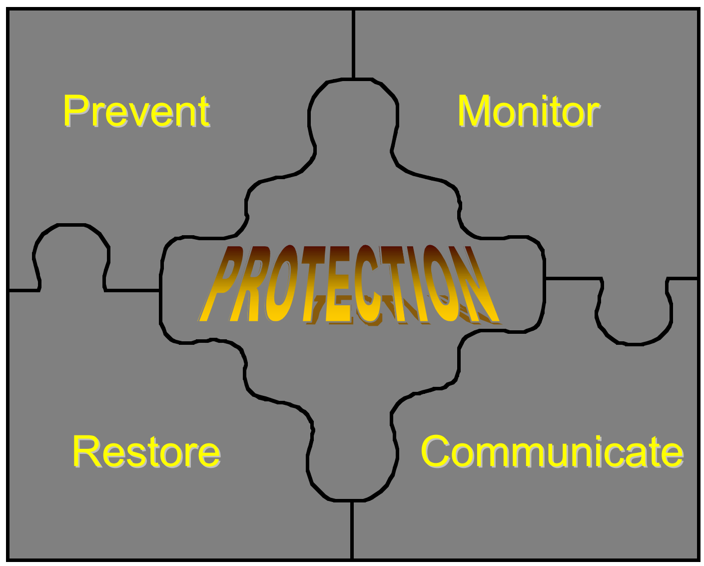
Groundwater Protection

CHAPTER 8

The Brookhaven National Laboratory (BNL) Groundwater Protection Program is made up of four elements: prevention, monitoring, restoration, and communication. In addition to implementing aggressive pollution prevention measures to protect groundwater resources, BNL has established an extensive groundwater monitoring well network to verify that prevention and restoration activities are effective. In 1998, BNL collected groundwater samples from 470 monitoring wells during 1,750 individual sampling events. Six significant volatile organic compound (VOC) plumes and six radionuclide plumes were tracked and evaluated. During 1998, four onsite groundwater remediation systems removed approximately 490 pounds of VOCs and returned approximately 2,800 million liters (740 million gallons) of treated water to the Upper Glacial aquifer.

The DOE Order 5400.1, “General Environmental Protection Program” requires development and implementation of a groundwater protection program. The primary goal of the BNL Groundwater Protection Management Program (GPMP) is to ensure that plans for groundwater protection, management, monitoring and restoration are fully defined, integrated and managed in a cost-effective manner that is consistent with federal, state and local regulations. The BNL GPMP includes policy, strategy, requirements and regulations applicable to groundwater protection (Paquette et al., 1998). As shown in the groundwater protection puzzle in center, the BNL GPMP consists of four interconnecting elements:
1) prevention,
2) monitoring,
3) restoration, and
4) communication.



BNL’s Groundwater Protection Program

Prevention: BNL has initiated a three-phased project to: 1) identify past or current activities with the potential to affect environmental quality; 2) conduct a BNL-wide review of all experiments and industrial-type operations to determine the potential impacts of those activities on the environment and to integrate pollution prevention/waste minimization, resource conservation, and compliance into planning, decision-making and implementation; and 3) develop and implement an Environmental Management System (EMS). These activities are designed to prevent further pollution of the sole source aquifer underlying the BNL site, and are described in Chapter 2. In addition, as described in Chapter 3, efforts are being made to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater. Examples include upgrading underground storage tanks, closing cesspools, adding engineering controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (i.e., reducing the toxicity and volume of chemicals in storage or use).

Monitoring: BNL has an extensive groundwater monitoring network designed to evaluate groundwater contamination from historical and active operations. Groundwater monitoring is being conducted under two programs - the Environmental Monitoring Program designed to satisfy DOE and New York State (NYS) monitoring requirements for active research and support facilities, and the Environmental Restoration (ER) Program for monitoring related to BNL’s obligations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These programs are coordinated to ensure completeness and to prevent any duplication of effort in the installation and abandonment of wells, and the sampling and analysis of groundwater. Furthermore, Data Quality Objectives (DQOs), plans and procedures, sampling and analysis, quality assurance, data management, and well installation, maintenance and abandonment programs are being integrated to optimize the groundwater monitoring system, and to ensure that water quality data are available for review and interpretation in a timely manner. In 1998, there were no major changes to BNL’s groundwater monitoring program in terms of number of wells sampled, frequency of sampling or analytes tested for.

Restoration: BNL was added to the National Priorities List in 1989 (see Chapter 2 for discussion of the BNL’s ER Program). Twenty-nine Areas of Concern (AOC) have been grouped into six Operable Units (OU). Remedial Investigation/Feasibility Studies (RI/FS) have been conducted for each OU. A primary goal of the

ER program is remediating soil and groundwater contamination, and preventing additional groundwater contamination from migration offsite. To that end, contaminant sources (e.g., contaminated soil, underground tanks) are being removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the Interagency Agreement (IAG) among the United States Environmental Protection Agency (USEPA), New York State Department of Environmental Conservation (NYSDEC) and DOE.

Communication: BNL has a community involvement, government and public affairs program to ensure that BNL communicates with the community in a consistent, timely and accurate manner. The majority of communications regarding groundwater protection have been associated with the ER Program. A number of communication mechanisms are in place, such as web pages, mailings, public meetings, briefings and roundtables.

8.1 GROUNDWATER MONITORING

Groundwater monitoring is an integral part of BNL's GPMP. Groundwater monitoring program elements include: installing monitoring wells; planning and scheduling; quality assurance; sample collection; sample analysis; data verification, validation and interpretation; and reporting. Monitoring wells are generally used to monitor specific facilities where degradation of the groundwater is known or suspected to have occurred, to fulfill regulatory permit requirements, to assess the quality of groundwater entering or leaving the BNL site, and to ensure that corrective measures designed to protect and restore groundwater are, in fact, working.

The groundwater beneath the BNL site is considered by NYS as Class GA groundwater. Class GA groundwater is defined as a source of potable water supply and suitable for drinking. As such, federal drinking water standards, NYS Drinking Water Standards (NYS DWS), and NYS Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater have been used as groundwater protection and remediation goals. The BNL groundwater surveillance program uses monitoring wells (which are not utilized for drinking water supply) to monitor research and support facilities where there is a potential for environmental impact, and areas where past waste handling practices or accidental spills have already degraded groundwater quality. BNL evaluates the potential impact of radiological and non-radiological levels of contamination by comparing analytical results to NYS and DOE reference levels and background water quality levels. Non-radiological analytical results from groundwater samples collected from surveillance wells are usually compared to NYSDEC AWQS. Radiological data are compared to NYS DWS (for tritium, gross beta, and strontium-90), NYS AWQS (for gross alpha and radium-226/228), and Safe Drinking Water Act (SDWA)/DOE Derived Concentration Guides (DCGs) (for determining the 4 mrem/dose for other beta/gamma-emitting radionuclides). Contaminant concentrations that are below these 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 the timely investigation into the identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 420 onsite and 50 offsite surveillance wells (Figure 8-1). Active and inactive facilities that have groundwater monitoring programs include the following: the Sewage Treatment Plant/Peconic River Area, Biology Agricultural Fields, Former Hazardous Waste Management Facility (HWMF), New Waste Management Facility (WMF), two former landfill areas, Central Steam Facility/Major Petroleum Facility (CSF/MPF), Alternating Gradient Synchrotron (AGS), Waste Concentration Facility (WCF), Supply and Materiel, and several other smaller facilities. As the result of detailed groundwater investigations conducted over the past fifteen years, as many as six significant VOC plumes and six radionuclide plumes have been identified (Figures 8-2 and 8-3). Groundwater quality is also routinely monitored at all active potable supply wells and process supply wells. In addition to groundwater quality assessments, water levels are routinely measured in over 650 onsite and offsite wells to assess variations in directions and velocities of groundwater flow.

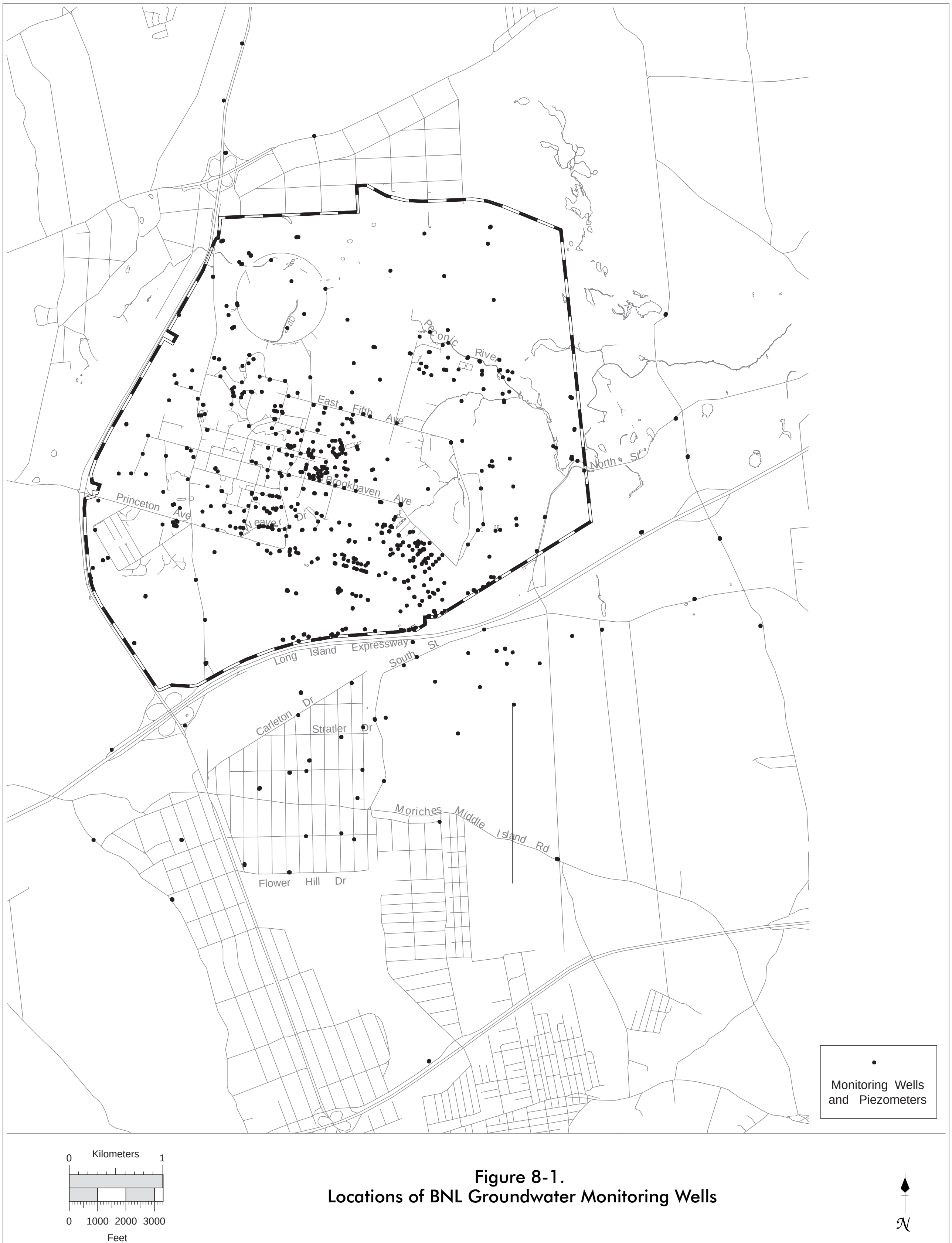


Figure 8-1.
Locations of BNL Groundwater Monitoring Wells

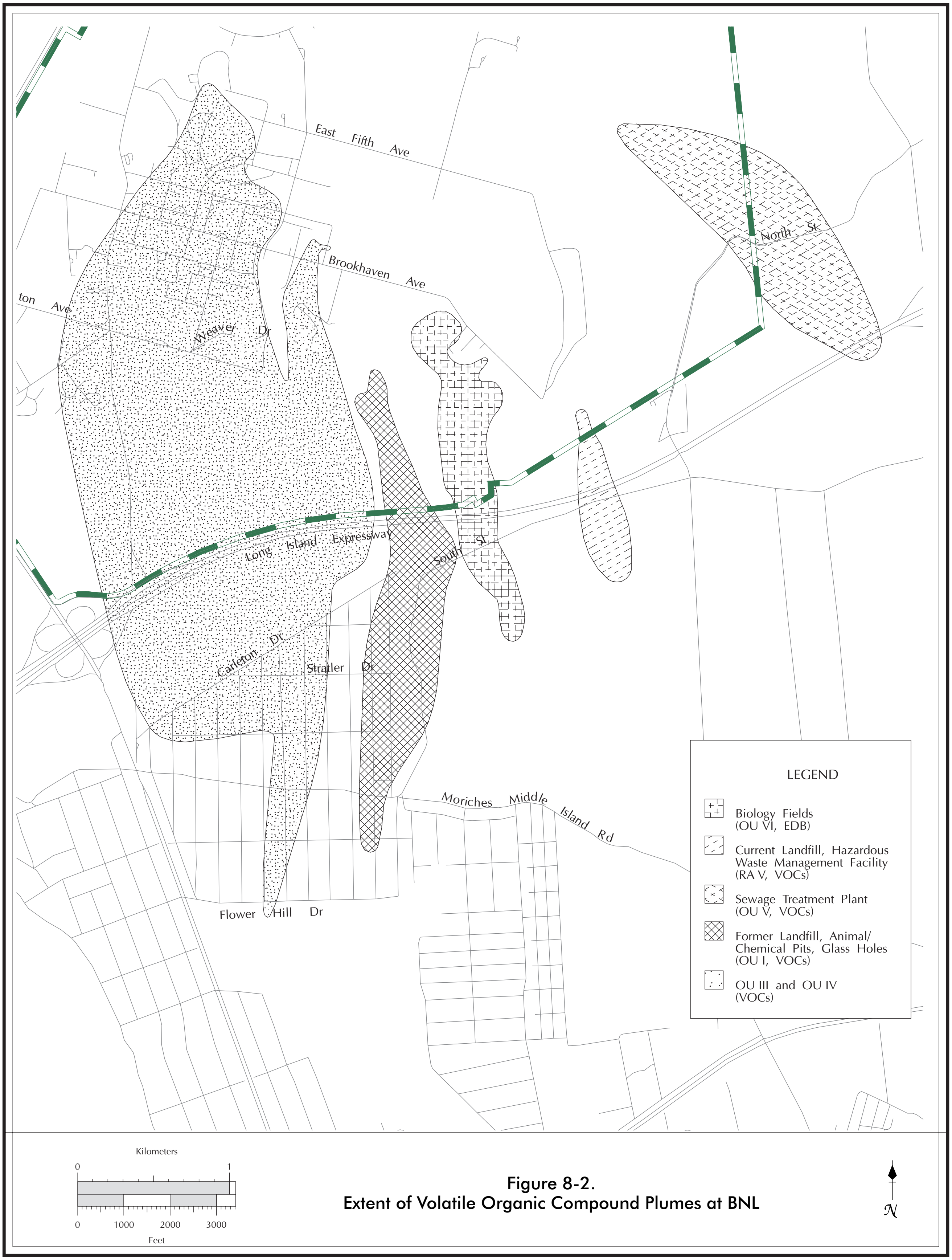


Figure 8-2.
Extent of Volatile Organic Compound Plumes at BNL

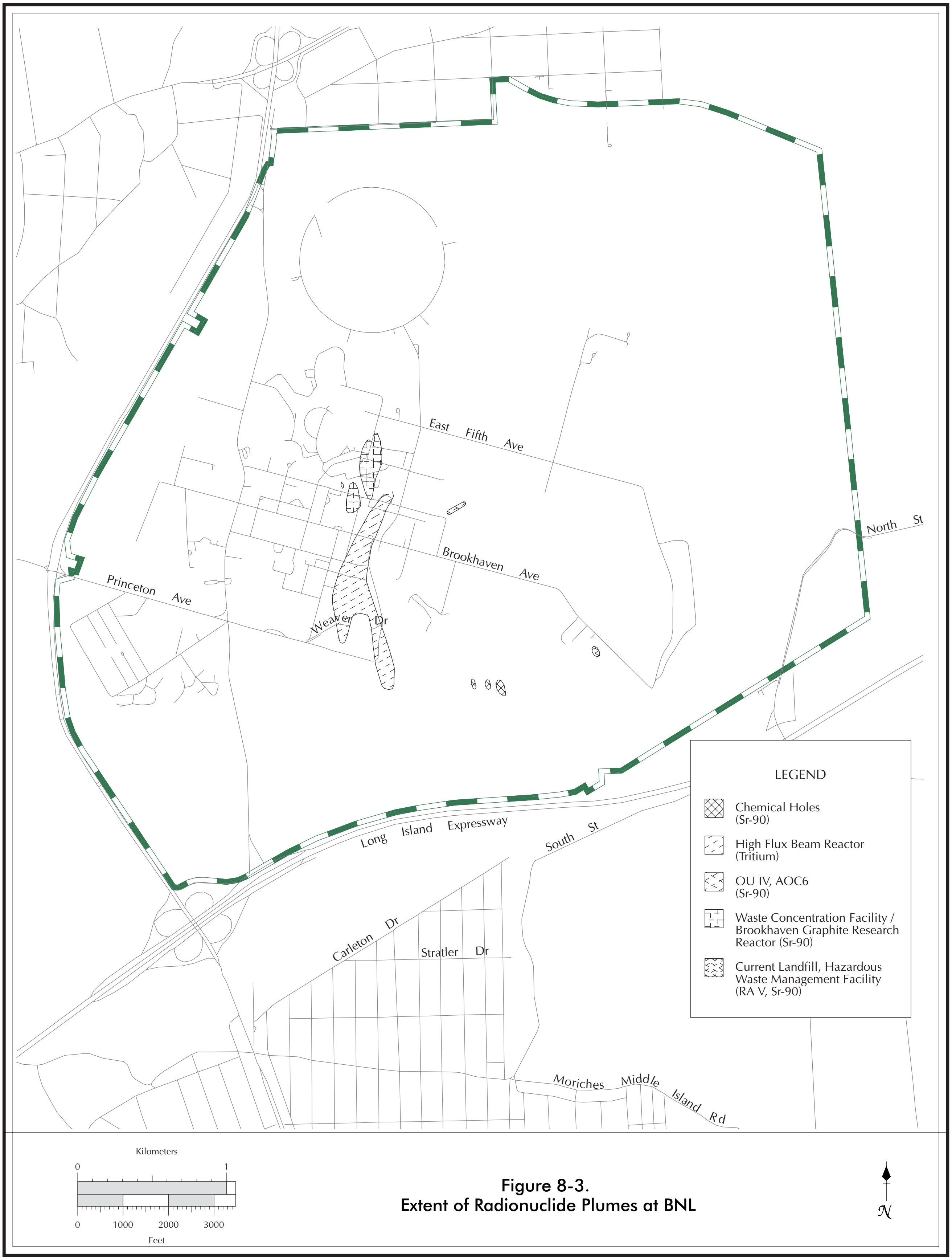


Figure 8-3.
Extent of Radionuclide Plumes at BNL

8.1.1 POTABLE AND PROCESS SUPPLY WELLS (SUPPLEMENTAL MONITORING PROGRAM)

Because of the proximity of BNL's potable supply wells to known or suspected groundwater contamination plumes and source areas, BNL conducts a supplemental potable supply well monitoring program that exceeds the monitoring required by the SDWA described in Chapter 3. This program also evaluates the quality of water obtained from process supply wells that is used to provide water for non-potable uses (secondary cooling water and biological experiments). Well water samples are typically collected quarterly and analyzed by the onsite Analytical Services Laboratory (ASL). Samples are usually analyzed for radionuclides (gross alpha, gross beta, gamma and tritium), VOCs (consisting of the primary volatile halogenated aliphatic hydrocarbons and aromatic hydrocarbons), inorganics (i.e., metals), and water quality parameters (nitrate, chlorides, and sulfates). These samples serve both as a quality control on contractor laboratory analyses of compliance samples (described in Chapter 3), and as an additional source of data used in evaluating groundwater quality.

The BNL supply well network consists of six potable supply wells (Wells 4, 6, 7, 10, 11, and 12) and five secondary cooling/process water supply wells (Wells 9, 101, 102, 103, and 105). All supply wells are screened entirely within the Upper Glacial aquifer (Figure 8-4). In 1998 Well 102 provided the secondary cooling water at the AGS, and Well 9 supplied process water to a facility where biological research is conducted with fish. Secondary-cooling water for the Brookhaven Medical Research Reactor (BMRR) was supplied exclusively from Well 105. Wells 101 and 103 were not operational during 1998, because Well 102 provided sufficient cooling water supply for AGS operations.

In 1998, samples were obtained quarterly from Potable Wells 10, 11 and 12 and analyzed for radioactivity, water quality indices, metals, and VOCs. Wells 4, 6, and 7 were sampled for field parameters, VOCs and radiological parameters. Wells 4, 6 and 7 were not sampled for water quality or metals under the surveillance program. Regulatory compliance samples were collected and analyzed in accordance with the BNL Potable Water System Sampling Plan. The results of the regulatory compliance samples were discussed in Chapter 3.

Process Supply Wells 9, 102, and 105 were analyzed for water quality, and inorganic and organic contaminants. Water chemistry analyses (e.g., pH and conductivity) were also performed for Well 102 by the AGS facility operators, as needed, to meet their operational requirements.

8.1.1.1 NON-RADIOLOGICAL ANALYSES

Tables 8-1 and 8-2 summarize the 1998 water quality and metals data for the BNL potable and process supply wells. The water quality data show that nitrates, sulfates, and chlorides are well within the limits established in the NYS DWS (Part 5 NYS Sanitary Code). The pH values in these wells ranged from 5.9 - 7.1 SU, and are typical of natural Long Island groundwater. (Note: The natural pH of groundwater at BNL has been found to range from 4.5 to 8.1 SU.) To reduce the corrosivity of the groundwater, Wells 10, 11, and 12 are equipped with metering pumps, which add sodium hydroxide to maintain the pH of the potable water effluent at approximately 8. The Water Treatment Plant (WTP) water softening process uses lime (calcium hydroxide) to reduce the corrosivity of the water obtained from Wells 4, 6 and 7.

Water samples were tested for nineteen inorganic parameters. Table 8-2 summarizes only those elements detected in one or more samples. Arsenic, beryllium, cadmium, mercury, thallium and selenium were not detected in any of the process or potable water supply wells in 1998. Lead, nickel, and manganese were not detected in any of the potable water supply wells. Aluminum, barium, cobalt, copper, iron, sodium, and zinc were detected in all potable wells at levels far below their respective NYS DWS. With the exception of well 105, the concentrations of inorganic elements in process supply wells, except iron, were within all drinking water standards. Naturally occurring iron is present in all wells located within the western sectors (e.g., Process Wells 102 and 105). In the case of potable wells, the ambient iron is removed at the WTP prior to site distribution. For the process wells, an iron sequestrant (a chemical which prevents the iron from precipitating from solution) is added.

Process Well 105 was sampled twice in 1998, in March and June. The concentrations of lead, iron and zinc in the sample collected in

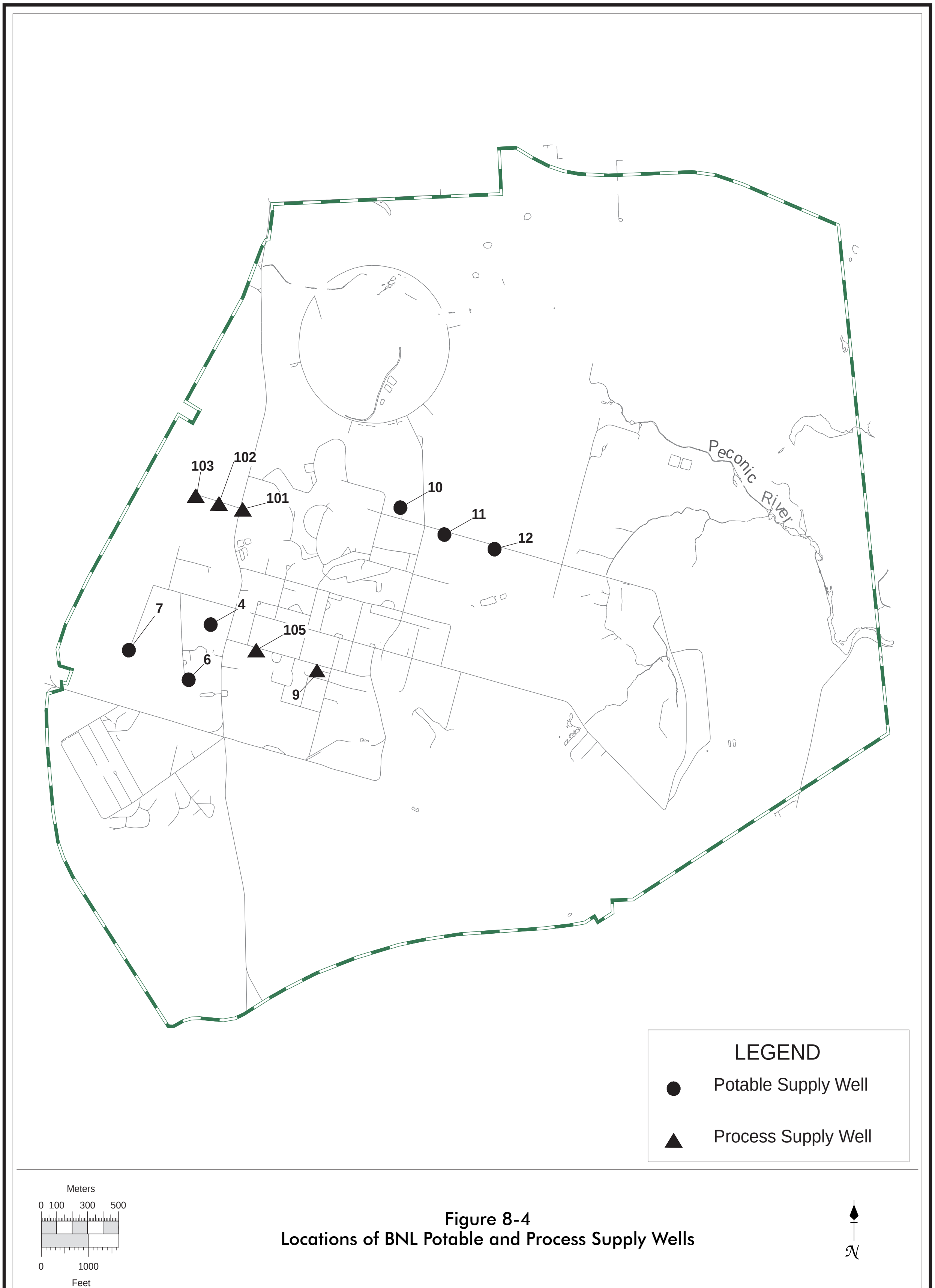


Figure 8-4
Locations of BNL Potable and Process Supply Wells

Table 8-1. Potable Water and Process Supply Wells Quality Data

Well Id. [Old Well Id.]		pH SU	Conductivity µS/cm	Chlorides mg/L	Sulfates[b] mg/L	Nitrate as N [b] mg/L
4 [FD]	N	3	3	0	0	0
	Min.	6	105			
	Max.	6.2	111			
	Avg.	NA	108			
6 [FF]	N	4	7	0	0	0
	Min.	6.1	102			
	Max.	6.2	104			
	Avg.	NA	104			
7 [FG]	N	3	3	0	0	0
	Min.	6	131			
	Max.	6.6	138			
	Avg.	NA	135			
10 [FO]	N	11	11	6	6	6
	Min.	6	93	< 4	8.7	<1.0
	Max.	7	125	17.1	11.6	< 1.0
	Avg.	NA	114	12.2	10.6	<1.0
11 [FP]	N	11	11	7	7	7
	Min.	5.9	119	17.3	11.4	<1.0
	Max.	6.7	146	20.7	13.5	<1.0
	Avg.	NA	126	19.4	12.9	<1.0
12 [FQ]	N	9	9	6	6	6
	Min.	6.2	122	16.7	10.5	<1.0
	Max.	6.8	143	21.4	13.6	<1.0
	Avg.	NA	127	17.5	11.5	<1.0
101 [FH]	N	5	0	0	0	0
	Min.	6.9				
	Max.	9				
	Avg.	NA				
102 [FI]	N	2	1	1	1	1
	Min.	6.9	135	21.2	8.9	< 1
	Max.	7.1	135	21.2	8.9	< 1
	Avg.	NA	135	21.2	8.9	< 1
103 [FJ]	N	0	0	0	0	0
	Value					
9 [FM]	N	4	4	2	2	2
	Min.	6.4	118	19.7	11.5	<1.0
	Max.	7.1	134	20.7	11.4	<1.0
	Avg.	NA	126.3	20.2	11.5	<1.0
105 [FL]	N	3	3	1	1	1
	Min.	6.2	187	33.7	13.9	<1.0
	Max.	6.4	199	33.7	13.9	<1.0
	Avg.	NA	192	33.7	13.9	<1.0
NYSDWS		(a)	(a)	250	250	10
Typical MDL		NA	10	4	4	1

Notes:
1. N: No. of samples
2. NA: Not Applicable
3. NYSDWS: New York State Drinking Water Standard
4. MDL: Minimum Detection Limit
   a. No standard specified.
   b. Holding times for nitrates and sulfates were typically exceeded.
5. Wells 101-103 show pH values for treated samples.

March exceeded typical levels by one to two orders of magnitude. Similar results were obtained in February 1997. The cause of the intermittent concentration spikes is unclear. However, this well is prone to heavy sediment (composed primarily of silt and clay minerals) build-up as evidenced by frequent clogging of the activated carbon adsorption vessels. Increases in sediment could result in elevated elemental concentrations. This theory will be

Table 8-2
Potable and Process Supply Wells Metals Data

Well Id. (# Samples)		Al µg/L	Ag µg/L	Ba µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Hg µg/L	Mn µg/L	Ni µg/L	Na mg/L	Pb µg/L	V µg/L	Se µg/L	Zn µg/L
10 [FO] (6)	Min.	25.4	< 1	38.9	< 1.1	< 0.12	< 1	8.6	< 15	< 0.2	< 2	< 1.1	7.6	< 1.3	< 5.5	< 5	15
	Max.	50	< 1	54.6	< 1.1	< 0.12	< 1	12.3	36.9	< 0.2	< 2	< 1.1	12.3	< 1.3	< 5.5	< 5	22.3
	Avg.	39.3	< 1	45.8	< 1.1	< 0.12	< 1	10.5	< 15	< 0.2	< 2	< 1.1	9.7	< 1.3	< 5.5	< 5	16.4
11 (FP) (6)	Min.	20.2	< 1	45.7	< 1.1	< 0.12	< 1	18.5	< 15	< 0.2	< 2	< 1.1	8.9	< 1.3	< 5.5	< 5	6.7
	Max.	46.6	< 1	61.1	< 1.1	0.14	< 1	36.5	20.4	< 0.2	< 2	< 1.1	12.7	< 1.3	5.5	< 5	36.5
	Avg.	39	< 1	55.5	< 1.1	< 0.12	< 1	24.7	< 15	< 0.2	< 2	< 1.1	11.9	< 1.3	< 5.5	< 5	19
12 (FQ) (6)	Min.	25.9	< 1	33.9	< 1.1	< 0.12	< 1	9	17.9	< 0.2	< 2	< 1.1	11.6	< 1.3	< 5.5	< 5	< 4
	Max.	59.3	1.3	75.5	< 1.1	0.13	< 1	38.4	36.4	< 0.2	< 2	< 1.1	13.4	< 1.3	5.5	< 5	38.4
	Avg.	37.8	< 1	50	< 1.1	< 0.12	< 1	13	32.2	< 0.2	< 2	< 1.1	13.1	< 1.3	< 5.5	< 5	11.9
9 (FM) (2)	Min.	30.7	< 1	52.7	< 1.1	< 0.12	< 1	2.7	116	< 0.2	3.2	< 1.1	11.2	< 1.3	< 5.5	< 5	9.6
	Max.	40.5	< 1	62.7	< 1.1	< 0.12	1.3	2.9	240	< 0.2	5	< 1.1	13	< 1.3	< 5.5	< 5	13.5
	Avg.	35.6	< 1	57.7	< 1.1	< 0.12	< 1	2.8	178	< 0.2	4.1	< 1.1	12.1	< 1.3	< 5.5	< 5	11
102 (FI) (1)	Value	47.2	< 1	50.9	< 1.1	1.9	1.1	113.5	3779	< 0.2	447.8	< 1.1	13.7	10.3	< 5.5	< 5	89.3
105 (FL) (2)	Min.	30.9	< 1	62.4	< 1.1	< 0.12	< 1	17.1	629.2	< 0.2	62.2	5.2	18.1	1.9	< 5.5	< 5	202.1
	Max.	40.4	< 1	62.9	< 1.1	0.2	3.9	65.6	8956	< 0.2	63.3	7.5	18.3	305.7	< 5.5	< 5	1470
	Avg.	35.7	< 1	62.6	< 1.1	< 0.12	2	41.4	4793	< 0.2	62.8	6.4	18.2	153.8	< 5.5	< 5	836.1
NYSDWS		NA	15	2000	5	NA	100	1300	300	2	300	100	NA	15	NA	50	5000
Typical MDL		2.2	1	1.8	1.1	0.12	1	2	15	0.2	2	1.1	1	1.3	5.5	5	4

Notes:
1. N: No. of samples
2. NYSDWS: New York State Drinking Water Standard
3. MDL: Minimum Detection Limit