7 Groundwater Protection

Brookhaven National Laboratory has implemented aggressive pollution prevention measures to protect groundwater resources. An extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. In 2010, BNL collected groundwater samples from 789 monitoring wells during 1,732 individual sampling events. Twelve groundwater remediation systems removed 183 pounds of volatile organic compounds and returned approximately 1.8 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the Laboratory has removed 6,553 pounds of volatile organic compounds by treating nearly 18 billion gallons of groundwater. During 2010, two groundwater treatment systems removed approximately 1.4 millicuries of strontium-90 while remediating 15 million gallons of groundwater. Since 2003, BNL has removed approximately 23 millicuries of strontium-90 from the groundwater while remediating 79 million gallons of groundwater.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's Groundwater Protection Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a manner that is consistent with federal, state, and local regulations. The program helps to fulfill the environmental monitoring requirements outlined in DOE Order 450.1, Environmental Protection Program. The program consists of four interconnecting elements: 1) preventing pollution of the groundwater, 2) monitoring the effectiveness of engineered and administrative controls at operating facilities, and 3) restoring the environment by cleaning up contaminated soil and groundwater, and 4) communicating with stakeholders on groundwater protection issues. The Laboratory is committed to protecting groundwater resources from further chemical and radionuclide releases, and to remediate existing contaminated groundwater.

7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented a number of pollution prevention activities that are designed to protect groundwater resources (see Chapter 2). BNL has established a work control program that requires the assessment of all experiments and industrial operations to determine their potential impact on the environment. The program enables the Laboratory to integrate pollution prevention and waste minimization, resource conservation, and compliance into planning and decision making. Efforts have been implemented to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater (see Chapter 3). Examples include upgrading underground storage tanks, closing cesspools, adding engineered controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (e.g., reducing the

toxicity and volume of chemicals in use or storage). BNL's comprehensive groundwater monitoring program is used to confirm that these controls are working.

7.1.2 Monitoring

The Laboratory's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from former and current operations and to track cleanup progress. Each year, BNL collects groundwater samples from an extensive network of on- and off-site monitoring wells (see Table 7-1). Results from groundwater monitoring are used to verify that protection and restoration efforts are working. Groundwater monitoring is focused on two general areas: 1) Facility Monitoring (FM), designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) Comprehensive Environmental Response, Compensation and Liability (CERCLA) monitoring related to the Laboratory's obligations under the Federal Facilities Agreement (FFA). These monitoring programs are coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and decommissioning of wells. The monitoring program elements include data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and the installation, maintenance, and decommissioning of wells. These elements are integrated to create a cost-effective monitoring system and to ensure that water quality data are available for review and interpretation in a timely manner.

Table 7-1. Summary of BNL Groundwater Monitoring Program, 2010.

	CERCLA Program	Facility Monitoring Program
Number of wells monitored	670	119
Number of sampling events	1,525	207
Number of analyses performed	2,588	413
Number of results	64,740	5,339

7.1.3 Restoration

BNL was added to the National Priorities List in 1989. To help manage the restoration effort, 31 separate Areas of Concern were grouped into six Operable Units (OUs). Remedial Investigation/Feasibility Studies have been conducted for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the FFA involving EPA, the New York State Department of Environmental Conservation (NYSDEC), and DOE.

7.1.4 Communication

BNL's Community Education, Government and Public Affairs Office ensures that the Laboratory communicates with its stakeholders in a consistent, timely, and accurate manner. A number of communication mechanisms are in place, such as press releases, web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include routine meetings with the Community Advisory Council and the Brookhaven Executive Roundtable (see Chapter 2, Section 2.4.2). Quarterly and annual technical reports that summarize data, evaluations, and program indices are prepared. In addition, BNL has developed a Groundwater Protection Contingency Plan (BNL 2008) that provides formal processes to promptly communicate off-normal or unusual monitoring results to Laboratory management, DOE, regulatory agencies, and other stakeholders, including the public and employees.

7.2 GROUNDWATER PROTECTION PERFORMANCE

BNL has made significant investments in environmental protection programs, and is making progress in achieving its goal of preventing new groundwater impacts and to remediate previously contaminated groundwater.

No new impacts to groundwater quality have been identified since 2001. A new impact is defined as the detection and confirmation of previously unidentified groundwater contamination. The Groundwater Protection Contingency Plan,

mentioned earlier as a communications tool, also is designed to ensure that appropriate and timely actions are taken if unusual or off-normal results are observed. The contingency plan provides guidelines for verifying the data, evaluating the source of the problem, notifying stakeholders, and implementing appropriate corrective actions. The Laboratory will continue efforts to prevent new groundwater impacts, and is vigilant in measuring and communicating its performance.

7.3 GROUNDWATER MONITORING

Elements of the groundwater monitoring program include installing monitoring wells; planning and scheduling; developing and following quality assurance procedures; collecting and analyzing samples; verifying, validating, and interpreting data; and reporting. Monitoring wells are used to evaluate BNL's progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater that enters and exits the site.

The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. The groundwater beneath the site is classified by New York State as Class GA groundwater, which is defined as a source of potable water. Federal drinking water standards (DWS), New York State DWS, and New York State Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and nonradiological contamination by comparing analytical results to the standards. Contaminant concentrations that are below the standards are also compared to background values to evaluate the potential effects of facility operations. The detection of low concentrations of facility-specific VOCs or radionuclides may provide important early indications of a contaminant release and allow for timely identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 789 on- and off-site wells (see SER Volume II, Groundwater Status Report, for details). In addition to water quality assessments, water levels are routinely measured in more than 775 on- and off-site wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions in the vicinity of the Laboratory are shown in Figure 7-1.

The following active facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP) area, Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), and several vehicle maintenance and petroleum storage facilities. Inactive facilities include the former Hazardous Waste Management Facility (HWMF), two former landfill areas, Waste Concentration Facility (WCF), Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and Brookhaven Medical Research Reactor (BMRR). Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively.

7.4 FACILITY MONITORING PROGRAM

BNL's Facility Monitoring program includes groundwater monitoring at 10 active research facilities (e.g., accelerator beam stop and target areas) and support facilities (e.g., fuel storage and waste management facilities). During 2010, groundwater samples were collected from 119 wells during 207 individual sampling events. Over 20 temporary wells were also installed as part of this program. Detailed descriptions and maps related to the FM groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Although no new impacts to groundwater quality have been discovered since 2001, groundwater quality continues to be impacted at two BNL facilities: continued periodic high levels of tritium at the g-2 tritium source area and continued high levels of VOCs at the Upton service station. Highlights of the surveillance program are as follows:

- Tritium continues to be detected in the g-2 source area monitoring wells, at concentrations above the 20,000 pCi/L, Federal DWS

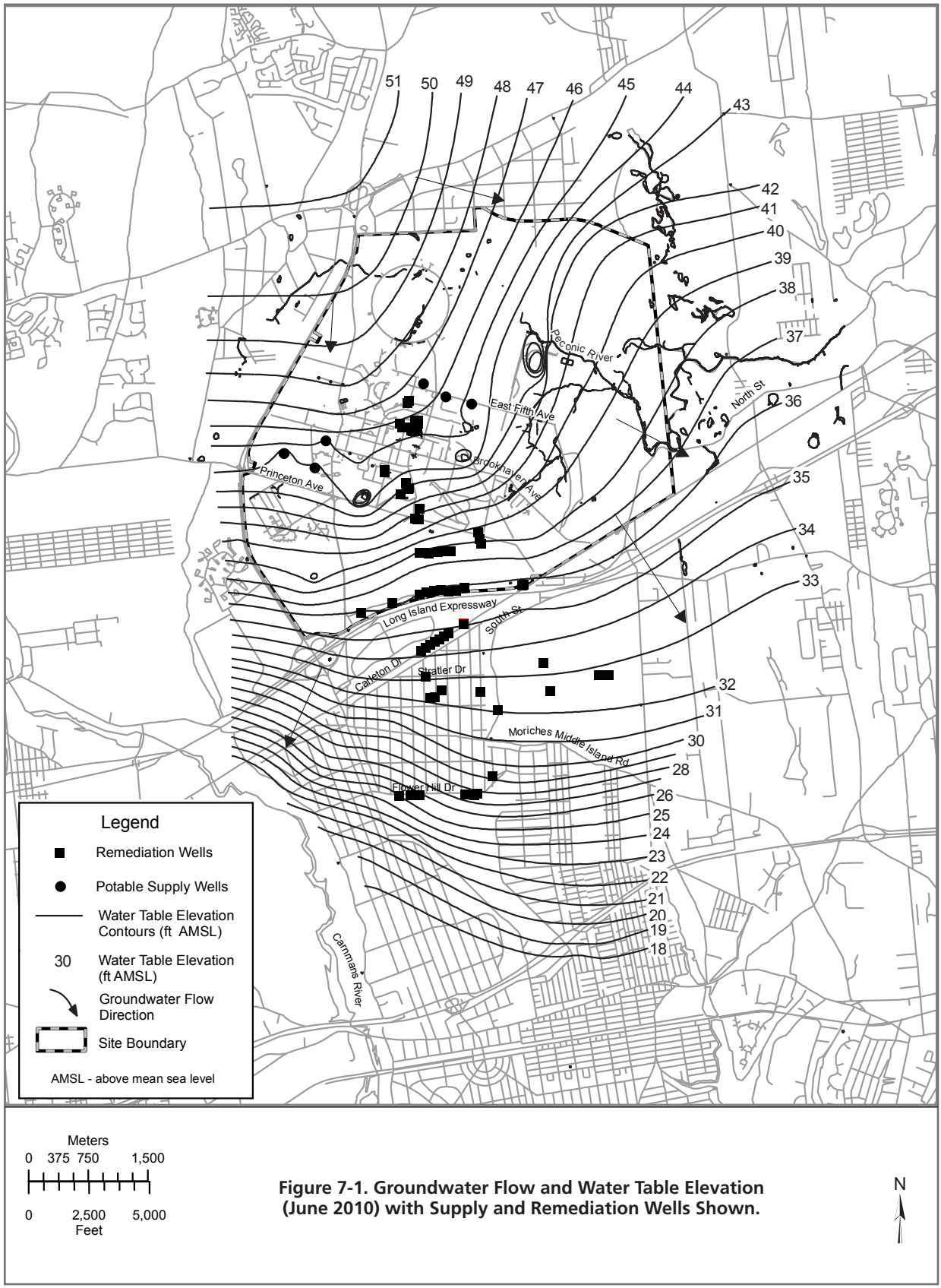

Figure 7-1. Groundwater Flow and Water Table Elevation (June 2010) with Supply and Remediation Wells Shown.

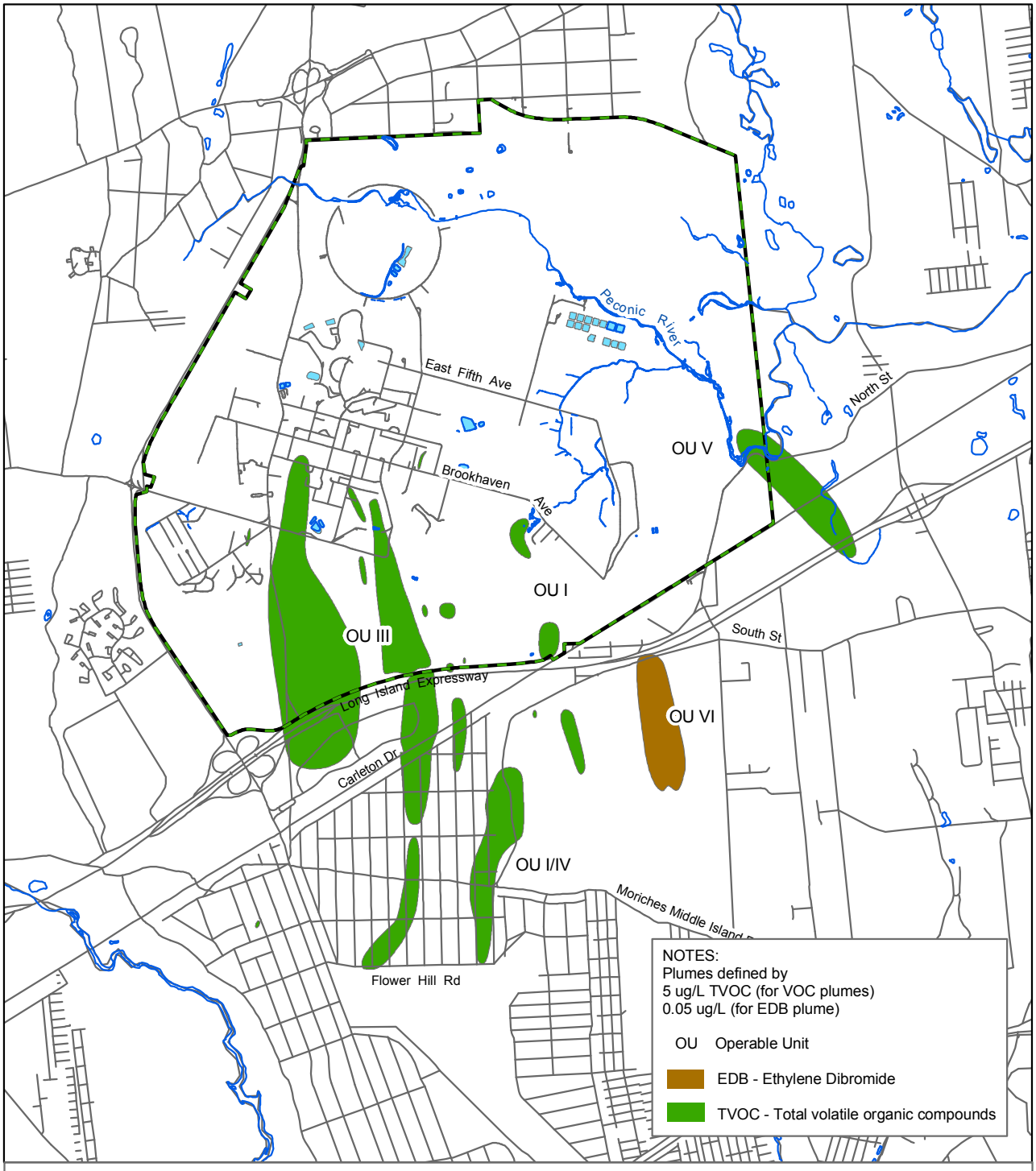

Figure 7-2. Extent of VOC Plumes.

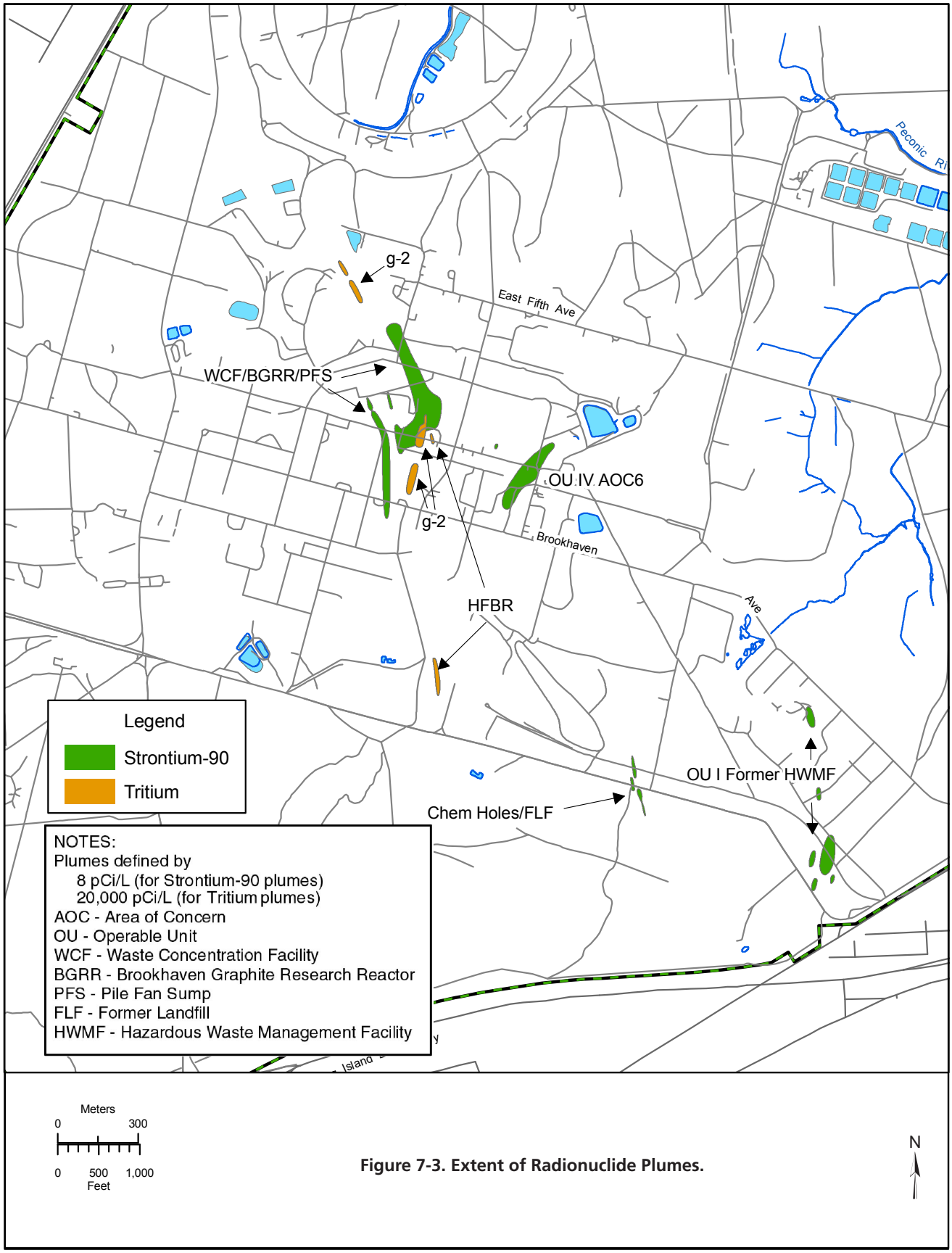

Figure 7-3. Extent of Radionuclide Plumes.

with a maximum concentration of 76,000 pCi/L during 2010. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicate that the continued release of tritium appears to be related to the flushing of residual tritium from the deep vadose zone following significant natural periodic fluctuations in the local water table.

- As a result of natural radioactive decay and dispersion in the aquifer, the downgradient portion of the g-2 tritium plume is breaking up into discrete segments. Several segments of the plume extend from southwest of the HFBR building to an area near the north side of the NSLS facility, a distance of approximately 600 feet. During 2010, the highest tritium concentration observed in the downgradient portion of the plume was 37,300 pCi/L.
- Since April 2006, all tritium concentrations in the Brookhaven Linear Isotope Producer (BLIP) facility surveillance wells have been less than the 20,000 pCi/L DWS. The maximum tritium concentration during 2010 was 7,320 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding, and that the amount of residual tritium in the deep vadose zone is diminishing.
- At the Upton Service Station, VOCs associated with petroleum products and the solvent PCE continue to be detected in the groundwater directly downgradient of the facility. Total VOC concentrations in one well reached a maximum of 139 µg/L; with the contamination consisting mostly of xylenes, ethylbenzene, and trimethylbenzenes. Groundwater monitoring results indicate that the petroleum-related compounds break down within a short distance from the facility. Monitoring of the leak detection systems at the Upton Service Station indicates that the gasoline storage tanks and associated distribution lines are not leaking, and all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the contaminants detected in groundwater originate from historical vehicle maintenance activities and are not related to current operations.

7.5 CERCLA MONITORING PROGRAM

The CERCLA groundwater monitoring program is used to track the progress that groundwater treatment systems are making toward plume remediation (see Section 7.6, below). During 2010, the CERCLA program monitored 789 monitoring wells during 1,525 individual groundwater sampling events. One hundred and four temporary wells were also installed as part of this program. Detailed descriptions and maps related to the CERCLA groundwater monitoring program can be found in SER Volume II, Groundwater Status Report.

Highlights of the program include:

- The HFBR Pump and Recharge system was operational during all of 2010. Monitoring data for 2010 indicate that the tritium concentrations have dropped below the 20,000 pCi/L DWS in the downgradient segment of the plume. A petition for shutdown of the pump and recharge system will be prepared during 2011 if tritium concentrations in the downgradient portion of the plume continue to remain below the DWS. Although tritium concentrations in groundwater monitoring wells immediately downgradient of the HFBR were below the DWS through all of 2009, tritium concentrations increased to 50,800 pCi/L in one well during 2010. This increase is associated with the historic high water table levels observed at the site in early 2010. The overall reduction in tritium concentrations over the past few years indicates that the inventory of tritium remaining in the deep vadose zone beneath the HFBR continues to diminish.
- The BGRR/Waste Concentration Facility Sr-90 Treatment System was modified in 2010 to incorporate four additional extraction wells to remediate an area of Sr-90 contaminated groundwater near the HFBR. Furthermore, Sr-90 concentrations in groundwater immediately downgradient of the BGRR have not decreased as expected

over the past 6 years. The continued release of Sr-90 from this area will be evaluated for the applicability of source area stabilization technologies.

- The removal of PCE contaminated soil, as described in the *Final Operable Unit III Explanation of Significant Differences for Building 96 Remediation* (BNL 2009), was completed in 2010. Approximately 370 cubic yards of contaminated soil was removed and shipped to permitted off-site waste disposal facilities. The Building 96 Groundwater Treatment System will continue to operate until the capture goal is achieved.
- Groundwater characterization of the deep Upper Glacial aquifer at the OU III South Boundary identified an area of deep VOC contamination that is migrating off site. The need for additional actions will be evaluated during 2011.
- Groundwater characterization showed a persistent area of VOCs just above the capture goal of 50 µg/L in the vicinity of the North Street East system, which was originally scheduled to be shut down during 2011. The system will remain in operation to address this remaining area of VOC contamination.
- There have been no individual VOC concentrations detected above DWS for the OU V plume since 2008. As a result, a petition to conclude the monitoring program will be submitted to the regulatory agencies in 2011.

7.6 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems and prevent additional groundwater contamination from migrating off site. The cleanup objectives will be met by a combination of active treatment and natural attenuation. The specific cleanup goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve MCLs for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070
- Achieve MCLs for Sr-90 at the Chemical Holes in the Upper Glacial aquifer by 2040

During 2010, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 14 groundwater treatment systems currently in operation. Table 7-2 provides a summary of the amount of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2010, 183 pounds of VOCs and approximately 1.4 mCi of Sr-90 were removed from the groundwater, and more than 1.8 billion gallons of treated groundwater were returned to the aquifer. To date, 6,553 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in the OU I South Boundary, OU III South Boundary, OU III Industrial Park, OU III Industrial Park East, OU III North Street, and Building 96 areas. Also to date, two of the treatment systems have removed approximately 23 mCi of Sr-90. Detailed information on the groundwater treatment systems can be found in SER Volume II, Groundwater Status Report.

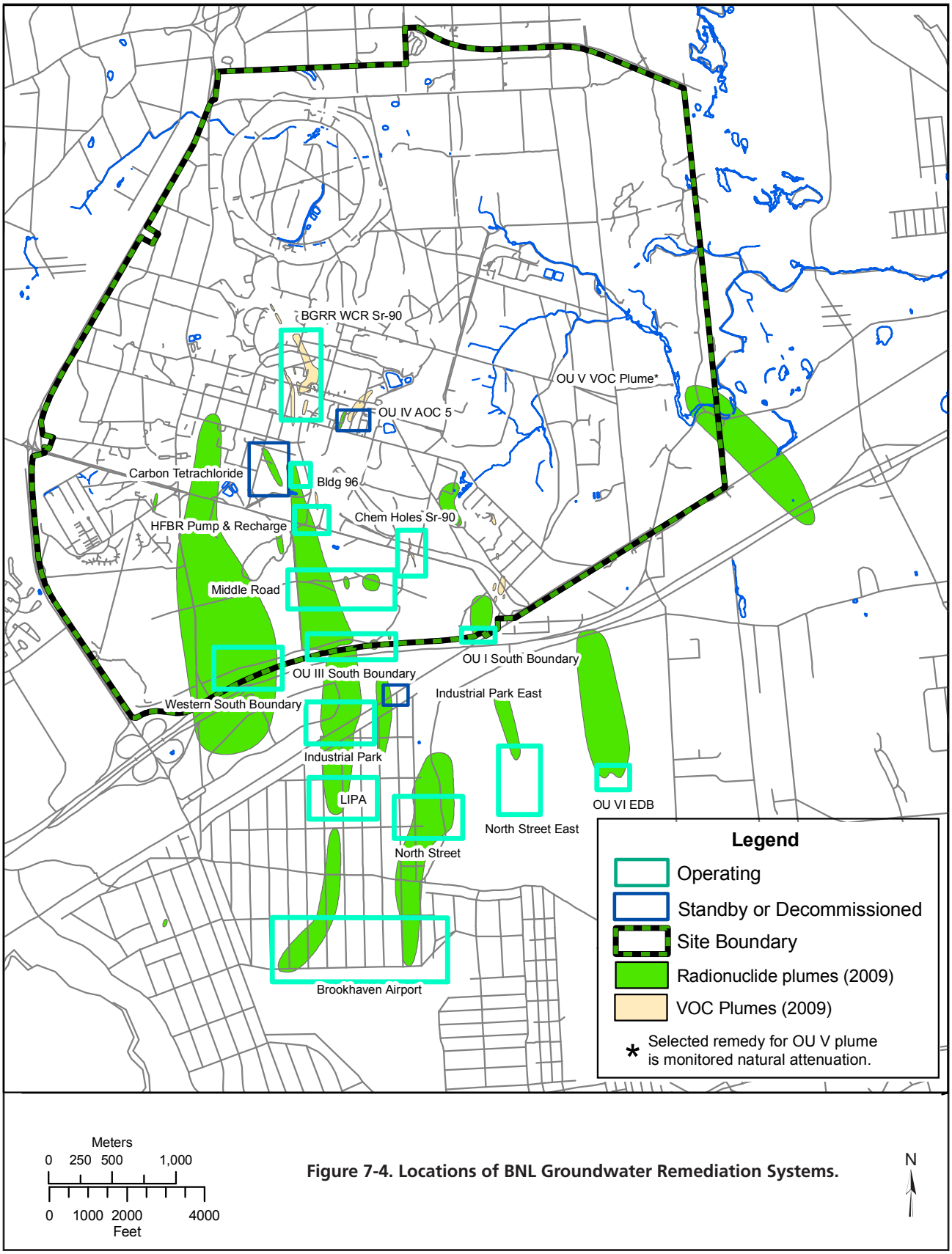

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

Table 7-2. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2010.

		1997-2009		2010	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)	**Water Treated** (Gallons)	**VOCs Removed** (Pounds) (e)
OU I South Boundary	12/1996	3,614,314,000	353	239,418,000	6
OU III HFBR Tritium Plume (a)	05/1997	437,987,000	180	99,142,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	222,297,416	92	26,525,000	7
OU III Middle Road	10/2001	1,594,911,550	867	264,477,000	53
OU III South Boundary	06/1997	3,520,952,850	2,728	169,902,000	58
OU III Western South Boundary	09/2002	782,947,000	67	128,169,000	13
OU III Industrial Park	09/1999	1,640,478,330	1,044	100,484,000	8
OU III Industrial Park East	06/2004	357,172,000	38	20,000	0
OU III North Street	06/2004	1,004,122,000	301	175,071,000	12
OU III North Street East	06/2004	566,976,000	31	116,796,000	5
OU III LIPA/Airport	08/2004	1,338,887,000	285	282,655,000	21
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	788,711,000	(f)	171,998,000	(f)
Total		**16,023,294,221**	**6,370**	**1,774,657,000**	**183**

		2003–2009		2010	
Remediation System	**Start Date**	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)	**Water Treated** (Gallons)	**Sr-90 Removed** (mCi)
OU III Chemical Holes Sr-90	02/2003	24,604,826	3.79	6,638,000	0.31
OU III BGRR/WCF Sr-90	06/2005	39,451,000	17.5	8,488,000	1.1
Total		**64,055,826**	**21.29**	**15,126,000**	**1.72**

Notes:
(a) System was reactivated in late 2007 as a contingency action.
(b) System was shut down on January 10, 2001 and decommissioned in 2003.
(c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance was measured by pounds of VOCs removed per cubic feet of air treated.
(d) System was shut down and placed in standby mode in August 2004 and decommissioned in 2009.
(e) Values are rounded to the nearest whole number.
(f) Because EDB has only been detected at trace levels in the treatment system influent, no removal of VOCs is reported.

BGRR = Brookhaven Graphite Research Reactor
EDB = ethylene dibromide
HFBR = High Flux Beam Reactor
LIPA = Long Island Power Authority
OU = Operable Unit
VOCs = volitile organic compounds
WCF = Waste Concentration Facility

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