - A value used to express the health risk from radiation exposure to a tissue or tissues in terms of an equivalent whole body exposure. It includes the sum of the effective dose equivalent due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of radionuclides. EDE is expressed in units of rem (or sieverts).

Effluent - Any liquid discharged to the environment, including stormwater runoff at a site or facility.

Emission - Any gaseous discharge to the atmosphere.

Environment - Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation.

Environmental Assessment (EA) - A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA identifies a "significant" impact (as defined by the National Environmental Policy Act [NEPA]), an Environmental Impact Statement (EIS) is required.

Environmental Media - Includes air, groundwater, surface water, soil, flora, and fauna.

Environmental Impact Statement (EIS) - A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.

Environmental Surveillance - Sampling for contaminants in air, water, sediments, soils, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

Environmental Protection Agency (EPA) – The federal agency responsible for developing and enforcing environmental laws. Although state regulatory agencies may be authorized to administer environmental regulatory programs, EPA retains oversight authority.

Evapotranspiration - A process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other above ground tissue.

G

Gamma Radiation - Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, and is capable of passing through dense materials such as concrete. X-rays are essentially a form of gamma radiation.

Gamma Spectroscopy - This analysis technique identifies specific radionuclides. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each nuclide, acting as a "fingerprint" to identify a specific nuclide.

Grab Sample - A single sample, collected at one time and place.

Groundwater - Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.

H

Half-life - The time required for one half of the atoms of any given amount of a radioactive substance to disintegrate.

Hazardous Waste - Toxic, corrosive, reactive, or ignitable materials that can negatively affect human health or damage the environment. They can be liquid, solid, or sludge, and include heavy metals, organic solvents, reactive compounds, and corrosive materials. They are defined and regulated by the Resource Conservation and Recovery Act (RCRA).

Hydrology - The science dealing with the properties, distribution, and circulation of natural water systems.

I

Inert - Lacking chemical or biological action.

Influent - Liquid (e.g., wastewater) flowing into a reservoir, basin, or treatment plant.

Isotope - Two or more forms of a chemical element, having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties.

Intermittent River - A stream that dries up on occasion. Seasonal factors frequently are the cause.

L

Leach/Leaching - The process by which soluble chemical components are dissolved and carried through soil by water or some other percolating liquid.

M

Maximally Exposed Individual (MEI) - The individual whose location and habits tend to maximize his/her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

Minimum Detection Limit (MDL) - The lowest level to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDL are sometimes measurable, they represent values which have a reduced statistical confidence associated with them (less than 95 percent confidence).

Mean Sea Level (MSL) - The average height of the sea for all stages of the tide. Used as a benchmark for establishing groundwater elevations.

Monitoring - The collection and analysis of samples or measurements of effluents and emissions for the purpose of characterizing and quantifying contaminants and demonstrating compliance with applicable standards.

Monitoring Well - A well that collects groundwater for the purposes of evaluating water quality, establishing groundwater flow and elevation, determining the effectiveness of treatment systems and determining whether administrative or engineered controls designed to protect groundwater are working as intended.

O

Onsite - The area within the boundaries of a site that is controlled with respect to access by the general public.

Operable Unit (OU) - Division of a contaminated site into separate areas based on the complexity of the problems associated with it. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action. They may also consist of any set of actions performed over time or any actions that are concurrent, but located in different parts of a site. An operable unit can receive specific investigation, and a particular remedy may be proposed. A Record of Decision (ROD) is prepared for each operable unit. (See Record of Decision.)

Outfall - The place where wastewater is discharged.

P

Permit - An authorization issued by a federal, state, or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including the Resource Conservation and Recovery Act (RCRA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Toxic Substance Control Act (TSCA), and they grant permission to operate, to discharge, to construct, etc. Permit provisions may include emission/effluent limits and other requirements such as the use of pollution control devices, monitoring, recordkeeping, and reporting. Also called a "license" or "registration" under some regulatory programs.

pH - A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 6, basic solutions have a pH greater than 7 and up to 14, and neutral solutions have a pH of 7.

Plume - A body of contaminated groundwater flowing from a specific source. The movement of the groundwater is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants.

Polychlorinated biphenyls (PCBs) - A family of organic compounds used from 1926 to 1979 (when they were banned by the U. S. Environmental Protection Agency [EPA]) in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process.

Potable Water - Water of quality sufficient for use as drinking water without endangering the health of people, plants, or animals.

Point source - Any confined and discrete conveyance (e.g., pipe, ditch, well, or stack) of a discharge.

Pollution - Levels of contamination that may be objectionable (perhaps due to a threat to health [see contamination]).

Precision - The dispersion around a central value, usually represented as a variance, standard deviation, standard error, or confidence interval.

Q

Quality Assurance (QA) - Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures such as interlaboratory comparison studies, evaluations, and documentation.

Quality Control (QC) - The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

R

Radionuclide - A radioactive element characterized by the number of protons and neutrons in the nucleus. There are several hundred known radionuclides, both artificially produced and naturally occurring.

Recharge - The process by which water is added to a zone of saturation (aquifer) from surface infiltration. An area where rainwater soaks through the earth to reach an aquifer.

Recharge Basin - A basin (natural or artificial) that collects water. The water will infiltrate to the aquifer.

Record of Decision (ROD) - Documents the regulators' decision for the selected remedial action. The ROD also includes the responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the ROD is finalized, remedial design and implementation can begin.

Release - Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment. The National Contingency Plan also defines the term to include a threat of release.

Removal Actions or Removals - Interim actions that are undertaken to prevent, minimize, or mitigate damage to the public health or environment that may otherwise result from a release or threatened release of hazardous substances, pollutants, or contaminants pursuant to the Comprehensive Environmental Response, Compensation, and Recovery Act (CERCLA), and that are not inconsistent with the final remedial action. Under CERCLA or Superfund, the U.S. Environmental Protection Agency (EPA) may respond to releases or threats of releases of hazardous substances by starting a removal action. The purpose of the removal action is to stabilize or clean up an incident or site that poses an immediate threat to public health or welfare. Removal actions differ from remedial actions. However, removal actions must contribute to the efficiency of future remedial actions.

Runoff - The movement of water over land. Runoff can carry pollutants from the land into surface waters or onto uncontaminated land.

S

Sampling - The extraction of a prescribed portion of an effluent stream or environmental media for purposes of inspection or analysis.

Sediment - The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers that may contain contaminants.

Sludge - Semi-solid residue from industrial or water treatment processes.

Sole Source Aquifer - An area defined by the U.S. Environmental Protection Agency (EPA) where the only source of drinking water is groundwater.

Stakeholder - People or organizations with vested interests in Brookhaven national Laboratory (BNL) and its environment and operations.

State Pollution Discharge Elimination System (SPDES) - A permit issued by the state that regulates the discharge of wastewaters. This permit specifies the maximum discharge limits for the parameters present in the particular discharge.

Sump - A pit or tank that catches liquid runoff for drainage or disposal.

T

TLD - Thermoluminescent dosimeter, a device used to measure integrated external penetrating radiation exposure.

U

Upgradient/Upslope - A location of higher groundwater elevation.

V

Vernal Pool – A small, isolated contained basin that holds water on a temporary basis, most commonly during winter and spring. It has no aboveground outlet for water, and is extremely important to the life cycle of many amphibians (such as the spotted salamander), as it is too shallow to support fish, a major predator of amphibian larvae.

Volatile Organic Compounds (VOCs) – Secondary petrochemicals, including light alcohols, acetone, trichlorethylene, perchloroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride. These potentially toxic chemicals are used as solvents, degreasers, paints, thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential exposure to humans. Due to their low water solubility, environmental persistence, and widespread industrial use, they are commonly found in soil and groundwater.

W

Water table - The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.

Watershed - The region draining into a river, a river system, or a body of water.

Wind Rose - A diagram that shows the frequency of wind from different directions at a specific location.

Sampling Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
Surface Water: Compliance					
SPDES - STP Effluent (Monthly)	Monthly	Yes (cc)	ESD	24 Hr. Composite	TAL metals, nitrogen series, BOD_5, TSS, total phosphorus; sampled and analyzed twice per month
SPDES - STP Effluent (Quarterly)	Quarterly	Yes (cc)	ESD	24 Hr. Composite	TAL metals, nitrogen series, BOD_5, TSS, total phosphorus, whole effluent toxicity testing, SVOCs (EPA 8270 and 15 compound library search), herbicides (EPA 8150); sampled and analyzed three times per month
SPDES - STP Influent (Monthly)	Monthly	Yes (cc)	ESD	24 Hr. Composite	TAL metals, BOD_5, TSS; sampled and analyzed twice per month
SPDES - STP Influent (Quarterly)	Quarterly	Yes (cc)	ESD	24 Hr. Composite	BOD_5, TSS; sampled and analyzed three times per month
SPDES - STP Effluent (Monthly)	Monthly	Yes (cc)	ESD	Grab Sample	VOCs (EPA 624) and ketones, cyanide, fecal coliform; sampled and analyzed twice per month
SPDES - STP Effluent (Quarterly)	Quarterly	Yes (cc)	ESD	Grab Sample	VOCs (EPA 624) and ketones, cyanide, fecal coliform, pesticides/PCBs (EPA 608); sampled and analyzed three times per month
SPDES - STP Effluent (Daily)	Monthly	Yes (cc)	PE	Grab Sample	pH, temperature, suspended solids; sampled and analyzed daily
SPDES – HO (Monthly)	Monthly	Yes (cc)	ESD	Grab Sample	pH, oil and grease, flow; sampled and analyzed monthly
SPDES – HO (Quarterly)	Quarterly	No	ESD	Grab Sample	HEDP, DBNPA, TTA, VOCs (EPA 624), zinc; sampled and analyzed quarterly
SPDES - HN, HT-W, HS, CSF, HT-E (Monthly)	Monthly	Yes (cc)	ESD	Grab Samples	pH, oil and grease, flow; sampled and analyzed monthly
SPDES - HN, HT-W, HT-E (Quarterly)	Quarterly	No	ESD	Grab Samples	HEDP, TTA, VOCs (HN only, EPA 624); sampled and analyzed quarterly
SPDES - HS	Quarterly	No	ESD	Grab Sample	Copper; sampled and analyzed quarterly
SPDES – HP (Monthly)	Monthly	No	ESD	Grab Sample	PH; reading taken monthly with portable water quality meter
SPDES – HP (Quarterly)	Quarterly	No	ESD	Grab Sample	VOCs (EPA 624), flow (PE); sampled and analyzed quarterly

AGS: Alternating Gradient Synchrotron
ASL: Analytical Services Laboratory
BLIP: Brookhaven Linac Isotope Producer
BMRR: Brookhaven Medical Research Reactor
BOD_5: Biological Oxygen Demand – 5 Day
DBNPA: Dibromonitrilo propionamide
ESD: Environmental Services Division
HEDP: Hydroxyethilydene diphosphoric acid
HFBR: High Flux Beam Reactor
MH: Manhole
PE: Plant Engineering Division
PPGMBE: Polypropylene glycol monobutyl ether
RHIC: Relativistic Heavy Ion Collider
SER: Site Environmental Report
SOC: Synthetic Organic Compound
SVOC: Semivolatile Organic Compound
SPDES: State Permit Discharge Elimination System
STP: Sewage Treatment Plant
TLD: Thermoluminescent Dosimeter
TAL: Target Analyte List
TSS: Total Suspended Solids
TTA: Tolyltriazole
WMF: Waste Management Facility
VOC: Volatile Organic Compounds
WQ: Water Quality

Sampling Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
***Surface Water: Compliance** (Continued)*					
SPDES - Bldg. 535 Printed Circuit Board Shop	Quarterly	No	ESD	Grab Sample	pH, SVOCs (EPA 625), flow (PE); sampled and analyzed quarterly
SPDES - Bldg. 498 PE Central Cleaning Facility	Quarterly	No	ESD	Grab Sample	pH, VOCs (EPA 624), SVOCs (EPA 625), TAL metals, flow (PE); sampled and analyzed quarterly
SPDES - Bldg. 197 Graphics Arts; 3 Locations	Quarterly	No	ESD	Grab Samples	pH, phenol, cyanide, silver; sampled and analyzed quarterly
SPDES - Bldg. 902 Cooling Tower	Quarterly	No	ESD	Grab Sample	pH, flow (AGS), PPGMBE
SPDES - Bldg. 1002, Bldg. 1004, Bldg. 1010	Monthly	Semiannual	ESD	Grab Samples	pH, flow, oil and grease; sampled and analyzed monthly
SPDES – Bldg. 1004	Quarterly	Semiannual	ESD	Grab Sample	HEDP, TTA; sampled and analyzed quarterly
SPDES – Satellite Boilers	Quarterly	No	PE/ESD	Grab Samples	PH, flow; sampling and analysis varies
Potable Water: Compliance					
Wells #4, #6, #7, #10, #10T, #11, #11T, #12, #12T, Water Treatment Plant Effluent	Quarterly	Yes (cc)	ESD	Grab Samples	Alpha, beta, gamma, tritium; sampled and analyzed quarterly
	Quarterly	Yes (cc)	ESD	Grab Samples	Sr-90; sampled and analyzed quarterly
	Quarterly	Yes (cc)	PE/ESD	Grab Samples	VOCs (EPA 624); sampled and analyzed quarterly
	Quarterly	Yes (cc)	PE/ESD	Grab Samples	Bacteriology, inorganics: sampled and analyzed quarterly (raw water only)
	Semiannual	Yes (cc)	PE/ESD	Grab Samples	SOCs; sampled and analyzed once per 1.5 years
Distribution System	Monthly	Yes (cc)	PE/ESD	Grab Sample	Bacteriology; sampled and analyzed at 7 locations monthly
	Semiannual	Yes (cc)	PE/ESD	Grab Sample	Inorganics; sampled and analyzed semiannually
	Annual	Yes (cc)	PE/ESD	Grab Sample	Asbestos; sampled and analyzed once per year

AGS: Alternating Gradient Synchrotron
ASL: Analytical Services Laboratory
BLIP: Brookhaven Linac Isotope Producer
BMRR: Brookhaven Medical Research Reactor
BOD_5: Biological Oxygen Demand – 5 Day
DBNPA: Dibromonitrilo propionamide
ESD: Environmental Services Division
HEDP: Hydroxyethilydene diphosphoric acid
HFBR: High Flux Beam Reactor
MH: Manhole
PE: Plant Engineering Division
PPGMBE: Polypropylene glycol monobutyl ether
RHIC: Relativistic Heavy Ion Collider
SER: Site Environmental Report
SOC: Synthetic Organic Compound
SVOC: Semivolatile Organic Compound
SPDES: State Permit Discharge Elimination System
STP: Sewage Treatment Plant
TLD: Thermoluminescent Dosimeter
TAL: Target Analyte List
TSS: Total Suspended Solids
TTA: Tolyltriazole
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Sample Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
Groundwater: Compliance					
Major Petroleum Facility (8 monitoring wells)	Semiannual	Yes (cc)	ESD	Grab Samples	SVOCs (EPA 625); sampled and analyzed semiannually
	Semiannual	Yes (cc)	ESD	Grab Samples	Floating product check; sampled and checked monthly
Motor Pool Facility (6 monitoring wells)	Quarterly	Yes (cc)	ESD	Grab Samples	Floating product check; sampled and checked monthly
	Quarterly	Yes (cc)	ESD	Grab Samples	VOCs (EPA 624), SVOCs (EPA 624); sampled and analyzed quarterly
Surveillance - Sewage Treatment Plant					
STP Effluent - EA	SER	SER	ESD	24 Hr. Composite	Metals, anions; sampled and analyzed monthly
	SER	SER	ESD	Grab Sample	VOCs (EPA 624); sampled and analyzed monthly
	SER	SER	ESD	24 Hr. Composite	Sr-90, gamma; sampled daily and analyzed monthly
	SER	SER	ESD	24 Hr. Composite	Alpha, beta, tritium; sampled and analyzed daily
STP - DA	SER	SER	ESD	24 Hr. Composite	Metals, anions; sampled and analyzed monthly
	SER	SER	ESD	24 Hr. Composite	Sr-90, gamma; sampled daily and composited by ASL for monthly analysis
	SER	SER	ESD	24 Hr. Composite	Alpha, beta, tritium; sampled and analyzed daily
HFBR – MH #232	SER	SER	ESD	24 Hr. Composite	Tritium; sampled and analyzed daily
	SER	SER	ESD	24 Hr. Composite	Alpha, beta, gamma; sampled and analyzed monthly

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Sample Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
Surface Water: Surveillance - Peconic River					
Peconic River – Outside RHIC Ring	SER	SER	ESD	Grab Sample	Alpha, beta, gamma, tritium; sampled and analyzed quarterly
Peconic River – Inside RHIC Ring	SER	SER	ESD	Grab Sample	Alpha, beta, gamma, tritium; sampled and analyzed quarterly
HE	SER	SER	ESD	24 Hr. Composite	Metals, anions, Sr-90, gamma, alpha, beta, tritium; sampled and analyzed quarterly. Filtered samples analyzed semiannually for metals.
	SER	SER	ESD	Grab Sample	VOCs (EPA 624); sampled and analyzed quarterly
HM-N	SER	SER	ESD	24 Hr. Composite	Metals, anions; sampled and analyzed monthly. Filtered samples analyzed semiannually for metals.
	SER	SER	ESD	24 Hr. Composite	Sr-90, gamma; sampled three times per week and analyzed monthly
	SER	SER	ESD	24 Hr. Composite	Alpha, beta, tritium; sampled and analyzed three times per week
	SER	SER	ESD	Grab Sample	VOCs (EPA 624); sampled and analyzed monthly
HM-S	SER	SER	ESD	Grab Sample	Metals, anions, VOCs (EPA 624), Sr-90, alpha, beta, gamma, tritium; sampled and analyzed quarterly. Filtered samples analyzed semiannually for metals.
HQ	SER	SER	ESD	24 Hr. Composite	Metals, anions; sampled and analyzed monthly. Filtered samples analyzed semiannually for metals.
	SER	SER	ESD	24 Hr. Composite	Sr-90, gamma; sampled three times per week and analyzed monthly
	SER	SER	ESD	24 Hr. Composite	Alpha, beta, tritium; sampled and analyzed three times per week
	SER	SER	ESD	Grab Sample	VOCs (EPA 624); sampled and analyzed monthly
HA	SER	SER	ESD	Grab Sample	Metals, anions, VOCs (EPA 624), alpha, beta, gamma, tritium; sampled and analyzed quarterly. Filtered samples analyzed semiannually for metals.

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Surface Water: Surveillance - Peconic River *(Continued)*					
HB	SER	SER	ESD	Grab Sample	Metals, anions, VOCs (EPA 624), alpha, beta, gamma, tritium; sampled and analyzed quarterly. Filtered samples analyzed semiannually for metals.
HC	SER	SER	ESD	Grab Sample	Metals, anions, VOCs (EPA 624), alpha, beta, gamma, tritium; sampled and analyzed quarterly. Filtered samples analyzed semiannually for metals.
HH	SER	SER	ESD	Grab Sample	Metals, anions, VOCs (EPA 624), alpha, beta, gamma, tritium; sampled and analyzed quarterly. Filtered samples analyzed semiannually for metals.
HR	SER	SER	ESD	Grab Sample	Metals, anions, VOCs (EPA 624), alpha, beta, gamma, tritium; sampled and analyzed quarterly. Filtered samples analyzed semiannually for metals.
Surveillance - Recharge Basins					
HT-E, HT-W, HS	SER	SER	ESD	24 Hr. Composite	Metals, anions, alpha, beta, tritium; sampled and analyzed quarterly
	SER	SER	ESD	Grab Samples	VOCs (EPA 624); sampled and analyzed quarterly
HN	SER	SER	ESD	24 Hr. Composite	Metals, anions, alpha, beta, tritium; sampled and analyzed quarterly
	SER	SER	ESD	Grab Sample	VOCs (EPA 624); sampled and analyzed quarterly
HW, CSF	SER	SER	ESD	Grab Samples	Metals, anions, VOCs (EPA 624); sampled and analyzed quarterly
HO	SER	SER	ESD	Grab Sample	Metals, anions, EPA 624, alpha, beta, tritium, gamma; sampled and analyzed quarterly
HP	SER	SER	ESD	Grab Sample	Metals, anions, VOCs (EPA 624), alpha, beta, tritium; sampled and analyzed quarterly
HS, HO, HN, HT-W, HE, HM-N, HM-S, HQ, HT-E (Flow chart exchange)	SER	SER	ESD	Grab Samples	Exchanged charts weekly

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Sample Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
Surveillance - Potable Water					
Wells #4, #6, #7, #10, #10T, #11, #11T, #12, #12T	No	No	ESD	Grab Samples	Anions, VOCs (EPA 624); sampled and analyzed quarterly
	No	No	ESD	Grab Samples	Metals; sampled and analyzed once per year
Surveillance - Precipitation					
P4, S5	SER	SER	ESD	Monthly Composite	Alpha, beta, gamma, tritium; sampled and analyzed quarterly
Surveillance – Particulate Filters					
088-200, 090-200, 090-201, 038-250, 109-200, 017-200, 006-200, 090-202, 064-250	SER	SER	ESD	Weekly Composite	Alpha, beta; sampled and analyzed weekly
075-251, 065-251	SER	SER	ESD	Weekly Composite	Alpha, beta, gamma; sampled and analyzed weekly
Surveillance – Charcoal					
075-151, 065-251	SER	SER	ESD	Weekly Composite	Gamma; sampled and analyzed weekly
064-250	SER	SER	ESD	Weekly Composite	Gamma; sampled and analyzed weekly when Bldg. 931 (BLIP) is running
109-100, 088-100, 090-100, 090-101, 038-150, 017-100, 066-100	SER	SER	ESD	Monthly Composite	Gamma; sampled and analyzed monthly
Groundwater: Surveillance					
AGS (42 wells)	SER	Semiannual	ESD	Grab Samples	Tritium, gamma; sampled and analyzed quarterly
	SER	Semiannual	ESD	Grab Samples	Alpha, beta, VOCs (EPA 624); sampled and analyzed semiannually

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Sampling Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
***Groundwater: Surveillance** (Continued)*					
BLIP (6 wells)	SER	Semiannual	ESD	Grab Samples	Tritium, gamma; sampled and analyzed quarterly
	SER	Semiannual	ESD	Grab Samples	Alpha, beta; sampled and analyzed semiannually
RHIC (12 wells)	SER	Semiannual	ESD	Grab Samples	Tritium, gamma; sampled and analyzed quarterly
	SER	Semiannual	ESD	Grab Samples	Alpha, beta; sampled and analyzed semiannually
WMF (8 wells)	SER	Semiannual	ESD	Grab Samples	VOCs (EPA 624), tritium, gamma; sampled and analyzed quarterly
	SER	Semiannual	ESD	Grab Samples	Metals, alpha, beta, anions; sampled and analyzed semiannually
BMRR (4 wells)	SER	Semiannual	ESD	Grab Samples	Tritium, gamma, alpha, beta; sampled and analyzed quarterly
STP (14 wells)	SER	Semiannual	ESD	Grab Samples	Metals, tritium, alpha, beta, gamma, anions; sampled and analyzed semiannually
Live Fire Range (2 wells)	SER	Semiannual	ESD	Grab Samples	Metals; sampled and analyzed semiannually
Shotgun Range (2 wells)	SER	Semiannual	ESD	Grab Samples	Metals; sampled and analyzed semiannually
Biology Greenhouse (2 wells)	SER	Semiannual	ESD	Grab Samples	Metals, anions, pesticides; sampled and analyzed semiannually
Public Service Station (5 wells)	SER	Semiannual	ESD	Grab Samples	VOCs (EPA 624), SVOCs (EPA 625), metals, floating product; sampled and analyzed semiannually
Water Treatment Plant (5 wells)	SER	Semiannual	ESD	Grab Samples	Metals, anions; sampled and analyzed semiannually
Bldg. 830 (4 wells)	SER	Semiannual	ESD	Grab Samples	Tritium, alpha, beta, gamma; sampled and analyzed semiannually

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Sampling Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
***Groundwater: Surveillance** (Continued)*					
Major Petroleum Facility (8 wells)	SER	Semiannual	ESD	Grab Samples	VOCs (EPA 624); sampled and analyzed semiannually
Motor Pool (6 wells)	SER	Semiannual	ESD	Grab Samples	Metals; sampled and analyzed quarterly
Flora and Fauna: Surveillance - Terrestrial Sampling (Onsite)					
Soil (10)	SER	SER	ESD	Grab Samples	Gamma; sampled and analyzed annually
Vegetation (10)	SER	SER	ESD	Grab Samples	Gamma; sampled and analyzed annually
Deer (25)	SER	SER	ESD	Grab Samples	Gamma, Sr-90; sampled and analyzed as available
Small mammal (10)	SER	SER	ESD	Grab Samples	Gamma, Sr-90; sampled and analyzed annually
Goose fecal & lawn vegetation (10 each)	SER	SER	ESD	Grab Samples	Gamma; sampled and analyzed annually
Vegetables (5)	SER	SER	ESD	Grab Samples	Gamma; sampled and analyzed annually
Soil (Vegetable Garden, 1)	SER	SER	ESD	Grab Sample	Gamma; sampled and analyzed annually
Flora and Fauna: Surveillance - Terrestrial Sampling (Offsite)					
Deer (40)	SER	SER	ESD	Grab Samples	Gamma, Sr-90; sampled and analyzed as available
Small mammal (5)	SER	SER	ESD	Grab Samples	Gamma, Sr-90; sampled and analyzed annually
Soil (Farms, 5)	SER	SER	ESD	Grab Samples	Gamma; sampled and analyzed annually
Vegetation (Farms, 25)	SER	SER	ESD	Grab Samples	Gamma; sampled and analyzed annually
Flora and Fauna: Surveillance - Aquatic Sampling					
Fish (65)	SER	SER	ESD	Grab Samples	Gamma, Sr-90, metals, pesticides/PCBs; sampled and analyzed annually

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***Flora and Fauna: Surveillance - Aquatic Sampling** (Continued)*					
Freshwater mussels (10)	SER	SER	ESD	Grab Samples	Gamma, metals, pesticides/PCBs; sampled and analyzed annually
Vegetation (7)	SER	SER	ESD	Grab Samples	Gamma, metals, pesticides/PCBs; sampled and analyzed annually
Sediment (7)	SER	SER	ESD	Grab Samples	Gamma, Sr-90, metals, pesticides/PCBs; sampled and analyzed annually
Estuarine Clams/Mussels (10)	SER	SER	ESD	Grab Samples	Gamma, metals, pesticides/PCBs; sampled and analyzed annually
Surface Water (Fresh, 5)	SER	SER	ESD	Grab Samples	Gamma, metals, pesticides/PCBs; sampled and analyzed annually
Surface Water (Estuarine, 4)	SER	SER	ESD	Grab Samples	Gamma, metals, pesticides/PCBs; sampled and analyzed annually
Radiological Air Monitoring: Surveillance – Silica Gel					
080-300,049-300, 030-300, 012-300, 011-300, 053-300, 063-300, 082-300, 111-300, 126-300, 105-300, 122-300, 108-300, 075-300, 034-300, 084-350, 084-351, 076-300, 076-301, 077-300, 076-302, 088-300, 090-300, 090-301, 071-300, 19-300, 006-300	SER	SER	ESD	Weekly Composite	Tritium; sampled and analyzed monthly
064-350	SER	SER	ESD	Weekly Composite	Tritium; sampled and analyzed weekly
Radiological Air: Surveillance - TLD Exchange (Onsite)					
011-400, 013-400, 030-400, 038-450, 049-400, 080-400, 090-400, 122-400, 108-450, 105-400, 066-400, 126-400, 111-400, 109-400, 082-400, 063-400, 073-400, 053-400, 034-401, 034-400, 017-400, 088-400, 037-400, 074-450, 074-451, 054-400, 075-402, 084-400, 085-400, 085-401, 086-400	SER	SER	ESD	Quarterly Composite	Beta/gamma; sampled and analyzed quarterly

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Sampling Location	Reporting to Regulators	Reporting to Departments	Lead Organization	Sample Type	Analysis/Frequency
Radiological Air: Surveillance - TLD Exchange (Offsite) - BNL Personnel					
000-401, 000-402, 000-403, 000-408, 000-411, 000-412, 000-403, 000-415, 000-416, 000-417, 000-418, 000-419, 000-422, 000-423, 000-451	SER	SER	ESD	Quarterly Composite	Beta/gamma; sampled and analyzed quarterly
Radiological Air: Surveillance - TLD Exchange (Offsite Facilities)					
000-414, 000-420, 000-424, 000-425, 000-426	SER	SER	ESD	Quarterly Composite	Beta/gamma; sampled and analyzed quarterly

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Instrumentation and Analytical Methods

The Analytical Services Laboratory (ASL) is divided into (1) radiological, and (2) nonradiological sections to facilitate analysis of specific parameters in each category. The following analytes are analyzed in each section:

- **Radiological:** Gross alpha, gross beta, gamma, tritium, and strontium-90.
- **Nonradiological:** Purgeable aromatics, purgeable halocarbons, PCBs, anions, and metals.

The methods and instrumentation for each category are briefly described below. Only validated and regulatory referenced methods were used during the analysis. All samples were collected and preserved by trained technicians according to appropriate referenced methods. Well qualified and trained analysts performed different analyses. The ASL is certified by the New York State Department of Health (NYSDOH) for the radiological and nonradiological parameters (except for PCBs) performed. The radiological laboratory participates in the following:

Gross Alpha and Gross Beta Analysis - Water Matrix

Water samples are collected in one-liter polyethylene containers, and preserved at the time of collection by acidification to pH 2 using nitric acid. If the samples are effluent or surface stream samples from locations DA, EA, HM or HQ, or Building 535B daily process samples, then 100 mL are extracted for analysis. Groundwater samples are typically analyzed using a 100-mL aliquot. The aliquot is evaporated to near dryness in a glass beaker, which is rinsed to remove the solids and the combined solids and rinsate are transferred to a 5-cm diameter stainless steel planchet, which is then evaporated to dryness. The planchettes are placed in a drying oven at 105° C for a minimum of 2 hours, removed to a desiccator and allowed to cool, weighed, and counted in a gas-flow proportional counter for 200 minutes. Samples are normally processed in batch mode. The first sample of each batch is a background, which is subtracted from the raw data before computing net activity concentration. System performance is checked daily with National Institute for Standards and Technology (NIST) traceable standards: Americium-241 for alpha and Strontium-90 for beta. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Gross Alpha and Gross Beta Analysis - Air Particulate Matrix

Air particulate samples are collected on 50-mm glass fiber filters at a nominal flow rate of 15 liters per minute. At the end of the collection, the filters are returned to the analytical laboratory for assay. Filters are counted twice in a gas flow proportional counter for 50 minutes. The first count occurs immediately upon receipt in the analytical laboratory, and is used to screen the samples for unusual levels of air particulate activity. The filters are then recounted approximately one week later. This delay permits the short-lived radon/thoron daughters to decay. The second analysis is used for environmental assessments. The first sample of each batch is a blank filter whose count rate is subtracted from the raw data before calculating net activity concentration. The system's performance is checked daily with NIST traceable standards: americium-241 for alpha and strontium-90 for beta.

Tritium Analysis - Water Matrix

Water samples are collected in polyethylene containers. No preservatives are added before collecting the sample. Effluent and surface stream samples from locations DA, EA, HM, or HQ, or Building 535B daily process samples, as well as groundwater samples were analyzed using a7-mL aliquot. Potable water samples were distilled following the method outlined in EPA 1980, 906.0 and a 7-mL aliquot analyzed. Liquid scintillation cocktail then is added to the aliquot so that the final volume in the liquid-scintillation-counting vial is 7 mL of sample plus 10 mL of cocktail. Samples then are counted in a low-background liquid scintillation counter for 50 minutes. Samples are normally processed in batch mode. The first sample of each batch is a steam distilled water background that issubtracted from the raw data before calculating the net activity concentration. The second sample in each batch is a NIST traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, quenching, and efficiency of the sample matrix are factored into the final net concentrations for each sample. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Tritium Analysis - Air Matrix

Concentration of tritium in ambient and facility air is measured by drawing the air through a desiccant at a rate of approximately 200 cc/min. At the end of each collection period, typically one week, the desiccant is brought to the analytical laboratory for processing. It is heated in a glass manifold system. Effluent samples have dedicated glassware, as do environmental samples. The off-gas, containing moisture from the sampled air, is collected by a water cooled glass condenser. A 7-mL aliquot of this water is then assayed for tritium content. Liquid scintillation cocktail is then added to the aliquot so that the final volume in the counting vial is 17-mL. Samples are then counted in a low background liquid scintillation counter for 50 minutes. Samples are normally processed in batch mode. The first sample of each batch is a steam distilled water background that is subtracted from the raw data before computing net activity concentration. The second sample in each batch is a NIST traceable tritium standard, which is used to verify the system's performance and efficiency. Each sample is also monitored for quenching. Corrections for background, water recovery, air sample volume, quenching, and efficiency for the sample matrix are factored into the final net concentrations for each sample. Laboratory duplicates and spiked duplicates are performed within each batch of samples to determine precision and accuracy, respectively.

Strontium-90 Analysis

Strontium-90 analyses are currently performed on water, soil, and aquatic biota samples. Ground water samples are processed in house using DOE Method RP500, which utilizes a crown ether to selectively separate strontium from the acidified sample matrix. The strontium is then eluted using dilute nitric acid. The resulting eluent is evaporated on a 2.5 cm stainless steel planchet and the sample counted in a gas flow proportional counter. Samples are prepared in batches, including a standard and a method blank in each batch. Chemical recovery is determined for each sample by the recovery of strontium carbonate. NIST traceable strontium-90 standards are used to calibrate and verify the performance of the counting instrument. Samples are counted twice to verify strontium-90 and yttrium-90 in growth.

Potable water samples as well as samples of solids are shipped to a contractor laboratory, which is certified to perform the EPA 1980, 905.0 method for strontium-90 in drinking water. This method employs time consuming and costly wet chemistry techniques to isolate strontium from the sample. Samples are counted twice to verify strontium-90 and yttrium-90 in growth. Samples are typically processed in a batch. Backgrounds and system performance are verified with each batch. Chemical recoveries are determined by a combination of gravimetric and strontium-85 standard addition techniques. *Gamma Spectroscopy Analysis.*

Surface, potable, and groundwater surveillance samples are typically of 12 liters and are placed in polyethylene bottles without preservatives. Samples are then passed through a mixed bed ion exchange column at a rate of 20 cc/min. The column is then removed, the resin placed in a Teflon-lined aluminum can and counted on a calibrated gamma spectroscopy detector for 50,000 seconds. Where effluent is sampled in a flow proportional manner, a 10-mL aliquot is passed through the mixed bed column on an as needed basis. Typically, the sizes for such samples approach 50 to 100 liters. Air particulate filters and air charcoal canisters are counted directly on the calibrated gamma spectroscopy detector for 10,000 seconds. Soil, vegetation, and aquatic biota are all processed following collection. Typically, a 50, 100, or 300-g aliquot is taken, placed in a Teflon-lined aluminum can and directly counted. For gamma spectroscopy analyses, overnight backgrounds are counted once per week, with calibration check and background checked daily. Analytical results reflect net activity that has been corrected for background and efficiency for each counting geometry used.

Purgeable Aromatics and Purgeable Halocarbons

Water samples are collected in 40 mL glass vials with removable teflon-lined caps without any headspace, and preserved with 1:1 HCl to pH <2.0. Samples are stored at 4° C and analyzed within 14 days.

Routine wastewater and groundwater samples are analyzed for thirty-seven volatile halogenated or nonhalogenated aliphatic or aromatic hydrocarbons following EPA Method 624 (40 CFR Part 136). Capabilities also exist to perform drinking water methods, EPA Method 524, for the same parameters. The ASL is certified by NYSDOH for both methods. There are currently two Hewlett-Packard GC/MS instruments. One instrument is exclusively used to analyze of purgeable compounds and the other for screening extractables and other extraneous compounds in nonroutine samples. Since the groundwater under BNL is classified as a sole source aquifer under the Safe Drinking Water Act (SDWA) and Class GA groundwater by the New York State Department of Environmental Conservation (NYSDEC), the detection limits reported for the compounds are close to New York State drinking water standards and the ambient water quality standard. Even though the QC generated for the purgeable analysis meets the EPA drinking water method 524.2 requirements, to facilitate certification NYSDOH for limited number of analytes required by BNL, EPA method 624 is used under nonpotable water category.

The method involves purging a 25-mL aliquot of the sample with ultra pure helium in a specially designed sparger using the Purge and Trap technique. Each sample is spiked with a known concentration of internal standards and surrogates before purging to facilitate identifying, quantifying, and determining the extraction efficiency of analytes from the matrix. The purged analytes are trapped on to a specially designed trap and thermally desorbed on to the DB-624 megabore capillary-chromatographic column by back flushing the trap with helium. Individual compounds are separated with a temperature program of the GC and enter the mass spectrometer where they undergo fragmentation to give characteristic mass spectra. The unknown compounds are identified by comparing their mass spectra and retention times with reference compounds and quantitated by internal standard method. The quantitation data is supported by extensive QA/QC, such as tuning the mass spectrometer to meet bromofluoro-benzene criteria, initial and continuing calibrations verifying daily response factors, method blanks, surrogate recoveries, duplicate analysis, matrix spike and matrix spike duplicate analysis, and reference standard analysis to verify the daily working standard.

PCB Analysis

Samples are collected in 50-100 mL glass containers with teflon-lined lid and stored at 4° C and analyzed within 30 days.

Transformer oil, mineral oil, hydraulic fluid, waste oil and spill wipe-samples are analyzed for PCBs using gas chromatography-electron capture detector (GC-ECD) method. This method is similar to EPA SW-846 method 8080 and is targeted to identify and quantify seven different mixtures of PCB congeners in the samples.

The method consists of diluting a known weight of the sample with isooctane and removing the interfering compounds with one or more aliquots of concentrated sulfuric acid till the acid layer is almost colorless. The entire oil matrix, along with other interfering polar compounds, are selectively removed from the sample, leaving the PCBs in isooctane solvent.

There are two GC-ECD instruments for analyzing PCBs. Each GC-ECD instrument is calibrated with different concentrations of each PCB mixture to establish linearity. The PCBs found in the samples are identified and quantitated by comparing the retention times and chromatographic patterns with the standards. Methods blanks, duplicates, spikes, and reference standards are run as part of QA/QC.

Anions

Chloride, nitrate-N, and sulfate are analyzed using Dionex Ion-chromatography (IC) with ion suppression and conductivity detection technique.

Samples from monitoring wells are collected in 100-mL polyethylene bottles, cooled to 4° C, and analyzed within 28 days. For nitrate in drinking water analysis, samples are supposed to be analyzed within 48 hrs. However, even though holding times were exceeded for nitrate analysis of some nonpotable monitoring well samples, the depletion of nitrate is expected to be negligible.

The anions are passed through an anion-exchange polymer column and eluted with carbonate/bicarbonate solution. Then the eluent passes through an ion-suppressing column where the background contribution from the eluent is suppressed, leaving the target anions to be detected by conductivity meter.

Initially, the IC system is calibrated with standards to define its working range. The target anions in the samples are identified and quantitated by comparing the retention times and areas with the standards. Method blanks, duplicates, replicates, spikes, and reference standards are routinely analyzed as part of QA/QC.

Metals

Samples are collected in 500-mL glass bottles and stabilized with ultra-pure nitric acid to a pH of < 2. The samples are analyzed within 6 months, except for mercury, which is analyzed within 26 days.
Cadmium, chromium, lead (furnace), copper, iron, manganese, silver, sodium, zinc (flame), and mercury (manual cold vapor) are analyzed with a Perkin-Elmer atomic absorption spectrometer. Using the flame technique, the sample containing the target element is nebulized and atomized in an oxy-acetylene flame. At the same time, a beam of light from a element-specific hollow cathode lamp corresponding to the absorption frequency of target element is passed through the flame. The atomized element absorbs the energy specific to that element from the cathode lamp and the intensity of absorption is proportional to

the concentration of the element in the sample. Calibration curves establish the linearity of the system and samples are quantitated by comparing with standards.

Using the furnace technique, chemical interference is eliminated in two stages: first, by heating the sample at 105 to 110° C to remove moisture, and second, at 600 to 900° C to burn out any organic matrix. Final atomization is achieved by heating the furnace to 2400 to 2700° C. The rest of the technique is similar to the flame method, above. Using this furnace technique, sub-ppb detection limits are possible for water samples.

Using a cold-vapor technique for mercury, a 100-mL aliquot of the sample is digested with potassium permanganate/persulfate oxidizing solution at 95° C for 2 hours to oxidize any organically bound and/or monovalent mercury to mercury (II) ion state. Excess oxidizing agent is destroyed with hydroxylamine hydrochloride. The mercuric ion later is reduced to elemental mercury with excess stannous chloride, which is purged with helium into the absorption cell. The absorption is directly proportional to the concentration of mercury in the sample.

All these atomic absorption techniques involve initial calibrations to define the calibration range, continuing calibrations, method blanks, duplicates, replicates, matrix spikes, and reference standard analysis as a part of QA/QC.

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