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. During 2013, BNL collected groundwater samples from approximately 780 permanent monitoring wells and 65 temporary wells during 2,815 individual sampling events. Eleven groundwater remediation systems removed 183 pounds of volatile organic compounds (VOCs) and returned approximately 1.4 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the treatment systems have removed 7,133 pounds of VOCs by treating nearly 22 billion gallons of groundwater. Also during 2013, two groundwater treatment systems removed approximately 1.3 millicuries of strontium-90 (Sr-90) while remediating approximately 26 million gallons of groundwater. Since 2003, BNL has removed approximately 29 millicuries of Sr-90 from the groundwater while remediating 130 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 various New York State operating permits, DOE Order 458.1, *Radiation Protection of the Public and Environment*, and DOE Order 436.1, *Departmental Sustainability*. This program also satisfies the requirements of several Comprehensive Environmental Response, Compensation and Liability (CERCLA) Records of Decision (RODs). 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, 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. 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, designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) 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.

7.1.3 Restoration

BNL was added to the National Priorities List in 1989. To help manage the restoration effort, 32 separate Areas of Concern (AOC) were grouped into six Operable Units (OUs). Remedial actions have been implemented for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant sources (e.g., contaminated soil and underground storage tanks) have been 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 groundwater protection issues and cleanup progress 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, The Laboratory has developed a Groundwater Protection Contingency Plan (BNL 2013) that provides formal processes to promptly communicate off-normal or unusual monitoring results to BNL 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 over the past 20 years and continues to make progress in achieving its goal of preventing new groundwater impacts and to remediate previously contaminated groundwater. No new impacts to groundwater quality were discovered during 2013. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

7.3 GROUNDWATER MONITORING PROGRAMS

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 volatile organic compounds (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 780 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 725 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 BNL facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP), Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), 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 the 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 GROUNDWATER MONITORING RESULTS

During 2013, the Facility Monitoring program monitored 127 wells during 225 individual sampling events. No new impacts to groundwater quality were discovered during the year. The CERCLA groundwater monitoring program monitored 653 monitoring wells during 2,590 individual groundwater sampling events. Sixty-five temporary wells were also installed as part of this program. Detailed descriptions and maps related to the groundwater monitoring programs can be found in *SER Volume II, Groundwater Status Report*.

Highlights of the groundwater monitoring programs for 2013 include:

- Significant reductions in contaminant concentrations continue to be observed in a number of on- and off-site areas. As a result, the OU I South Boundary Treatment System, OU III Industrial Park Treatment System, OU III North Street Treatment System, and the HFBR Tritium Pump and Recharge System were shut down and placed in standby mode.
- Monitoring results indicated that the OU III Industrial Park East Treatment System, which was placed in standby mode in late 2009, met its cleanup objectives. As a result, the treatment system was decommissioned in 2013.
- Monitoring results indicate that the North Street East Treatment System has met its cleanup objectives. A *Petition for Shutdown* will be submitted to the regulatory agencies in early 2014.
- Natural attenuation monitoring of the remaining portion of the OU V VOC plume was concluded in 2013 after verification that all VOC concentrations had attenuated to levels below applicable NYS AWQS. The monitoring requirements for complet-

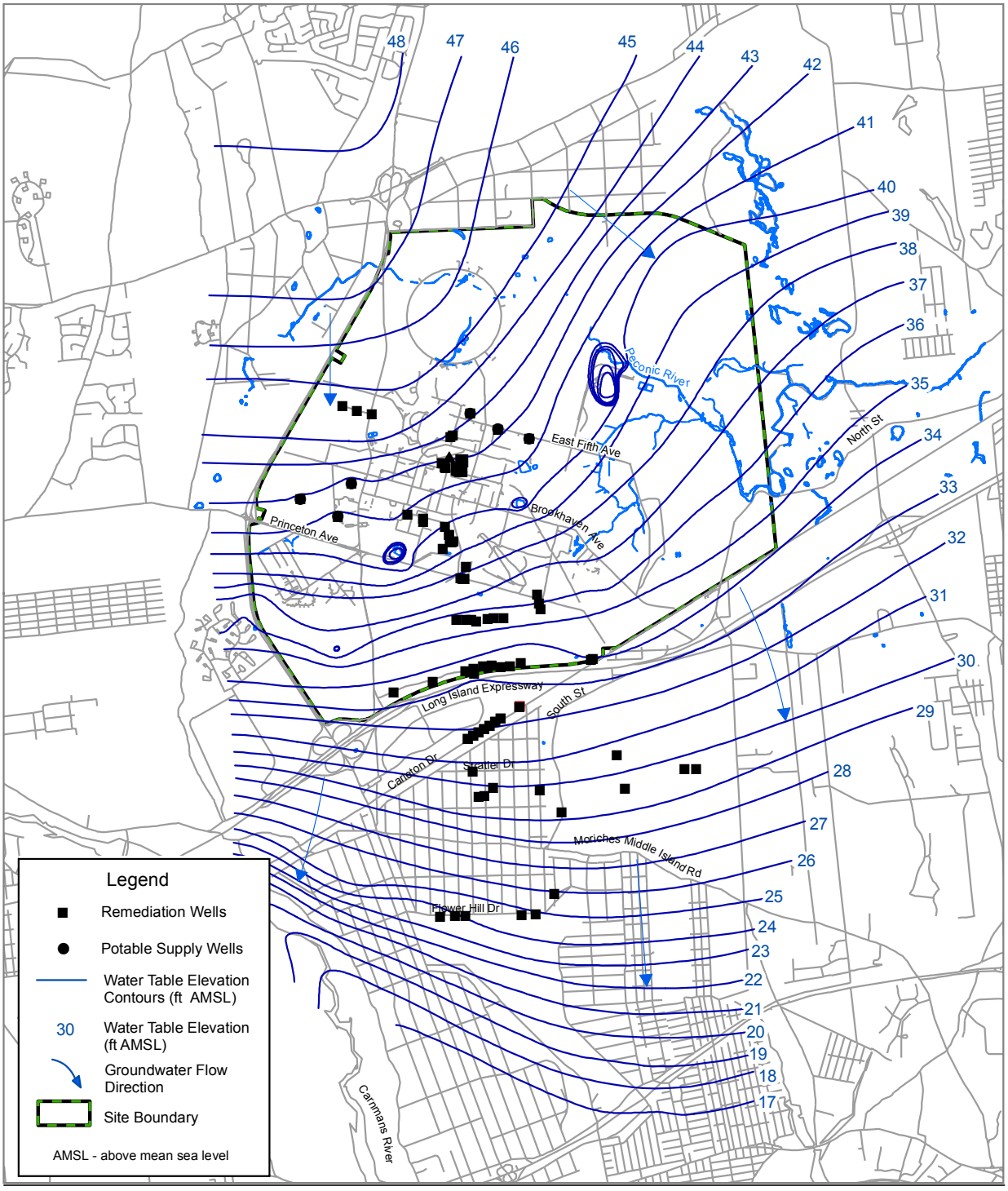

Figure 7-1. Groundwater Flow and Water Table Elevation (December 2013) with Supply and Remediation Wells Shown.

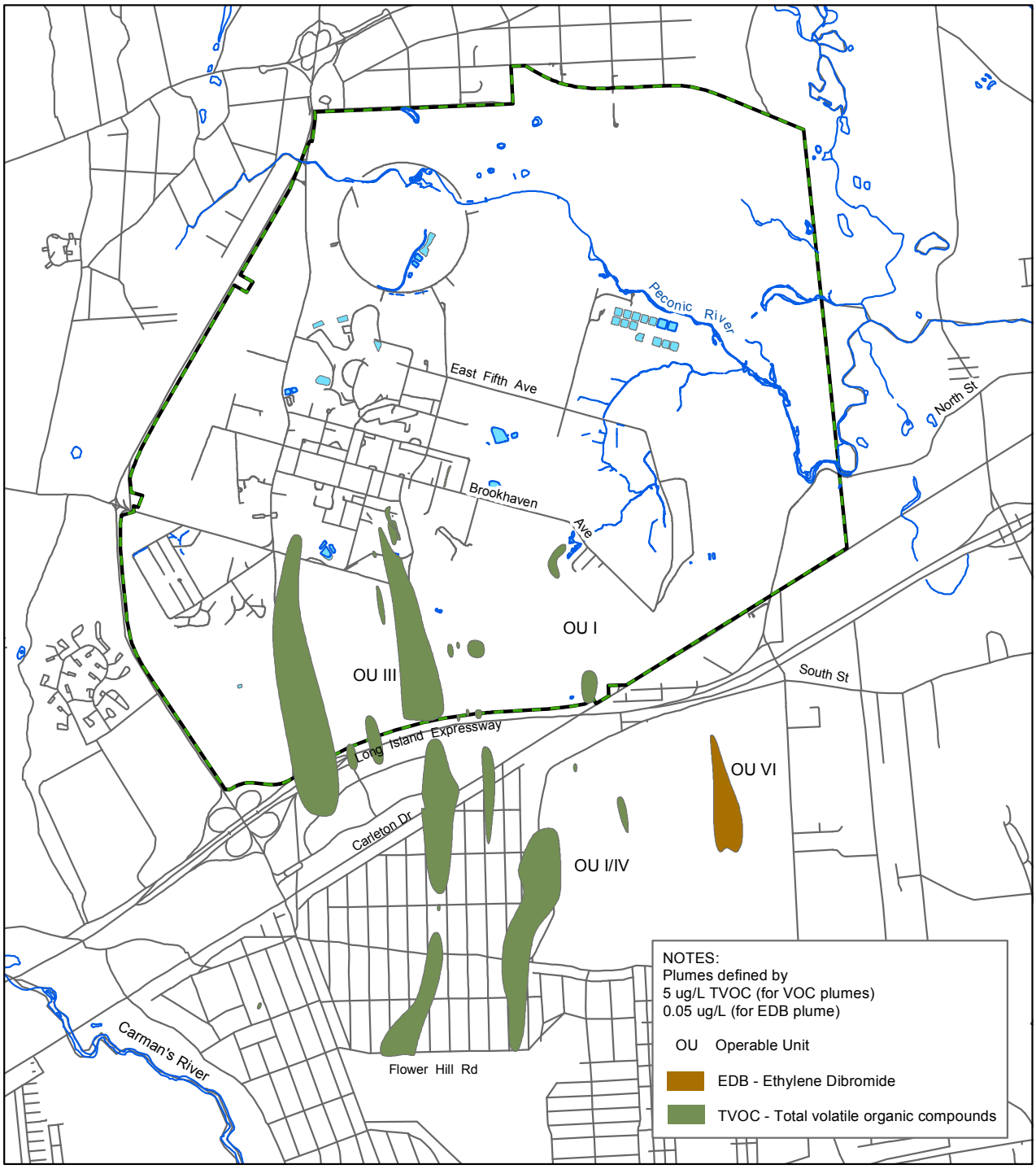

Figure 7-2. Extent of VOC Plumes.

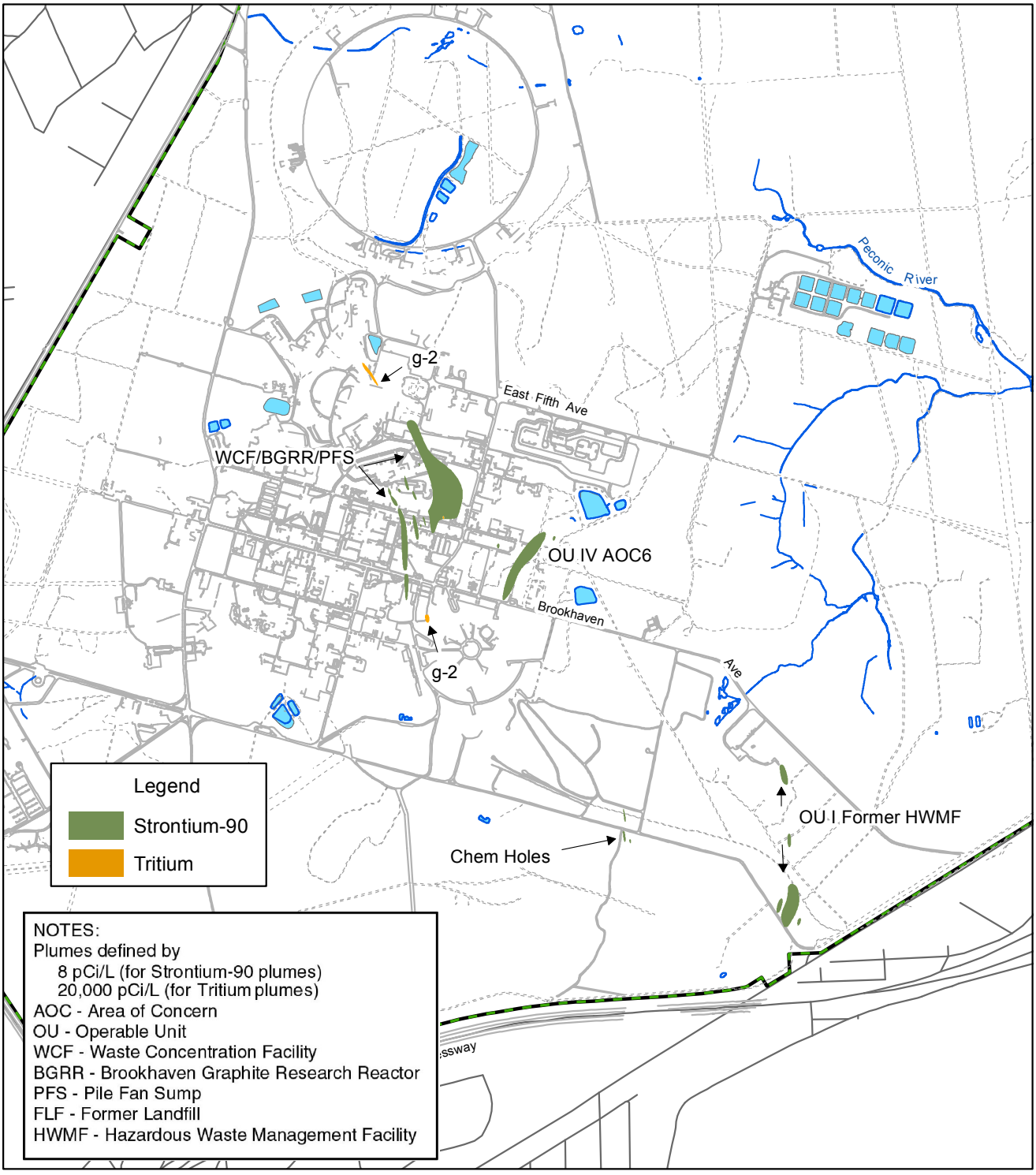

Figure 7-3. Extent of Radionuclide Plumes.

ing this program were documented in the *Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012).

- Groundwater characterization work in the off-site Industrial Park area identified a deep zone of VOC contamination, with total VOC concentrations up to 149 µg/L. This deeper zone of contamination cannot be effectively remediated using the existing Industrial Park Treatment System. During 2014, additional groundwater characterization will be performed to determine the location for the installation of a deeper extraction well(s).
- Significant reductions in VOC concentrations have been observed in the Building 96 source area monitoring wells following the 2010 excavation of contaminated source area soils. In a monitoring well located immediately downgradient of the excavation, total VOC concentrations decreased from a maximum of 2,435 µg/L in early 2011, to 201 µg/L in late 2013.
- During 2012 and 2013, approximately 85 pounds of Freon-11 were removed from the aquifer, and significant reductions in Freon-11 concentrations were observed in the source area and downgradient portions of the plume. Freon-11 concentrations in groundwater have decreased from a maximum concentration of 38,000 µg/L when the plume was discovered 2011, to less than 251 µg/L in November 2013.
- Although Sr-90 concentrations in the groundwater immediately downgradient of the BGRR had decreased to less than 10 pCi/L by the end of 2012, Sr-90 levels increased to as high as 487 pCi/L in 2013. It is believed that the increase is related to a 2010 rise in the water table which flushed residual Sr-90 from the unsaturated zone soils located beneath the building. The amount of Sr-90 in this deep soil zone is expected to diminish over time, and the engineered cap installed in 2011 was designed to prevent rainwater infiltration into contaminated soils immediately below the BGRR.
- Tritium concentrations in the groundwater immediately downgradient of the HFBR exceeded the 20,000 pCi/L drinking water standard only once during 2013, with a concentration of 39,700 pCi/L detected in one well.
- Tritium continued to be detected in the g-2 source area monitoring wells at concentrations above the 20,000 pCi/L DWS, with a maximum concentration of 45,600 pCi/L. Natural radioactive decay and dispersion has significantly reduced the size of the downgradient portion of the g-2 tritium plume, which is now located west of the National Synchrotron Light Source II facility. This small plume segment, which had tritium concentrations up to 31,400 pCi/L during 2013, is expected to naturally attenuate to less than the 20,000 pCi/L drinking water standard within several years.

7.5 GROUNDWATER TREATMENT SYSTEMS

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems to remediate contaminant plumes both on- and off-site. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. 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 and tritium 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 2013, 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 7-1 provides a summary of the amount of VOCs and Sr-90 removed from the aquifer

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2013.

Remediation System	Start Date	1997-2012		2013	
		Water Treated (Gallons)	VOCs Removed (Pounds) (e)	Water Treated (Gallons)	VOCs Removed (Pounds) (e)
OU I South Boundary	12/1996	4,138,473,000	368	39,000,000	1
OU III HFBR Tritium Plume (a)	05/1997	699,295,000	180	225,000,000	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	339,602,416	117	39,805,000	10
OU III Middle Road	10/2001	2,323,348,550	1,026	224,000,000	56
OU III South Boundary	06/1997	4,107,751,850	2,900	276,000,000	54
OU III Western South Boundary	09/2002	1,152,784,000	105	124,000,000	10
OU III Industrial Park	09/1999	1,940,798,330	1,059	36,000,000	2
OU III Industrial Park East (g)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street	06/2004	1,441,617,000	327	61,500,000	2
OU III North Street East	06/2004	852,558,000	41	103,000,000	2
OU III LIPA/Airport	08/2004	2,006,529,000	334	255,000,000	29
OU III Building 452 Freon-11	03/2012	26,812,000	71	31,500,000	17
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	1,253,664,000	(f)	157,000,000	(f)
Total		**20,793,963,221**	**6,950**	**1,369,305,000**	**183**

Remediation System	Start Date	2003–2012		2013	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	44,835,826	4.6	6,500,000	0.11
OU III BGRR/WCF Sr-90	06/2005	59,582,000	22.85	19,500,000	1.17
Total		**104,417,826**	**27.45**	**26,000,000**	**1.28**

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 = volatile organic compounds
WCF = Waste Concentration Facility

since the start of active remediation in December 1996. During 2013, approximately 183 pounds of VOCs and approximately 1.3 mCi of Sr-90 were removed from the groundwater, and approximately 1.4 billion gallons of treated groundwater were returned to the aquifer.

To date, 7,133 pounds of VOCs have been removed from the aquifer and noticeable improvements in groundwater quality are evident in a number of on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 29 mCi of Sr-90.

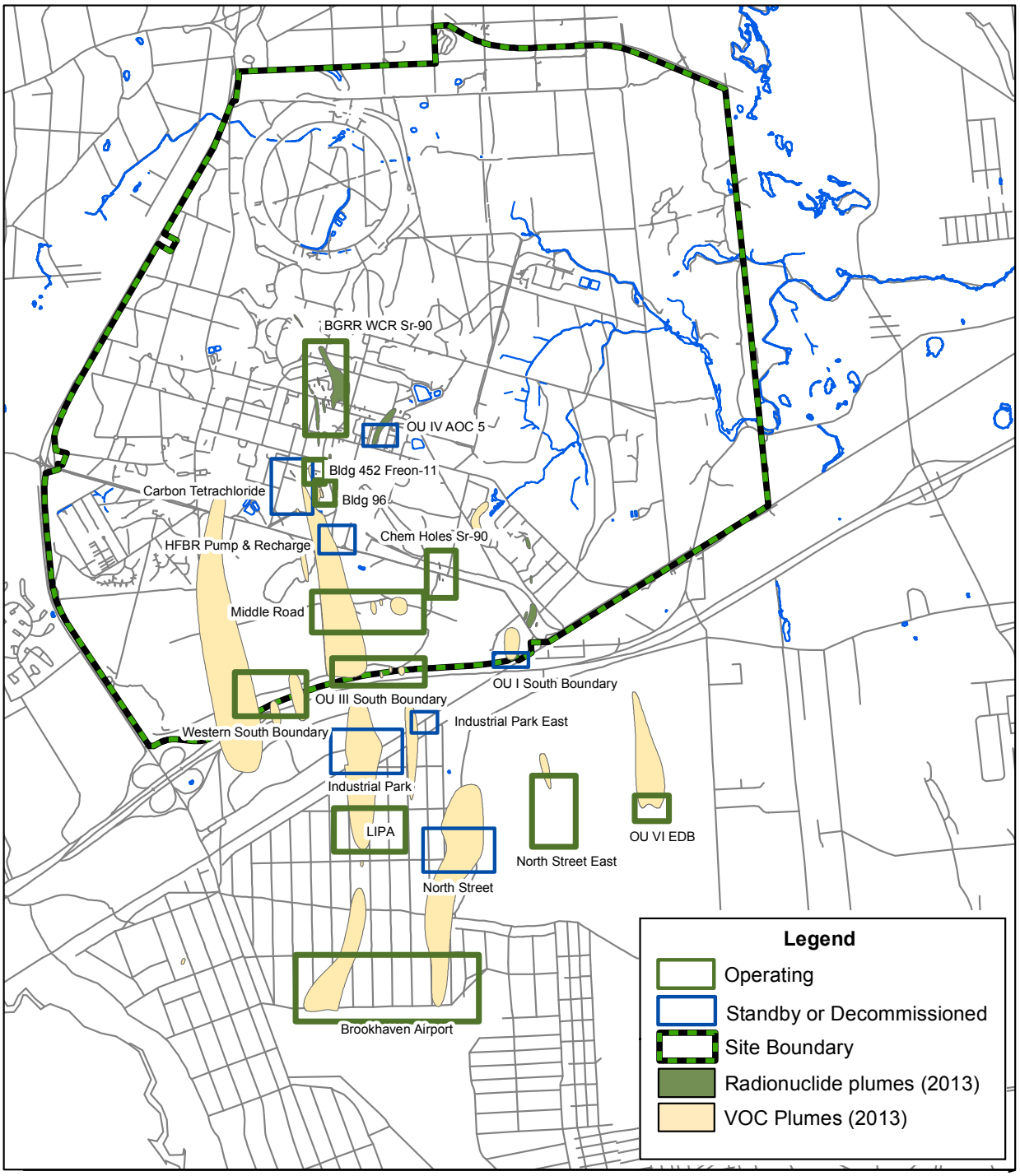

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

During 2013, BNL received regulatory agency approval to shut down four groundwater treatment systems: the OU I South Boundary Treatment System, OU III Industrial Park Treatment System, OU III North Street Treatment System, and the HFBR Tritium Pump and Recharge System. These systems met their active remediation goals for reduction of contaminant concentrations. A period of standby monitoring of these plumes will be performed to detect any rebound of contaminant concentrations. The OU III Industrial Park East Treatment System, which was placed in standby mode in late 2009, was decommissioned in 2013. Furthermore, a Petition for Shutdown for the North Street East Treatment System will be submitted to the regulatory agencies in early 2014. Monitoring of the remaining portion of the OU V VOC plume was concluded in 2013. Detailed information on the groundwater treatment systems can be found in *SER Volume II, Groundwater Status Report*.

REFERENCES AND BIBLIOGRAPHY

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