

# Groundwater Protection

Brookhaven National Laboratory (BNL) implements aggressive pollution prevention measures to protect groundwater resources and uses an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. During 2021, BNL collected groundwater samples from 580 permanent monitoring wells and 70 temporary wells. Seven groundwater remediation systems removed 58 pounds of volatile organic compounds (VOCs) and returned approximately one 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 7,758 pounds of VOCs by treating almost 30 billion gallons of groundwater. Also, one groundwater treatment system removed approximately 0.3 millicurie of strontium-90 (Sr-90) while remediating approximately 14 million gallons of groundwater. Since 2003, BNL has removed approximately 34 millicuries of Sr-90 from the groundwater while remediating approximately 274 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have occurred in 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 remediation 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, Department of Energy (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 remediating existing contaminated groundwater.

### 7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented several 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 remediation 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 Remediation

BNL was added to the National Priorities List in 1989. To help manage the restoration effort, 34 separate Areas of Concern are grouped into ten 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 the Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), and DOE.

### 7.1.4 Communication

BNL's Stakeholder & 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. Several 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 2018) 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 30 years and continues to make progress in achieving its goal of preventing new impacts to groundwater quality and remediating previously contaminated groundwater. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance. During 2017, several Per- and Poly-fluoroalkyl Substances (PFAS) were detected in water samples collected from three BNL water supply wells. In response to these detections, in 2018 BNL conducted a search of available records to determine the source of the PFAS. As a result, BNL identified eight areas where firefighting foam had been used for firefighter training or fire suppression system maintenance from 1966 through 2008. Groundwater

characterization conducted in 2018 and 2019 confirmed the presence of PFAS in each of the eight areas. During 2021, BNL identified a ninth PFAS source area near dormitory Building 170, which had been used for firefighter training. In all nine foam release areas, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) concentrations were found to exceed the 10 ng/L drinking water standards that were adopted for these chemicals by New York State in August 2020. The highest PFAS concentrations in groundwater are associated with firefighter training that occurred at the former firehouse (in operation from 1947-1985), the current firehouse, and the Building 170 areas. At the former firehouse area, the maximum PFOS and PFOA concentrations detected to date in the groundwater were 5,210 ng/L and 1,400 ng/L, respectively. At the current firehouse area, the maximum PFOS and PFOA concentrations detected to date were 12,440 ng/L and 602 ng/L, respectively. And near the Building 170 source area, the maximum PFOS and PFOA concentrations detected were 8,470 ng/L and 66 ng/L, respectively. During 2021, BNL began the construction of two groundwater treatment systems that will be used to remediate these high concentration PFAS plumes. It is anticipated that construction of the treatment systems will be completed by Fall 2022. In addition to PFAS, BNL has been characterizing the extent of 1,4-dioxane contamination in groundwater. It was used as a chemical stabilizer for the solvent 1,1,1-trichloroethane (TCA). BNL has confirmed the presence of 1,4-dioxane in several on-site and off-site areas that have been impacted by TCA contamination, with a maximum concentration of 23.9 µg/L in a Western South Boundary area monitoring well. In August 2020, New York State adopted a drinking water standard for 1,4-dioxane of 1.0 µg/L.

### 7.3 GROUNDWATER MONITORING PROGRAMS

Elements of the groundwater monitoring program include installing permanent and temporary 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, comply with regulatory permit requirements, monitor active research and support facilities, and 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 for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and non-radiological contamination by comparing analytical results to the regulatory 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 VOCs or radionuclides may provide important early indications of a contaminant release and allow for timely identification and remediation of the source.

BNL maintains an extensive network of groundwater monitoring wells that are located on- and off-site. Water levels are routinely measured in about 185 of the wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions near the Laboratory are shown in Figure 7-1.

The Laboratory also routinely collects groundwater samples from over 600 wells to test for various contaminants that may be in the water (see SER Volume II, Groundwater Status Report, for details).

The following active BNL facilities have groundwater monitoring programs: Sewage Treatment Plant (STP), Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Brookhaven Linac Isotope Producer (BLIP), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), and several vehicle maintenance and petroleum storage facilities. Inactive and remediated facilities are also monitored, including the

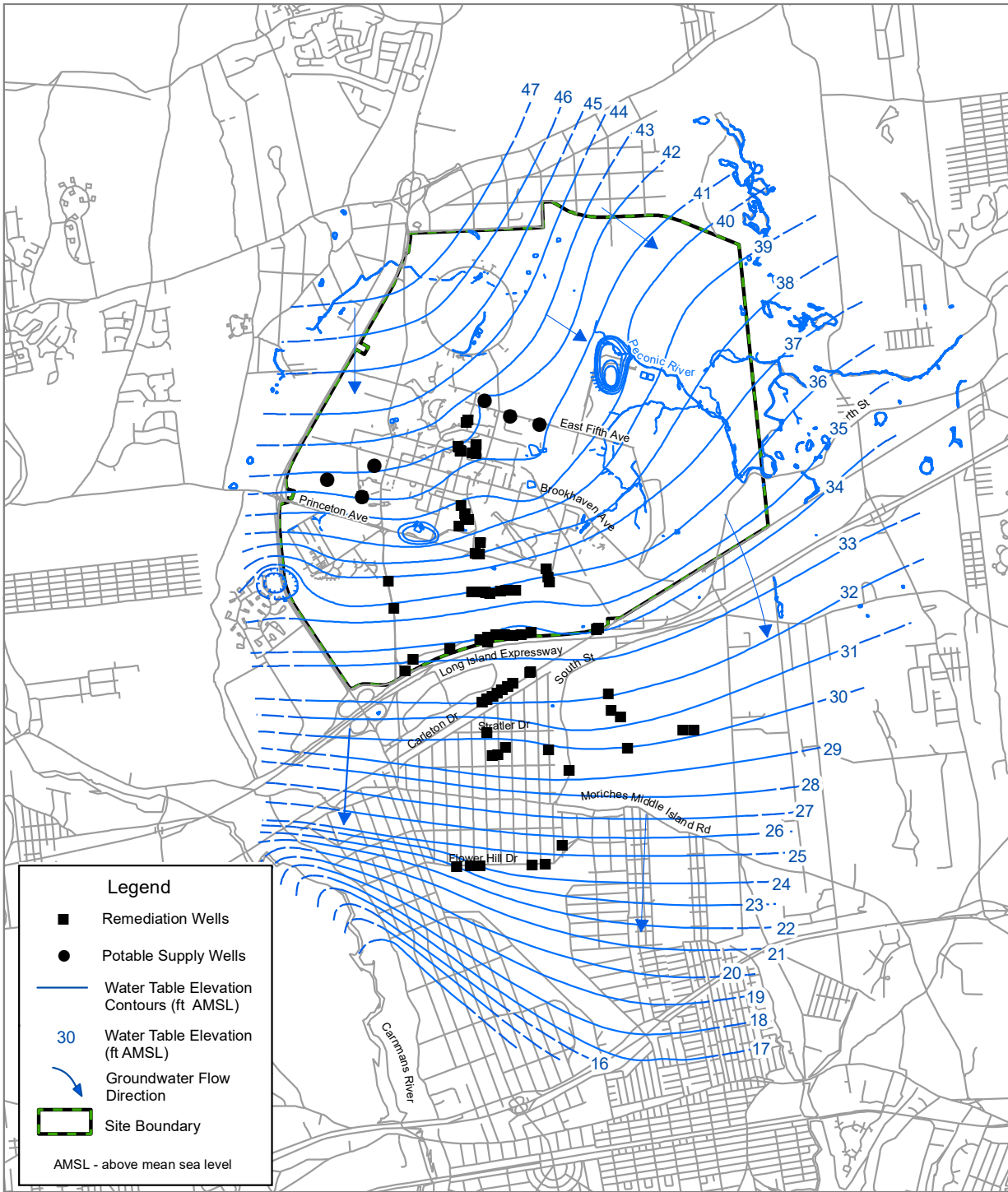
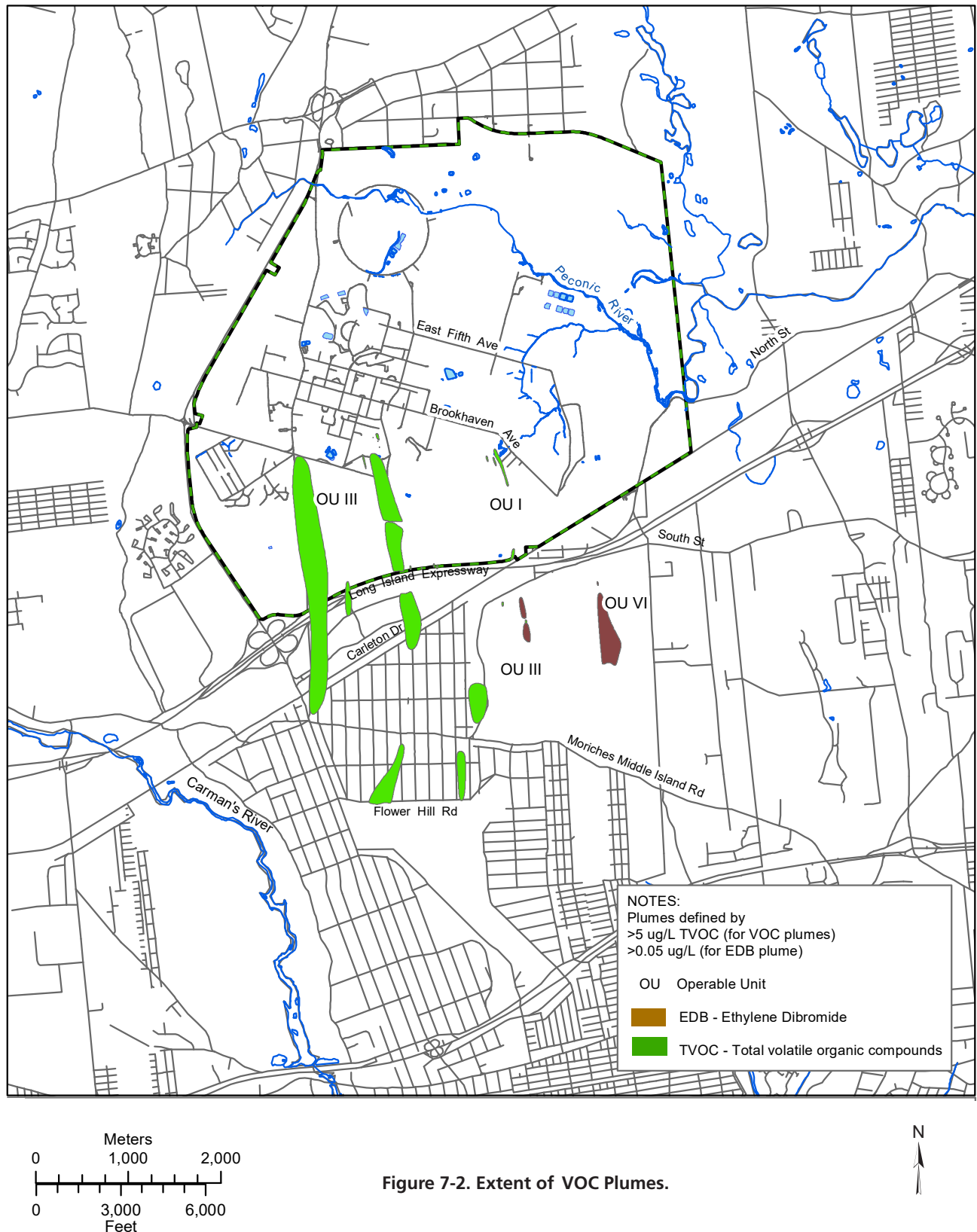
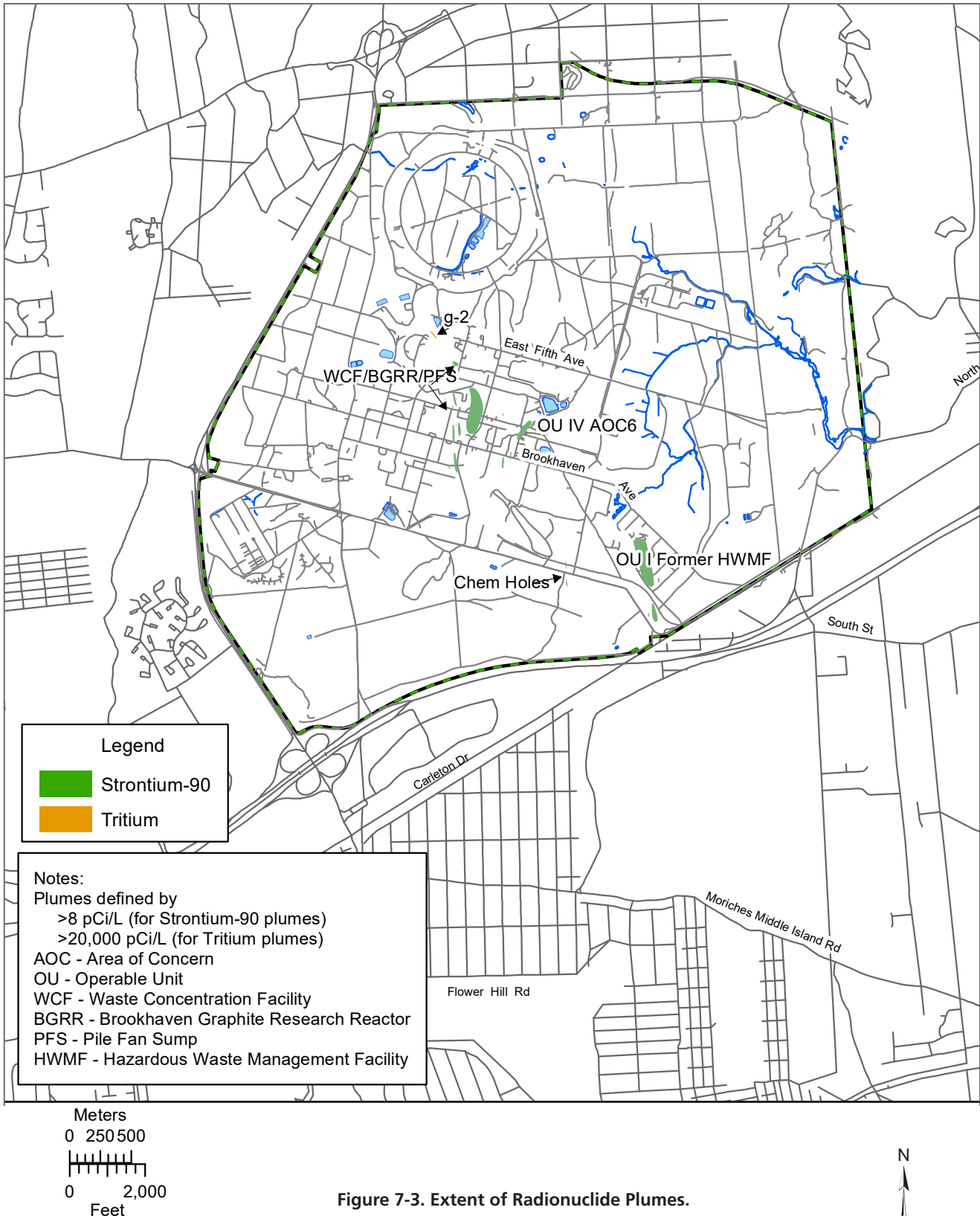


Figure 7-1. Groundwater Flow and Water Table Elevation (January 2021) with Supply and Remediation Wells Shown.







former Hazardous Waste Management Facility (HWMF), two former landfill areas, former Waste Concentration Facility (WCF) area, 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 2021, the Facility Monitoring program monitored 89 permanent wells during 117 individual sampling events. The CERCLA groundwater monitoring program monitored 491 permanent wells during 1,805 individual groundwater sampling events. Seventy temporary wells were also installed as part of the CERCLA program, most of which were installed for the characterization of the PFAS plume and ongoing monitoring of several Sr-90 plumes. 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 2021 include the following:

- Monitoring conducted at BNL's major research facilities (e.g., AGS, RHIC, NSLS-II, and BLIP) and most support facilities (e.g., WMF, MPF, and the site vehicle maintenance facility) did not identify any new impacts to groundwater quality resulting from current operations. However, during 2021, the corrosion inhibitor tolyltriazole (TTA) was detected in the groundwater downgradient of the STP recharge basins at concentrations up to 1.53 mg/L, which exceeded the NYS AWQS of 0.05 mg/L. Tolyltriazole was also detected at concentrations above the NYS AWQS in the groundwater downgradient of recharge basin HN at concentrations up to 0.67 mg/L.
- Temporary vertical profile wells were installed in 2021 for the OU III Middle Road and South Boundary VOC contamination and the Operable Unit VI ethylene dibromide (EDB) contamination. The 2021 CERCLA Five-Year Review indicated the need for the installation of additional groundwater extraction wells to meet the ROD cleanup goal of achieving maximum contamination levels (MCLs) by

2030. The temporary well data will be used in the pre-design groundwater modeling for modification of those remediation systems.

- Following the significant increase in Sr-90 concentrations to 1,170 pCi/L observed during 2019 in BGRR source area monitoring wells, Sr-90 concentrations decreased significantly during 2020, and were less than 5 pCi/L by early 2021. The variations in Sr-90 concentrations appear to be related to seasonal changes in the position of the water table, with higher concentrations observed following significant rises in the water table (such as in 2019) when residual Sr-90 present in the deep vadose zone soils can be leached into the groundwater.
- During 2021, BNL identified a ninth PFAS source area west of dormitory Building 170 where firefighter training apparently took place from 1986 through the early 1990s. The highest PFAs concentrations were identified in the area immediately downgradient of the training area, with maximum PFOS and PFOA concentrations of 8,470 ng/L and 66 ng/L, respectively. The plume was tracked from the former training area approximately 1,600 feet downgradient.
- Temporary and permanent wells were used to characterize PFAS in the southwest portion of the BNL site that is within the source water contributing area of the Suffolk County Water Authority's William Floyd Well Field. Low levels of PFOS and PFOA were detected in several of the wells, with maximum concentrations of 13 ng/L and 9.8 ng/L, respectively.

Detailed groundwater monitoring results including plume maps, hydrogeological cross sections, and trend charts are presented in Volume 2 of the 2021 Site Environmental Report.

#### 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

**Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2021.**

Remediation System	Start Date	1997-2020		2021	
		Water Treated (Gallons)	VOCs Removed (Pounds) (f)	Water Treated (Gallons)	VOCs Removed (Pounds) (f)
OU I South Boundary (a)	12/1996	4,177,473,000	396	Shutdown	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	Shutdown	0
OU III South Boundary	06/1997	5,284,151,000	3,061	92,000,000	9
OU III Industrial Park	09/1999	2,577,662,000	1,077	Shutdown	0
OU III Carbon Tetrachloride (d)	10/1999	153,538,000	349	Decommissioned	0
OU III Building 96	01/2001	558,697,000	145	30,000,000	1
OU III Middle Road	10/2001	3,776,547,000	1,310	165,000,000	22
OU III Western South Boundary	09/2002	2,078,855,000	165	210,000,000	16
OU III Industrial Park East (e)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street (j)	06/2004	1,680,942,000	342	Shutdown	0
OU III North Street East (h)	06/2004	1,044,798,000	45	107,000,000	2
OU III LIPA/Airport	08/2004	3,741,145,000	487	236,000,000	8
OU III Building 452 Freon-11 (i)	03/2012	124,997,000	106	Shutdown	0
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	2,498,057,000	(g)	159,000,000	(g)
<b>Total</b>		<b>28,765,549,000</b>	<b>7,700</b>	<b>999,000,000</b>	<b>58</b>

Remediation System	Start Date	2003–2020		2021	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	65,663,000	4.94	Shutdown	0
OU III BGRR/WCF Sr-90	06/2005	194,603,000	29.1	14,000,000	0.3
<b>Total</b>		<b>260,266,000</b>	<b>34.04</b>	<b>14,000,000</b>	<b>0.3</b>

**Notes:**

- (a) System placed in standby mode in 2013. Approved for closure in 2019.  
 (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 2014.  
 (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.  
 (h) North Street East system was restarted in July 2020 for treatment of EDB plume.

- (i) System placed in standby mode in March 2017. Approved for closure in 2019.  
 (j) System placed in standby mode in August 2016.  
 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

of active treatment and natural attenuation: The specific cleanup goals are as follows:

- Achieve 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 2021, BNL continued to make significant progress in restoring groundwater quality.



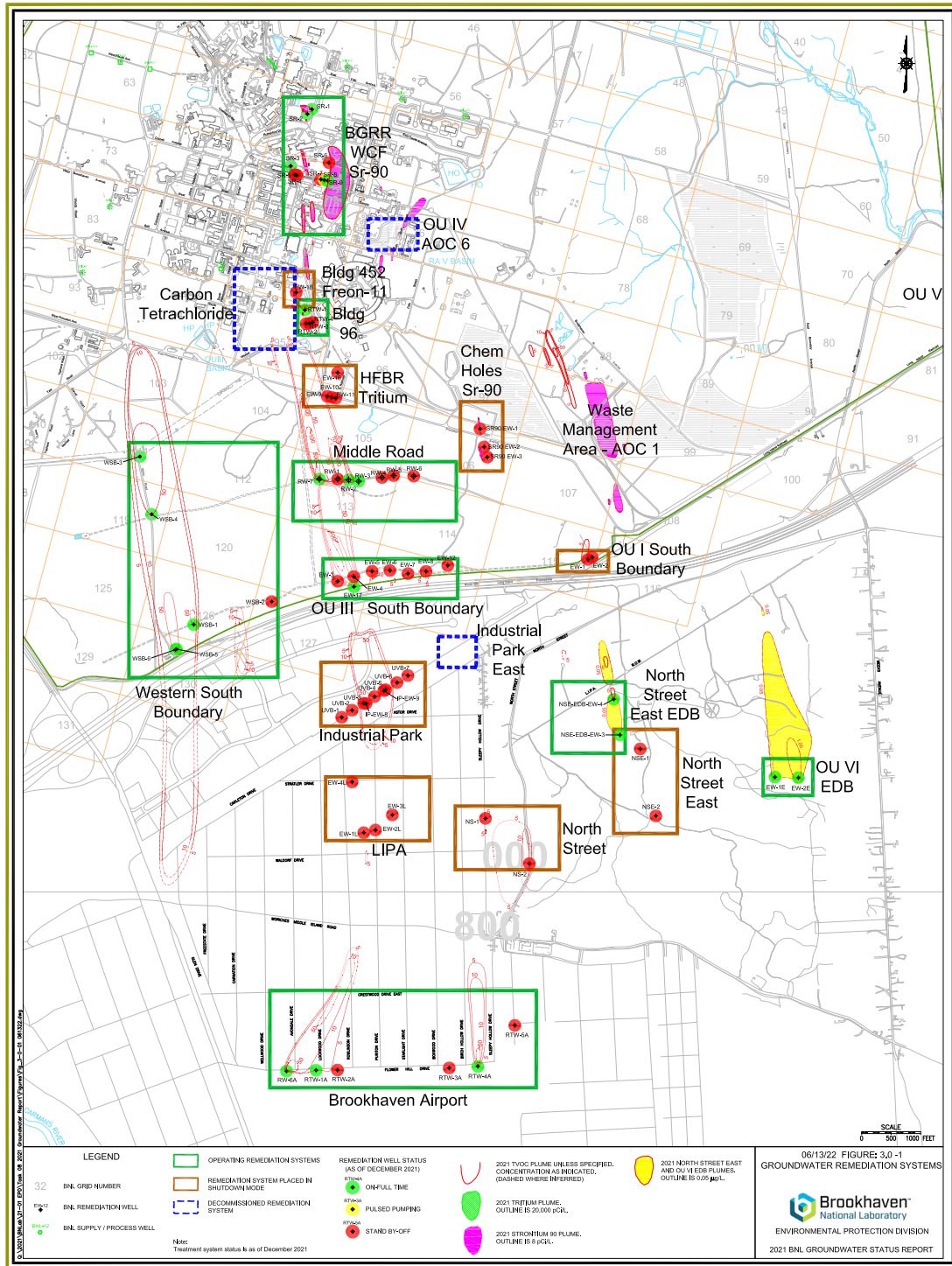


Figure 7-4. Locations of BNL Groundwater Remediation Systems.

## CHAPTER 7: GROUNDWATER PROTECTION

Figure 7-4 shows the locations of eight groundwater treatment systems currently in operation. Table 7-1 provides a summary of the amounts of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2021, approximately 58 pounds of VOCs and 0.3 mCi of Sr-90 were removed from the groundwater and nearly one billion gallons of treated groundwater were returned to the aquifer. To date, 7,758 pounds of VOCs have been removed from the aquifer and noticeable improvements in groundwater quality are evident

in several on and off-site areas. Furthermore, two of the treatment systems have removed approximately 34.3 mCi of Sr-90. Detailed information on the groundwater contaminant plumes and treatment systems can be found in SER Volume II, Groundwater Status Report.

### REFERENCES AND BIBLIOGRAPHY

BNL 2018. Groundwater Protection Contingency Plan – Response to Unexpected Monitoring Results. Environmental Monitoring Procedure EM-SOP-309. Brookhaven National Laboratory, Upton, NY. August 2018.