7 Groundwater Protection

Brookhaven National Laboratory has implemented aggressive pollution prevention measures to protect groundwater resources, and an extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. During 2014, BNL collected groundwater samples from 756 permanent monitoring wells and 67 temporary wells during 1,737 individual sampling events. Ten groundwater remediation systems removed 143 pounds of volatile organic compounds (VOCs) and returned approximately 1.2 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 7,276 pounds of VOCs by treating nearly 23 billion gallons of groundwater. Also during 2014, two groundwater treatment systems removed approximately 1.2 millicuries of strontium-90 (Sr-90) while remediating approximately 13 million gallons of groundwater. Since 2003, BNL has removed approximately 30 millicuries of Sr-90 from the groundwater while remediating 143 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have been observed in a number of on- and off-site areas.

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 monitoring and remediation requirements defined in Comprehensive Environmental Response, Compensation and Liability Act (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 Stakeholder and Community Relations Office works with the Groundwater Protection Program to ensure 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 2014. 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 even 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 760 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 of the 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 2014, the Facility Monitoring program monitored 125 wells during 223 individual sampling events. No new impacts to groundwater quality were discovered during the year. The CERCLA groundwater monitoring program monitored 631 monitoring wells during 1,514 individual groundwater sampling events. Sixty-seven 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 2014 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, and the HFBR Tritium Pump and Recharge System were shut down 2013, and were in standby mode during 2014.
- Although the North Street Treatment System was placed in standby mode in 2013, the system was restarted in June 2014 due to a rebound in VOC concentrations above the cleanup goal in several monitoring wells.
- Monitoring results indicate that the North Street East Treatment System has met its cleanup objectives. Following regulatory agency approval of a Petition for Shutdown (BNL 2014), the system was placed in a standby mode in June 2014.
- Groundwater characterization work in the off-site Industrial Park area identified a

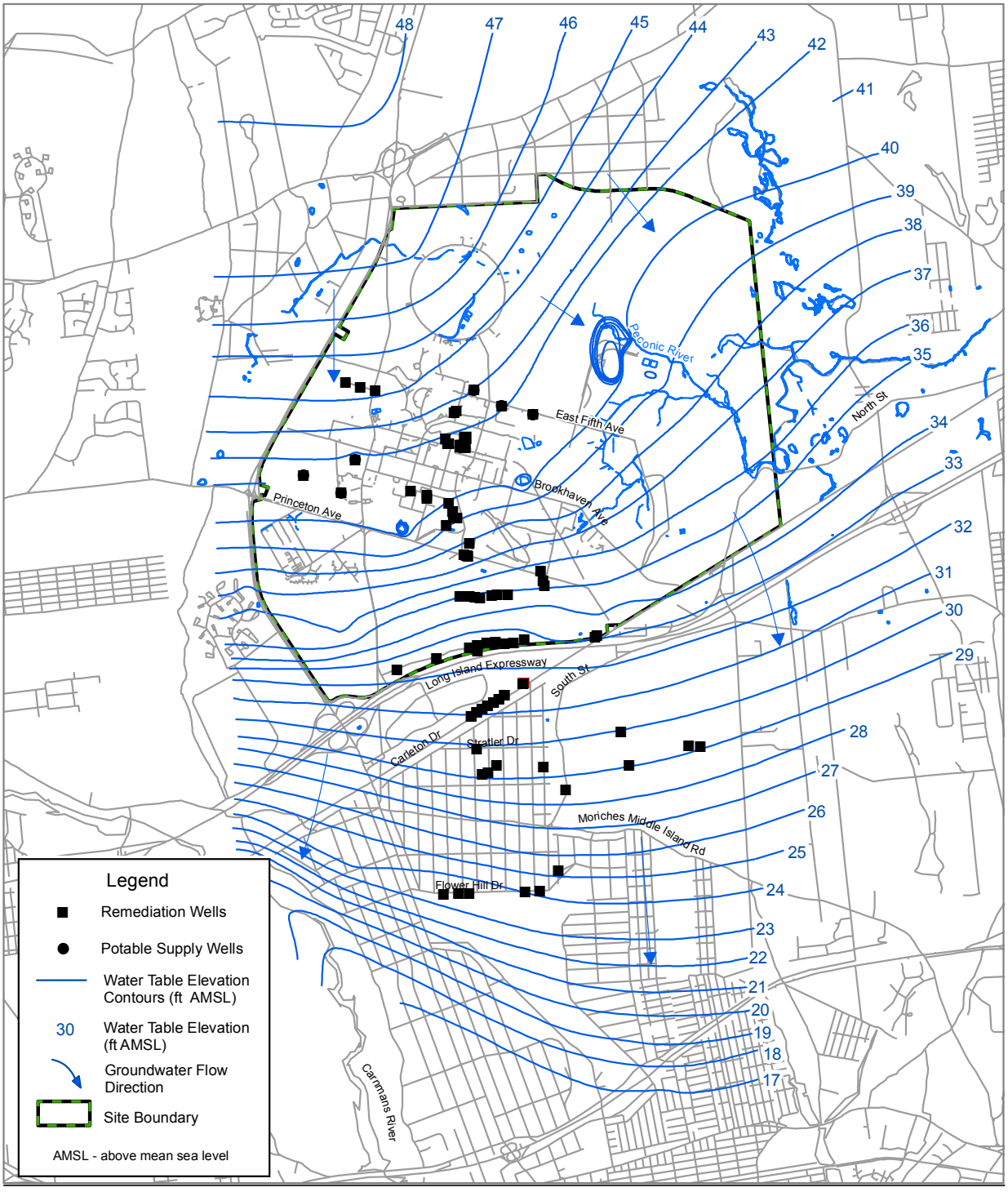

Figure 7-1. Groundwater Flow and Water Table Elevation (December 2014) with Supply and Remediation Wells Shown.

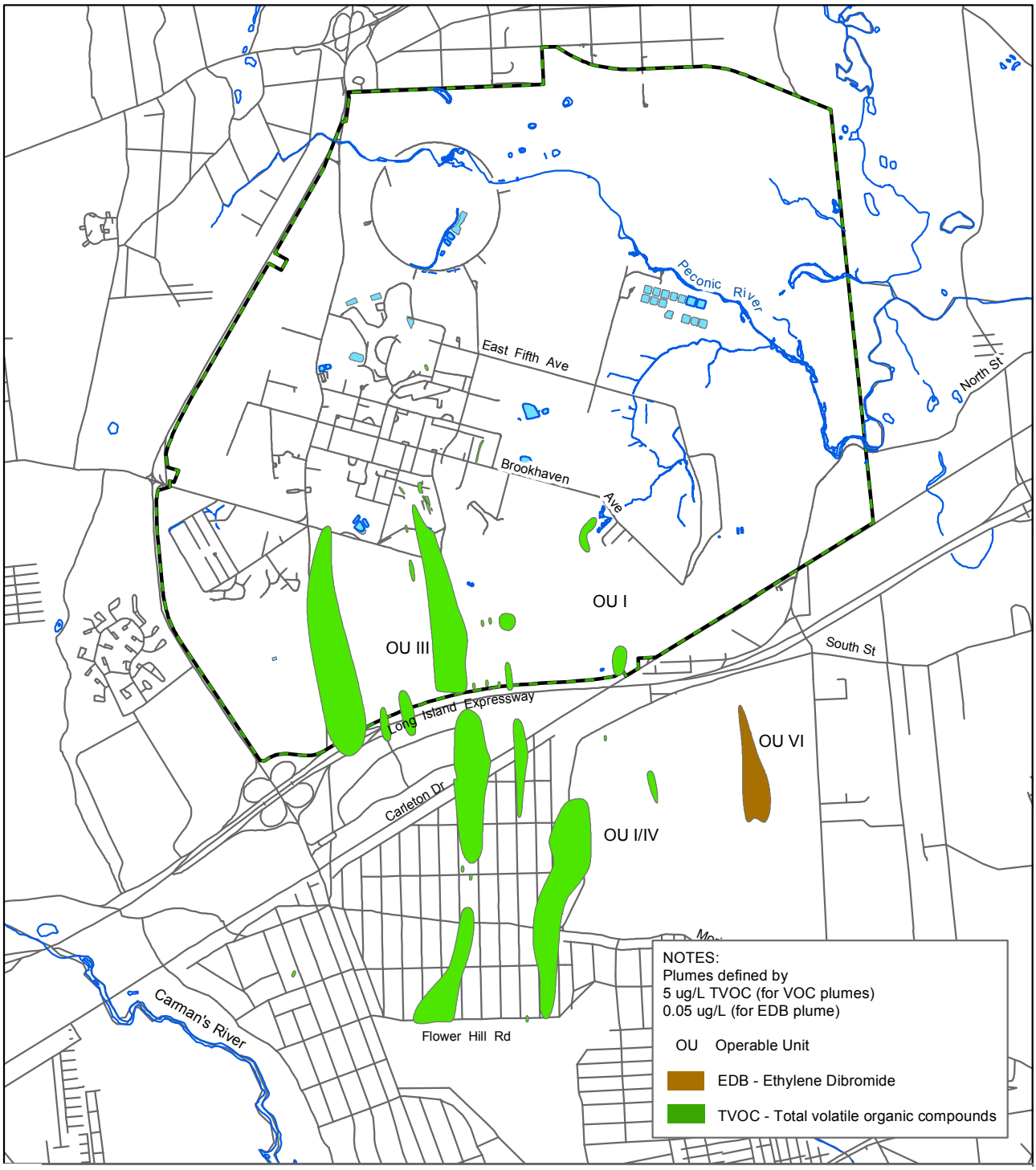

Figure 7-2. Extent of VOC Plumes.

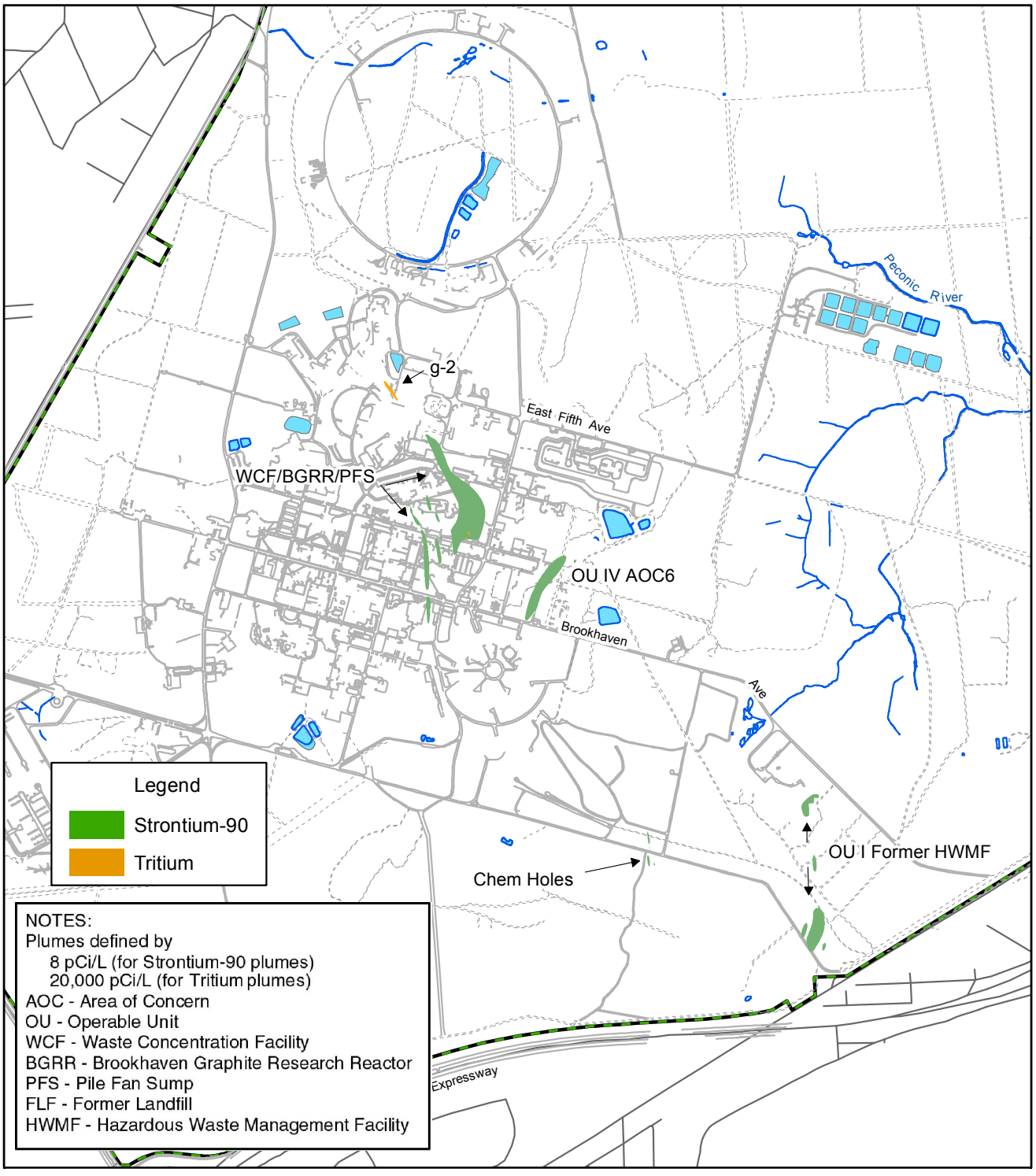

Figure 7-3. Extent of Radionuclide Plumes.

deep zone of VOC contamination, with total VOC concentrations up to 268 µg/L. Because this deeper zone of contamination cannot be effectively remediated using the existing Industrial Park Treatment System, two deeper extraction wells were installed during 2014. The new extraction wells will begin operating in January 2015.

- 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 less than 200 µg/L in late 2014.
- During 2012 through 2014, approximately 96 pounds of Freon-11 were removed from the aquifer, and significant reductions in Freon-11 concentrations were observed in the Building 452 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 in 2011, to less than 77 µg/L in late 2014.
- 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. During 2014, Sr-90 levels decreased to less than 5 pCi/L. It is believed that the short-term increase observed during 2013 was 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 is designed to prevent rainwater infiltration into the contaminated soils immediately below the BGRR.
- During 2014, tritium concentrations in the groundwater immediately downgradient of the HFBR continued to exceed the 20,000 pCi/L DWS in several wells, with a maximum concentration of 31,200 pCi/L.
- 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 37,100 pCi/L. Natural radioactive decay and dispersion has reduced tritium concentrations in the downgradient portion of the g-2 tritium plume. In early 2014, remnants of the plume were detected near the National Synchrotron Light Source II facility, with tritium concentrations up to 31,400 pCi/L. Tritium concentrations were less than 20,000 pCi/L in temporary wells installed in January 2015.

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 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 2014, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 12 groundwater treatment systems currently in operation. Table 7-1 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 2014, approximately 143 pounds of VOCs and nearly 1.2 mCi of Sr-90 were removed from the groundwater, and nearly 1.3 billion gallons of treated groundwater were returned to the aquifer.

To date, 7,276 pounds of VOCs have been removed from the aquifer and noticeable

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2014.

Remediation System	Start Date	1997-2013		2014	
		Water Treated (Gallons)	VOCs Removed (Pounds) (e)	Water Treated (Gallons)	VOCs Removed (Pounds) (e)
OU I South Boundary (a)	12/1996	4,177,473,000	369	0	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	0	0
OU III South Boundary	06/1997	4,383,751,850	2,956	266,919,000	33
OU III Industrial Park	09/1999	1,976,798,330	1,061	68,114,000	2
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	379,407,416	127	39,196,000	7
OU III Middle Road	10/2001	2,547,348,550	1,082	249,371,000	58
OU III Western South Boundary	09/2002	1,276,784,000	116	99,745,000	6
OU III Industrial Park East (e)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street	06/2004	1,503,117,000	329	44,063,000	4
OU III North Street East	06/2004	955,558,000	43	53,000,000	1
OU III LIPA/Airport	08/2004	2,261,529,000	363	231,287,000	24
OU III Building 452 Freon-11	03/2012	58,312,000	88	37,484,000	8
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	1,410,664,000	(g)	176,502,000	(g)
Total		**22,163,268,221**	**7,133**	**1,265,681,000**	**143**

Remediation System	Start Date	2003–2013		2014	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	51,335,826	4.69	4,402,000	0.09
OU III BGRR/WCF Sr-90	06/2005	79,082,000	24.02	8,750,000	1.1
Total		**130,417,826**	**28.71**	**13,152,000**	**1.19**

Notes:
(a) System placed in standby mode in 2013.
(b) System 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 decommissioned in 2010.
(e) System decommissioned in 2013.
(f) Values are rounded to the nearest whole number.
(g) 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

improvements in groundwater quality are evident in a number of on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 30 mCi of Sr-90.

During 2014, BNL received regulatory agency approval to shut down the North Street East Treatment System. The North Street East System, along with the OU I South Boundary Treatment System, OU III Industrial Park Treatment System, and the HFBR Tritium Pump and Recharge System which were shut down earlier, met their active remediation goals for reduction of

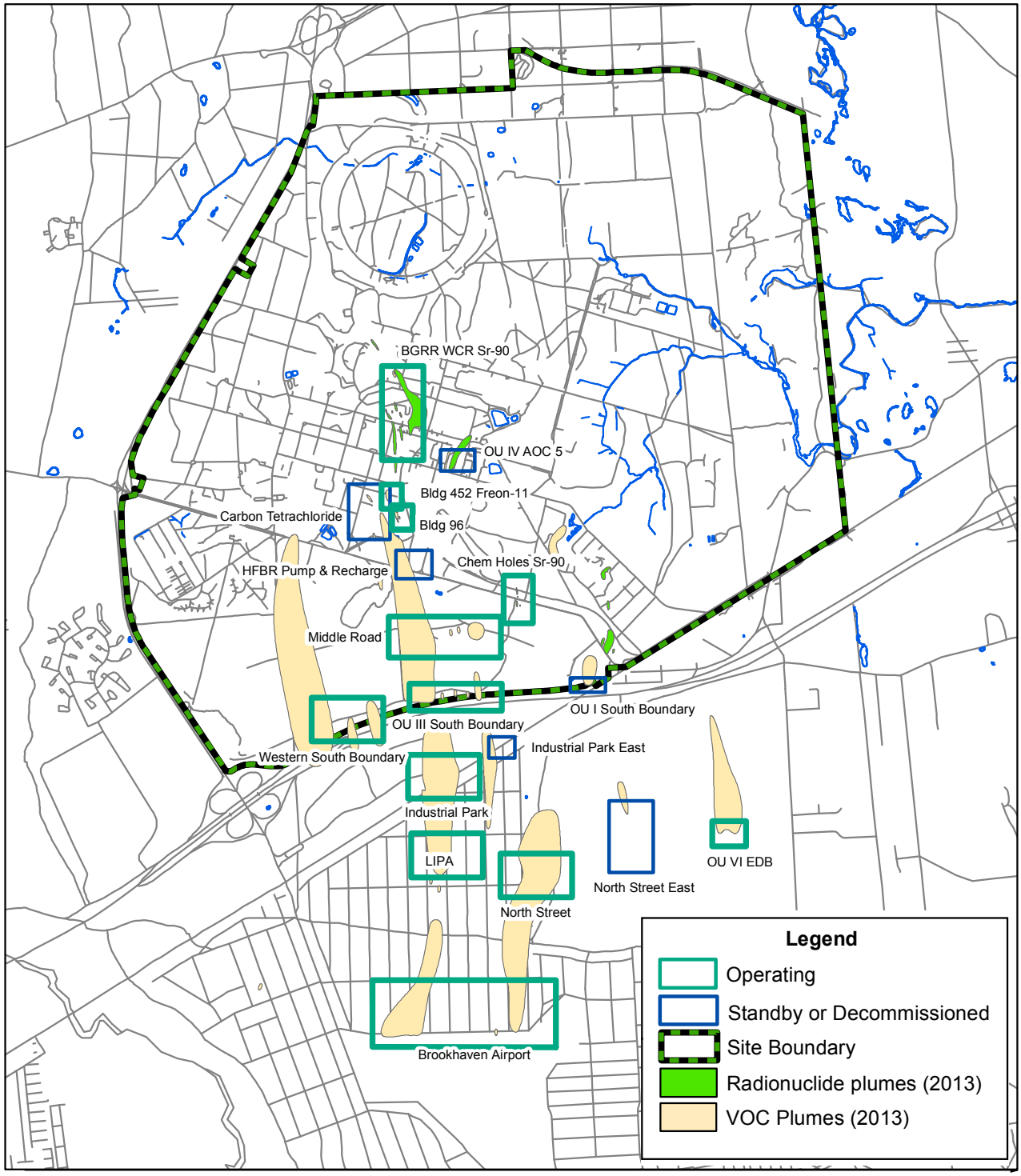

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

contaminant concentrations. A period of standby monitoring for the plumes associated with these treatment systems will be performed to detect any rebound of contaminant concentrations. Detailed information on the groundwater contaminant plumes and treatment systems can be found in SER Volume II, Groundwater Status Report.

REFERENCES AND BIBLIOGRAPHY

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