

evaluated further in 1999 by the collection of more frequent samples and the filtration of a sample aliquot prior to analysis.

Water samples are collected for VOC analyses from the wellhead before treatment (i.e., raw water) as well as post-treatment. No compounds were detected above the minimum detection limits (MDL) in treated water samples. Of the sixty compounds analyzed, 1,1,1-trichloroethane (TCA), chloroform, 1,1-dichloroethylene (DCE), 1,1-dichloroethane (DCA), and carbon tetrachloride were the only VOCs detected in raw water samples. The following observations were made:

- ♦ Only TCA exceeded NYS DWS. Chloroform and TCA were present in all wells (raw well water samples only). The concentration of TCA ranged from trace levels (i.e.,  $< 2 \mu\text{g/L}$ ) to a maximum of  $11.5 \mu\text{g/L}$  in Process Well 9. Of the potable wells, only Well 11 contained TCA at concentrations exceeding the NYS DWS of  $5 \mu\text{g/L}$ . The maximum concentration of TCA in this well was  $5.6 \mu\text{g/L}$ . This well is equipped with carbon filtration to remove VOCs from the water prior to distribution.
- ♦ Chloroform was found in most wells, with concentrations ranging from trace levels (i.e.,  $< 2 \mu\text{g/L}$ ) to a maximum of  $7 \mu\text{g/L}$ . All chloroform concentrations were equal to or below the NYS AWQS of  $7 \mu\text{g/L}$ , and well below the drinking water standard of  $100 \mu\text{g/L}$ .
- ♦ DCE was detected in Wells 9, 11, and 12. A maximum concentration of  $3.6 \mu\text{g/L}$  was detected in Well 9, which is less than the drinking water standard of  $5 \mu\text{g/L}$ .
- ♦ DCA was detected in trace concentrations. Low levels of carbon tetrachloride (up to  $3.6 \mu\text{g/L}$ ) and trace amounts of DCA were detected in Well 11. Both compounds were below the NYS DWS of  $5 \mu\text{g/L}$ .

Process Supply Wells 9 and 105 are located within a portion of the defined OU III VOC plume. Water pumped from these wells generally contains concentrations of TCA which exceed the NYS DWS of  $5 \mu\text{g/L}$ . Water from Process Well 105 is treated by carbon filtration to remove VOC contamination prior to its use in the BMRR (as once through cooling water) and subsequent discharge to Basin HP. Water from Well 9 is not treated prior to use. This water is not used for drinking and the concentrations present do not

interfere with the fish experiments conducted in Building 463. No VOCs were detected in the AGS Process Supply Well 102.

#### 8.1.1.2 RADIOLOGICAL ANALYSES

Potable and process well water was sampled and analyzed for gross alpha and gross beta activity, tritium and strontium-90; the results are listed in Table 8-3. Nuclide-specific gamma spectroscopy was also performed, supplementing the requirements of the SDWA, which does not strictly require this analysis unless gross beta activity exceeds  $50 \text{ pCi/L}$  ( $1.9 \text{ Bq/L}$ ). In response to employee concerns regarding the radiological content of the BNL potable water system, the total number of samples collected in 1998 was increased from previous years, to a maximum of eleven times for Wells 10, 11, and 12. These wells were in operation for the entire year and provided the majority of the drinking water for the site. Wells 4, 6 and 7 were only in operation half the year; consequently, they were sampled less frequently.

Average gross activity and tritium levels in the potable water wells were consistent with those of typical background water samples. Neither strontium-90 nor any man-made gamma-emitting radionuclides were observed above the MDL in any of the potable wells sampled. Throughout the year, Process Wells 9, 102, and 105 also showed radiological results that were consistent with background environmental values.

Compliance with the SDWA is based on the analytical results obtained from an annual composite of four quarterly samples or the average of the analyses of four quarterly samples. Compliance is demonstrated if:

- ♦ the annual average gross alpha activity is less than  $15 \text{ pCi/L}$  ( $0.6 \text{ Bq/L}$ );
- ♦ gross beta activity is less than  $50 \text{ pCi/L}$  ( $1.9 \text{ Bq/L}$ );
- ♦ strontium concentrations are less than  $8 \text{ pCi/L}$  ( $0.3 \text{ Bq/L}$ );
- ♦ tritium concentrations are less than  $20,000 \text{ pCi/L}$  ( $740 \text{ Bq/L}$ ); and,
- ♦ the total effective dose equivalent for all detected radionuclides combined is less than  $4 \text{ mrem}$  in a year.

During 1998, all of these criteria were satisfied, and therefore, the BNL potable water system was in full compliance with the radiological requirements of 40 CFR 141.

Table 8-3: Potable and Process Well Radiological Analysis Results.

Well ID		Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Sr-90 (pCi/L)
<b>Potable Wells</b>					
4 [FD]	N	4	4	4	1
	Max.	1.4±0.8	< 2.0	< 309	< 1.6
	Avg.	0.0±1.0	-21.7±37.1	0±92	
6 [FF]	N	4	4	4	1
	Max.	< 1.2	< 2.0	< 335	< 1.1
	Avg.	0.2±0.2	-8.6±15.3	-16±61	
7 [FG]	N	2	2	2	1
	Max.	< 1.1	6.9±1.6	< 335	< 1.1
	Avg.	-0.3±0.2	3.5±4.7	-66±99	
10 [FO]	N	11	11	11	3
	Max.	7.3±1.7	11.7±1.7	417±210	< 1.2
	Avg.	0.7±1.3	-5.9±15.2	113±111	0.4±0.5
11 [FP]	N	11	11	11	3
	Max.	3.7±1.2	2.0±0.7	< 320	< 1.7
	Avg.	0.3±0.7	-6.4±13.7	44±92	0.3±0.2
12 [FQ]	N	11	11	10	3
	Max.	4.7±1.0	10.1±2.7	353±209	< 1.8
	Avg.	0.6±0.9	-5.5±15.2	48±94	0.1±0.2
Tap Water Bldgs 535/490 (FN)	N	223	223	235	NA
	Max.	10.8±3.4	18.7±6.2	462±192	
	Avg.	2.6±0.3	4.7±0.5	24±16	
<b>Process Wells</b>					
102 [FI]	N	1	1	1	NA
	Max.	< 1.2	< 2.2	< 337	
105 [FL]	N	4	4	4	NA
	Max.	11.1±1.2	< 3.6	< 335	
	Avg.	2.7±4.8	-20.8±32.3	58±75	
9 [FM]	N	4	4	4	NA
	Max.	1.2±0.7	< 3.6	< 335	
	Avg.	0.2±0.8	-21.0±34.8	31±113	
SDWA Limit		15(a)	50(b)	20,000	8

## Notes:

- All values shown with 95% confidence interval.
- No anthropogenic gamma-emitting radionuclides were detected in samples collected from these wells in 1998.
- N = Number of samples collected.
- NS = Not sampled for this analyte.
  - Excluding radon and uranium.
  - Screening level above which analysis for individual radionuclides is required.

### 8.1.2 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING PROGRAM

The mission of the ER groundwater monitoring program is to monitor the various contaminant plumes located onsite and offsite, as well as to monitor the progress that the groundwater treatment systems are making on plume remediation. The long-term groundwater monitoring projects coordinated under the ER monitoring program are designed to address the following issues:

1. Pre-Record of Decision (pre-ROD) Monitoring: Addresses the short-term monitoring of plumes to track their movement following

the Remedial Investigation characterization and prior to remediation;

2. Post-Record of Decision (post-ROD) Monitoring: Addresses the long-term monitoring of plumes to track their movement following the initiation of remediation systems, including:
  - ♦ Source Removal Effectiveness: Includes monitoring wells installed to verify that remediation projects, such as the capping of previously used landfills, are performing to specifications; and,
  - ♦ Treatment System Performance: Includes monitoring the active pump-and-treat

systems to verify that they are effectively capturing and removing contaminants, and monitoring plumes undergoing passive remediation (i.e., natural attenuation) to verify that natural processes are effective in reducing contaminant concentrations.

3. **Outpost Detection Monitoring:** Samples wells located between the leading edge of contaminant plumes and a potential receptor, to give early warning of the arrival of the leading edge of the plume and trigger contingency remedial actions.

The groundwater monitoring information described below provides an overview of ER groundwater monitoring and remediation activities for 1998. During this period, a total of 407 groundwater surveillance wells were monitored during approximately 1,510 individual sampling events. Detailed analytical results for each sample obtained under the Sitewide Groundwater Program are provided in the 1998 ERD Sitewide Groundwater Monitoring Report (Dorsch and Wachino, 1999). Detailed information about the performance of the remediation systems and recommendations for potential adjustments to the systems are presented in the Operational Reports for the individual systems (described below).

Maps showing the main VOC and radionuclide plumes are provided as Figures 8-2 and 8-3. For each significant contaminant source area and plume described below, specific groundwater contaminant distribution maps and cross sections are also provided. These maps depict the areal extent of contamination, and were created by selecting the highest contaminant concentration observed for a given set of wells during a selected sample period. Associated cross sections show the vertical distribution/extent of contamination, as well as the hydrogeology. Each cross section is generally oriented through the highest areas of contaminant concentration of a given plume. The cross section transect lines are identified on the corresponding plume map. No significant change in contaminant concentrations occurred during the year, therefore a single representative round of monitoring was chosen for each plume.

#### 8.1.2.1 BACKGROUND MONITORING

Ambient (or background) groundwater quality for the BNL site is monitored through

a network of 13 wells located in the northern portion of the site and in offsite areas to the north. The site background wells provide information on the chemical and radiological composition of groundwater that has not been affected by activities at BNL. These background data are a valuable reference for comparison with groundwater quality data from areas that have been affected. This well network can also provide warning of any contaminants originating from potential sources of contamination that may be located upgradient of the BNL site.

There were no significant detections of VOCs in background wells. The highest concentration detected was tetrachloroethylene (PCE) at 2.6 micrograms per liter ( $\mu\text{g/L}$ ) in offsite Well 000-119. This well is screened in the middle Upper Glacial aquifer, and is located immediately north of the northwest corner of the site. Low concentrations of VOCs have been detected in previous years in wells 17-03, 17-04, 18-03 and 18-04. Radionuclide concentrations were consistent with background levels.

#### 8.1.2.2 OPERABLE UNIT 1

##### 8.1.2.2.1 FORMER LANDFILL, ANIMAL/CHEMICAL PITS AND GLASS HOLES

The Former Landfill area initially was used by the United States Army during World Wars I and II, then BNL used the southeast corner of the landfill from 1947 through 1966 to dispose of construction and demolition debris, sewage sludge, chemical and low-level radioactive waste, used equipment, and animal carcasses. From 1960 through 1966, BNL waste, glassware containing chemical and radioactive waste, and animal carcasses containing radioactive tracers were disposed of in shallow pits in an area directly east of the Former Landfill. From 1966 through 1981, BNL continued to dispose of used glassware in shallow pits located directly north of these chemical/animal pits.

A network of eight monitoring wells is used to monitor the Former Landfill area. The monitoring program for the Former Landfill is designed in accordance with post-closure operation and maintenance (O&M) requirements specified in 6 NYCRR Part 360, "Solid Waste Management Facilities." These requirements specify that the well network be moni-

tored quarterly for a minimum of five years, after which time BNL may petition the NYSDEC to modify the frequency and types of analyses based on supporting data. The objective of this program is to monitor radiological and non-radiological contamination in the shallow Upper Glacial aquifer immediately downgradient of the landfill. The program was initiated following the capping of the Former Landfill in November 1996, and will verify whether the cap effectively prevents the continued leaching of contaminants from the landfill and document anticipated long-term improvements to groundwater quality. In addition to these wells, BNL established a separate network of 24 wells to monitor the Animal/Chemical Pits/Glass Holes areas, and the downgradient portions of the Former Landfill plume. The downgradient portions of these plumes are currently being monitored as part of the OU I/IV Pre-ROD Monitoring Program.

**Volatile Organic Compounds:** The primary chemical contaminants observed in the Former Landfill - Animal/Chemical Pits and Glass Holes plume are carbon tetrachloride, TCA, DCE, TCE, and chloroform. These constituents are typically observed at concentrations of less than 100 µg/L, total concentration VOCs (TVOC) (Note: a TVOC concentration is a summation of all individual VOC values for a given groundwater analysis.) The NYS AWQS for carbon tetrachloride, TCA, DCE, and TCE is 5 µg/L, whereas the standard for chloroform is 7 µg/L. The Former Landfill - Animal/Chemical Pits and Glass Holes plume extends approximately 3,500 meters (11,500 feet) from the source areas, south to the approximate vicinity of Crestwood Drive (see Figure 8-5). The plume is approximately 460 meters (1,500 feet) at its maximum width, as defined by the 5-µg/L contour. The higher concentration segment of the plume (>50 µg/L) is approximately 300 meters (1,000 feet) in width.

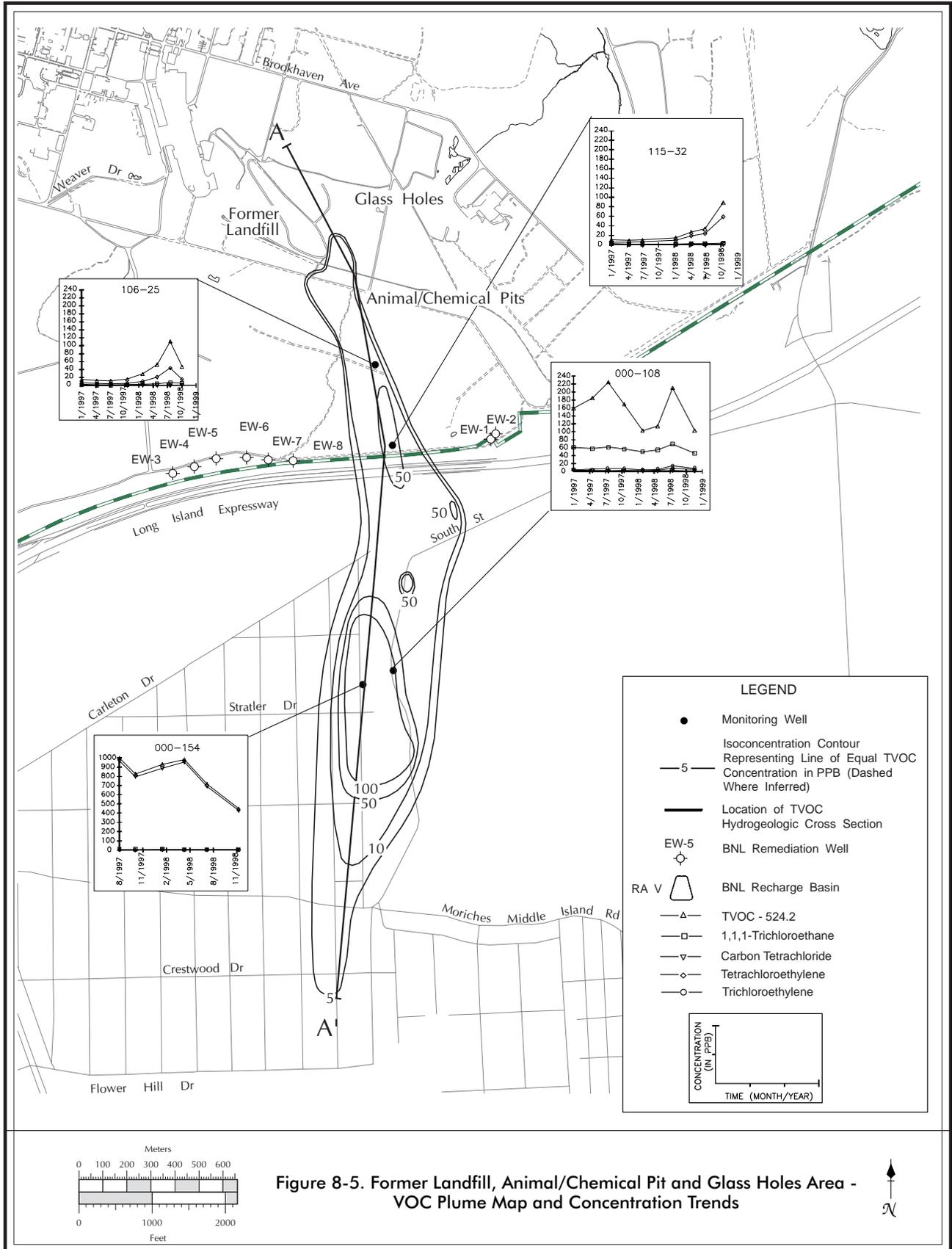
The vertical distribution of VOC contamination is shown on Figure 8-6. In general, the VOCs are found in the shallow sections of the Upper Glacial aquifer in the vicinity of the Former Landfill, Animal/Chemical Pits and Glass Holes, in the mid-Upper Glacial aquifer at the southern site boundary, and in the deep Upper Glacial aquifer offsite to the south. The area of the plume showing the highest TVOC concentration is offsite in the vicinity of

Stratler Drive in North Shirley, New York. This area of the plume is composed primarily of carbon tetrachloride, with a TVOC concentration of 428 µg/L in Well 000-154 during October 1998. A zone of VOC contamination, consisting primarily of TCA, DCA and DCE, was detected in the upper Magothy aquifer (greater than 90 meters [300 feet] below land surface) in an area south of the Long Island Expressway and north of North Street during the OU III RI/FS. Additional characterization and the installation of permanent wells to monitor this contamination will be addressed in 2000.

**Radionuclides:** Strontium-90 has been routinely detected in groundwater in the Animal/Chemical Pits, Former Landfill and Glass Holes Area at concentrations above the DWS of 8 pCi/L, specifically in Wells 97-64, 106-16 and 106-13. The high levels of strontium-90 contamination (as defined by the DWS of 8 pCi/L) are in close proximity to the individual source areas (Figure 8-7). The highest strontium-90 concentrations have been detected in Well 106-16, where a maximum concentration of 554 pCi/L (20 Bq/L) was observed in July 1998. In 1997, trace amounts of strontium-90 were detected in temporary wells installed as far south as the onsite BNL Middle Road. Based upon these results, additional downgradient monitoring wells were installed during 1998. Monitoring wells are now located in advance of the leading edge of this plume and are sampled on a quarterly basis. Strontium-90 concentration trends plots for Wells 97-64 and 106-16 are presented in Figure 8-7.

#### 8.1.2.2.2 CURRENT LANDFILL

The Current Landfill operated from 1967 through 1990, when it was closed in accordance with the 6 NYCRR Part 360, "Long Island Landfill Law." It was used to dispose of putrescible waste, sludge containing precipitated iron from the WTP, and anaerobic digester sludge from the Sewage Treatment Plant (STP). The latter contained low concentrations of radionuclides, and possibly metals and organic compounds. BNL also disposed of limited quantities of laboratory wastes containing radioactive and chemical material at the landfill. As a result, the Current Landfill is a source of groundwater contamination. Permanent closure (capping) of this landfill



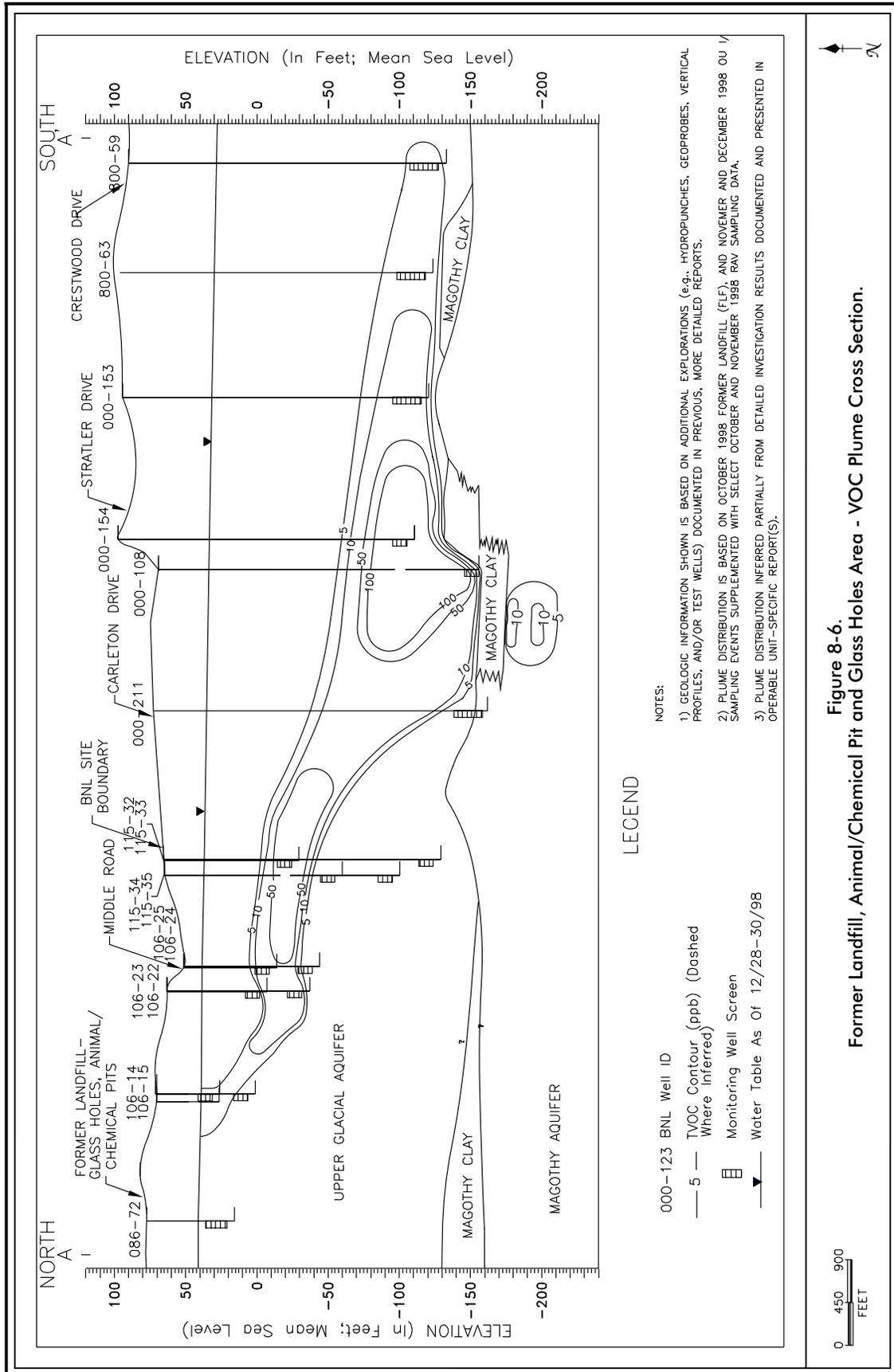
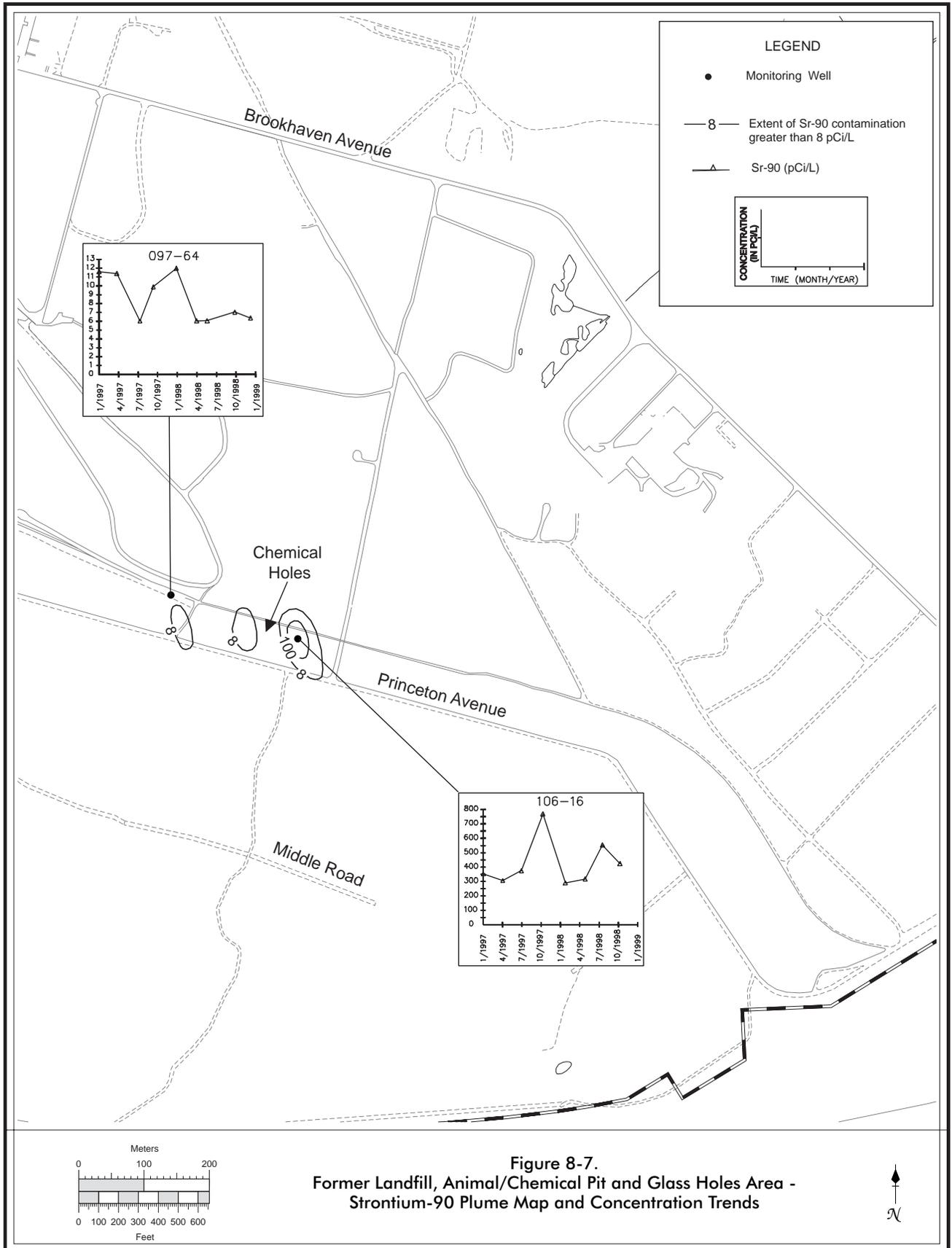


Figure 8-6. Former Landfill, Animal/Chemical Pit and Glass Holes Area - VOC Plume Cross Section.



was completed in November 1995 as part of the ER Program.

The Current Landfill post-closure monitoring program consists of a network of 11 monitoring wells situated adjacent to the landfill in both upgradient and downgradient locations. These wells are monitored quarterly, and are used to determine the cap's effectiveness in preventing the continued leaching of contaminants from the landfill, and to document the anticipated long-term improvements to groundwater quality. The monitoring well network was designed in accordance with NYS specified post-closure O&M requirements.

**Volatile Organic Compounds:** During 1998, VOCs were routinely detected in wells located downgradient of the Current Landfill including chloroethane, benzene, and DCA. Chloroethane was detected at concentrations exceeding the NYS AWQS of 5 µg/L in monitoring Wells 87-11, 87-23, 87-27, 88-22, 88-109, and 88-110, with a maximum concentration of 289 µg/L detected in Well 88-109. Benzene was found in monitoring wells 87-11, 87-23, 87-27, 88-22, 88-109, and 88-110 at concentrations exceeding the NYS AWQS of 0.7 µg/L, with a maximum concentration of 2.7 µg/L. DCA was detected in Wells 88-22, 88-109 and 88-110, with a maximum concentration of 59 µg/L found in Well 88-109.

**Radionuclides:** Tritium was occasionally detected in downgradient Wells 87-11, 87-23, 87-27, 88-21, 88-22, 88-109, and 88-110, with concentrations ranging from slightly above the typical MDL of 400 pCi/L to as high as 3,098 pCi/L (115 Bq/L).

#### 8.1.2.2.3 FORMER HAZARDOUS WASTE MANAGEMENT FACILITY (HWMF) PLUME AND DOWNGRADIANT SECTION OF CURRENT LANDFILL PLUME

Groundwater contamination originating from the Former HWMF and the downgradient section of the Current Landfill plume is being monitored under the Removal Action V (RA V) Program. Until 1997, the Former HWMF was BNL's central RCRA receiving facility for processing, neutralizing, and storing hazardous and radioactive wastes before offsite disposal. As the result of past waste handling and storage practices, the soil and groundwater at the Former HWMF are contaminated with both chemicals and radio-

nuclides at concentrations that exceed NYS AWQS.

The Current Landfill and Former HWMF plumes become commingled south of the HWMF due, at least partially, to the pumping and recharge effects of the Former Spray Aeration System, which operated from 1985 to 1990 in an effort to treat VOC contaminated groundwater originating from the HWMF. The Current Landfill/HWMF plume is currently being remediated using a groundwater extraction and treatment system consisting of two wells screened in the deep portion of the Upper Glacial Aquifer at the site boundary (see RA V Treatment System described in section 8.1.2.7). This system provides hydraulic containment of those onsite portions of the plume that have TVOC concentrations greater than 50 µg/L.

The RA V monitoring program uses a network of 51 monitoring wells located in areas downgradient of the Current Landfill and HWMF. This monitoring program is specifically designed to address the following issues on groundwater contamination and plume remediation:

- ♦ Monitoring of VOC and radiological contamination of groundwater in the shallow zone of the Upper Glacial aquifer at, and immediately adjacent to, the HWMF;
- ♦ Monitoring of VOC and radiological contaminant plumes located south of the Current Landfill and HWMF that have been commingled due, in part, to the effects of the former Spray Aeration Groundwater Remediation System, which was located to the south of the HWMF; and,
- ♦ Evaluating the effectiveness of the RA V groundwater pump-and-treat system that was initiated in December 1996 at the southern site boundary using wells EW-1 and EW-2. The monitoring program will characterize the effects of this treatment system on the contaminant plume, and provide data necessary to make decisions on the future operations of the system.

Readers are referred to the RA V Groundwater Treatment Annual Operations Report 1998 (BNL, 1999c) for a detailed description of the remediation system and its effects on the VOC plume. A detailed discussion of the groundwater monitoring results for the Current Landfill area is included in the 1998 Environmental Monitoring Report, Current And Former

Landfill Areas (BNL 1999a).

**Volatile Organic Compounds:** The primary VOCs found onsite in this plume include chloroethane, TCA, and DCA, whereas the compounds detected offsite consist of TCA, DCE, TCE, and chloroform. The Current Landfill and HWMF plume (as defined by the 5 µg/L contour) extends approximately 2,210 meters (7,250 feet) from the Current Landfill and HWMF areas south, to an area approximately 457 meters (1,500 feet) south of North Street (Figure 8-8). The plume is approximately 420 meters (1,375 feet) wide at its maximum width. The width of the higher concentration portions of the plume (>50 µg/L) is approximately 152 meters (500 feet). The vertical distribution of VOCs is shown on Figure 8-9. Chloroethane, TCA, and DCA are shown in the shallow Upper Glacial aquifer near the source areas and in the deep Upper Glacial aquifer at the site boundary and offsite. TCA, DCE, TCE and chloroform are found in the middle to deep Upper Glacial aquifer offsite south of North Street.

There are three areas of the plume displaying VOC concentrations of >200 µg/L. These areas are located immediately downgradient of the Current Landfill/HWMF, immediately south of the southern boundary extraction system, and offsite south of North Street. When comparing the configuration of the plume from 1997 to 1998, the continued operation of the RA V groundwater treatment system at the site boundary appears to be shrinking the width of the plume in this area (see Dorsch and Wachino, 1999).

Historical VOC concentration trends for key wells along the Current Landfill/HWMF Plume are provided in Figure 8-8. Onsite, source area Wells 88-109 and 88-22 displayed decreasing VOC concentration trends. Wells 098-59 and 115-36, located between the source areas and the site boundary, displayed fluctuating or slightly increasing VOC concentration trends. Well 115-14, located in close proximity to the extraction system has maintained a low and steady VOC concentration trend. VOC concentrations have trended upward in 1998 for offsite Wells 115-42 and 000-124 whereas Well 000-138 has displayed a slight downward trend in VOC concentrations. The VOCs detected in Well 115-42 are probably the result of contamination being pulled back by the southern boundary extraction system.

**Radionuclides:** Tritium was detected below DWS in a number of Current Landfill/HWMF wells during Only Well 88-26 (located inside the Former HWMF) had tritium concentrations that exceeded the 20,000 pCi/L, NYS DWS, with a concentration of 34,832 pCi/L (1,289 Bq/L) in May 1998. Tritium concentrations in samples from this well were below the DWS during the other three quarters of 1998. This well has historically shown concentrations above the DWS. Tritium concentration trend plots for key Current Landfill/HWMF wells are provided in Figure 8-10. Offsite Well 000-137 showed slightly increasing tritium concentrations during 1998; however the concentrations were well below the NYS DWS.

Strontium-90 was detected in two wells (88-26 and 98-30) in the Current Landfill and Former HWMF areas during 1998 at concentrations exceeding the DWS. Figure 8-11 provides a strontium-90 plume distribution map and concentration trend data for key wells.

### 8.1.2.3 OPERABLE UNIT III

The monitoring well network established to monitor the OU III VOC and radionuclide source areas and resulting contaminant plumes is composed of approximately 180 monitoring wells positioned from the north-central portion of the site to the southern site boundary and offsite. The OU III groundwater-monitoring program is specifically designed to address the following groundwater contamination issues and plume remediation:

- ♦ Monitor VOC plumes with identified or suspected sources in the AGS Complex, Paint Shop, former Building 96 area, and the Supply and Materiel area. These plumes extend from the north-central portion of the site to south of the site boundary and then into North Shirley. The plumes become deeper as the distance from the source areas increases. Plumes at the southern site boundary and offsite are in the deep portion of the Upper Glacial aquifer and the upper portion of the Magothy aquifer.
- ♦ Monitor the tritium plume associated with the High Flux Beam Reactor (HFBR), and strontium-90 plumes associated with the WCF and the formerly operated Brookhaven Graphite Research Reactor (BGRR).
- ♦ Evaluate the effectiveness of the OU III south boundary groundwater pump-and-treat

