Groundwater Status Report

2004 Site Environmental Report

BROOKHAVEN NATIONAL LABORATORY

Volume II

EXPLORING EARTH'S MYSTERIES
…PROTECTING ITS FUTURE

2004 BNL GROUNDWATER STATUS REPORT

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Environmental and Waste Management Services Division
and
Environmental Restoration

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Contents

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List of Appendices

List of Figures

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List of Tables

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Acronyms and Abbreviations

These acronyms and abbreviations reflect the typical manner in which terms are used in Volume II of this document, and may not apply to all situations.

AGS	Alternating Gradient Synchrotron
AOC	Area of Concern
AS/SVE	Air Sparge/Soil Vapor Extraction
ASL	Analytical Services Laboratory
ASTM	American Society for Testing and Materials
AWQS	Ambient Water Quality Standards
BERA	Brookhaven Employees Recreation Association
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven LINAC Isotope Producer
BLS	below land surface
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Chain of Custody
CRDL	Contract Required Detection Limit
CSF	Central Steam Facility
CY	calendar year
DCA	1,1-dichloroethane
DCE	1,1-dichloroethene
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DTW	Depth to Water
DWS	Drinking Water Standard
EDB	ethylene dibromide
EDD	Electronic Data Deliverable
EE/CA	Engineering Evaluation/Cost Analysis
EIMS	Environmental Information Management System
EM	Environmental Management
EMS	Environmental Management System
EPA	United States Environmental Protection Agency
ER	Environmental Restoration
ERP	Emissions Rate Potential
ES	Environmental Surveillance
ESD	Explanation of Significant Differences
EWMSD	Environmental and Waste Management Services Division
FFA	Federal Facility Agreement
FRP	Facility Response Plan
FFS	Focused Feasibility Study
FS	Feasibility Study
ft msl	feet above mean sea level
GAC	granular activated carbon
gal/hr	gallons per hour
GeV	giga electron volt
GPM	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Inter Agency Agreement
ID	identification
K gal	thousand gallons
lb/gal	pounds per gallon
lbs	pounds
LEL	Lower Explosive Limit
LIE	Long Island Expressway
LINAC	Linear Accelerator
LIPA	Long Island Power Authority
LOAEL	Lowest Observed Adverse Effects Level
MCL	Maximum Contaminant Level
MDL	Minimum Detection Limit
mg/L	milligrams per liter
MGD	millions of gallons per day
MNA	Monitored Natural Attenuation
MPF	Major Petroleum Facility
MS/MSD	Matrix Spike/Matrix Spike Duplicate
msl	mean sea level
MTBE	methyl tertiary butyl ether
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NSRL	NASA Space Radiation Laboratory
NYCRR	New York Code of Rules and Regulations
NYS	New York State

NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance
OU	Operable Unit
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
pCi/L	pico Curies per liter
PE	Plant Engineering
PLC	programmable logic controller
ppb	parts per billion
QA/QC	Quality Assurance and Quality Control
RA V	Removal Action V
RCRA	Resource Conservation and Recovery Act
RHIC	Relativistic Heavy Ion Collider
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPD	Relative Percent Difference
RTW	Recirculating Treatment Well
SCDHS	Suffolk County Department of Health Services
SCGs	Standards, Criteria and Guidances
SCWA	Suffolk County Water Authority
SDG	Sample Delivery Group
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
µg/L	micrograms per liter

2004 BROOKHAVEN NATIONAL LABORATORY
GROUNDWATER STATUS REPORT

Executive Summary

The mission of the Laboratory's Groundwater Protection Program is to protect and restore the aquifer system at Brookhaven National Laboratory (BNL). Four key elements make up the program:

- **Pollution prevention** – preventing the potential pollution of groundwater at the source
- **Monitoring** – monitoring the effectiveness of pollution-prevention efforts, as well as progress in restoring the quality of degraded groundwater
- **Restoration** – restoring groundwater quality that BNL has impacted
- **Communication** – communicating the findings and the results of the program to regulators and other stakeholders

The *2004 BNL Groundwater Status Report* is a comprehensive summary of data collected during the calendar year, and an evaluation of Groundwater Protection Program performance. This is the eighth annual groundwater status report issued by BNL. This document is unique in that it examines the performance of the program on a project-by-project basis, as well as comprehensively in a "watershed-like" analysis.

How to Use This Document. This detailed technical document includes summaries of laboratory data, as well as data interpretations. It is intended for internal BNL users, regulators, and other technically oriented stakeholders. Less technical summaries of this information can be obtained through the BNL website, BNL Community Relations office, as well as Chapter 7 of this *Site Environmental Report*. Environmental Restoration (ER) refers to work being performed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), including measuring and monitoring of groundwater remediation performance, and efforts in achieving cleanup goals. Environmental Surveillance (ES) refers to the monitoring of groundwater quality at active research and support facilities, primarily in response to Department of Energy (DOE) Order 450.1, Environmental Protection. Data are presented in five key subject areas:

- Improvements to the understanding of the hydrogeologic environment beneath BNL and surrounding areas
- Identification of any new impacts on groundwater quality due to BNL's active operations
- Progress in cleaning up the groundwater contamination
- Performance of individual groundwater remediation systems
- Recommended changes to the groundwater protection program

This document satisfies BNL's requirement to report groundwater data under the Interagency Agreement (IAG) and partially fulfills the commitment of BNL's Groundwater Protection Program to communicate the findings and progress of the program to regulators and stakeholders.

Chapter 1 summarizes the drivers of the data collection work in 2004, the site's groundwater classification, and the objectives of the groundwater monitoring efforts. Chapter 2 discusses improvements to our understanding of the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2004. Chapter 3 summarizes the groundwater cleanup data, progress towards achieving the site's cleanup goal, and recommended modifications to the remediation systems or monitoring programs. Chapter 4 summarizes the groundwater surveillance data used to verify that operational and engineering controls are preventing further contamination from the site's active experimental and support facilities. The recommended changes to the Groundwater Protection Program are summarized in Chapter 5.

HYDROGEOLOGIC DATA

The following were important hydrogeologic findings in 2004.

- Groundwater flow directions were relatively stable during 2004, due in part to the efforts of the BNL Groundwater Pump and Recharge Management Subcommittee. Supply pumping was relegated primarily to the western supply well field during the year (approximately 75 percent of the pumping was from the western well field over the year).
- Total precipitation in 2004 was recorded as 35.9 inches, well below the annual average of 48.5 inches. This is the lowest level for the past 24 years, and is the third lowest annual rainfall since 1949 (the record low was 34.4 inches in 1965). In an average year, it is estimated that 24 inches of rainfall recharge the Upper Glacial aquifer. Taking into account seasonal variations in evapotranspiration, the recharge rate for 2004 was estimated at approximately 18 inches.

PROGRESS IN GROUNDWATER RESTORATION ACTIONS (CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In 2004, 652 pounds of volatile organic compounds (VOCs) were removed from the aquifers by the treatment systems. To date, approximately 4,800 of the estimated 25,000 to 30,000 pounds of VOCs in the aquifer have been removed. The startup of the Operable Unit (OU) III Chemical Holes Strontium-90 System in 2003 has resulted in 1.27 mCi of strontium-90 (Sr-90) being removed from the Upper Glacial aquifer.

Groundwater remediation is expected to be a long-term process for most of the plumes. Noticeable improvements in groundwater quality are evident in the OU I South Boundary, OU III Carbon Tetrachloride, Building 96, and OU III South Boundary areas. Groundwater remediation activities are expected to continue until approximately 2030 to meet the ultimate cleanup objective for most of the plumes (i.e., to reduce contaminant levels in the Upper Glacial aquifer to below maximum contaminant levels [MCLs]). MCLs for Sr-90 in the Upper Glacial aquifer and for VOCs in the Magothy aquifer will be met within 70 years. The cleanup objectives will be met by a combination of active treatment and natural attenuation. The comprehensive groundwater monitoring program will guide the remediation progress.

The locations and extent of the primary VOC and radionuclide plumes at BNL as of December 2004 are summarized in Figures E-1 and E-2, respectively. Significant items of interest during 2004 were the following.

- 703 wells were sampled as part of the Environmental Restoration (ER) Groundwater Monitoring Program in 2004, comprising a total of 1,889 groundwater samples. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site. By the end of 2004, twelve VOC groundwater remediation systems were in operation, as well as the Chemical Holes Strontium-90 Treatment System. The second Sr-90 treatment system, for the BGRR/WCF (Brookhaven Graphite Research Reactor/Waste Concentration Facility) plumes, was constructed in 2004 and will begin operation in 2005. The HFBR (High Flux Beam Reactor) Tritium Pump and Recharge System remained in standby mode in 2004. A petition to shut down the carbon tetrachloride system was approved by the regulators, and the system was subsequently placed in standby mode in August 2004.
- During 2004, 1.5 billion gallons of groundwater were treated. All 16 groundwater treatment systems were constructed by 2004.
- Remediation of the Magothy aquifer groundwater contamination was enhanced with two additional extraction wells located south of BNL property at Industrial Park and Stratler Drive.
- Additional groundwater characterization work was performed in the Building 96 system source area and immediately west of the system, at the Industrial Park East treatment system, and for the HFBR tritium plume. Data obtained from these investigations refined our understanding of the BNL contaminant plumes. Progress of the groundwater restoration program is summarized in Table E-2.

Other progress highlights include:

- Because VOC concentrations in three of the four OU III Building 96 recirculation wells remained low in 2004 (below 30 µg/L TVOCs [total VOCs]), they were shut down and placed in standby mode in July 2004. In addition, the oxidizer potassium permanganate was applied in late 2004 and early 2005 to degrade the PCE groundwater contamination in the silt zone source area. TVOC concentrations in RTW-1 were significantly reduced, to about 30 µg/L.
- The high concentration segment of the HFBR tritium plume continued to be monitored during 2004. Concentrations in a well on the HFBR lawn were 378,000 pCi/L during the first quarter of 2004. This indicates that tritium continues to be flushed out of the unsaturated zone beneath the HFBR by natural water table fluctuations. The high-concentration, downgradient portion of the plume was located in the vicinity of Grove and Rowland Streets. The high concentration observed for this portion of the plume in 2004 was 55,000 pCi/L, in temporary well 085-344. The plume continues to attenuate as expected.
- The OU III Chemical Holes Strontium-90 Treatment System continued operating in 2004 at a 6 gpm pumping rate. Based on the results of the column study, it was decided to replace the UOP A51 zeolite resin with clinoptilolite to increase cost effectiveness.
- Core team meetings were completed with the regulatory agencies during 2004 to address groundwater remediation of VOC contamination in the Magothy aquifer and the BGRR/WCF Sr-90 plume. Based on additional information obtained during the Strontium-90 Pilot Study, the *OU III Explanation of Significant Differences* (ESD) (BNL 2005) identified changes to the OU III cleanup goal timeframes for the Sr-90 plumes. For the BGRR/WCF and Chemical Holes Sr-90 plumes, MCLs must be reached within 70 years and 40 years, respectively. In addition, cleanup of the Magothy aquifer VOC contamination must meet MCLs within 65 years. The ESD was submitted to the public for review in December 2004 and was approved by U.S. Environmental Protection Agency (EPA), with New York State Department of Environmental Conservation (NYSDEC) concurrence, in spring 2005.
- OU III Middle Road extraction wells EW-4 and EW-5 remained on standby due to low VOC concentrations.
- OU III South Boundary extraction well EW-12 remained on standby due to low VOC concentrations.

INSTITUTIONAL CONTROLS

Institutional controls are in place at BNL to ensure effectiveness of all groundwater remedies. During 2004, the institutional controls continue to be effective in protecting human health and the environment. In accordance with the *BNL Land Use Controls Management Plan*, dated August 2003, the following institutional controls continued to be implemented for the groundwater remediation program.

- Groundwater monitoring, including BNL potable supply systems and Suffolk County Department of Health Services (SCDHS) monitoring of Suffolk County Water Authority (SCWA) well fields closest to BNL
- 5-year reviews, as required by CERCLA, until cleanup goals are met and to determine the effectiveness of the groundwater monitoring program
- Controls on the installation of new supply wells and recharge basins on BNL property
- Public water service in plume areas south of BNL
- Prohibitions on the installation of new drinking water wells and other pumping wells where public water service exists (Suffolk County Sanitary Code Article 4)
- Property access agreements for treatment systems off of BNL property (deed restriction transfer with property ownership change will be completed in mid 2005).

The deeds for certain private properties beyond the BNL boundary are being updated to reflect the operation of the North Street, North Street East, and OU VI remediation systems.

Table E-1.
BNL Groundwater Remediation System Treatment Summary for 1997 – 2004.

	1997 – 2003		2004	
Remediation System (start date)	Water Treated (gallons)	VOCs Removed (pounds)(c)	Water Treated (gallons)	VOCs Removed (pounds)(c)
OU III South Boundary (June 1997)	2,254,859,850	2,104	310,000,000	172
OU III Industrial Park (Sept. 1999)	789,928,330	758	177,000,000	80
OU III W. South Boundary (Sept. 2002)	213,048,000	22	144,000,000	10
OU III Carbon Tetrachloride (Oct. 1999)	150,146,300	341	17,775	7
OU I South Boundary (Dec. 1996)	2,424,780,000	297	271,495,000	16
OU III HFBR Tritium Plume (May 1997) (a)	241,528,000	180	0	0
OU IV AS/SVE (Nov. 1997) (b)	--	35	0-	0
OU III Building 96 (Feb. 2001)	98,265,416	55	24,600,000	12
OU III Middle Road (Oct. 2001)	614,353,,550	364	194,000,000	156
OU III Chemical Holes Sr-90 (Feb 2003)	3,834,826	0.88(d) --	1,226,000	0.388 (d)
OU III Industrial Park East (May 2004)	-	-	57,113,000	17
OU III North Street (June 2004)	-	-	144,702,000	115
OU III North Street East (June 2004)	-	-	84,000,000	5
OU III LIPA/Airport (June 2004)	-	-	134,444,000	62
OU VI EDB (August 2004)	-	-	20,000,000	<1(e)
Total	6,790,744,272	4,156	1,562,597,000	652

Notes:

(a) System was shut down and placed in standby mode on Sept. 29, 2000.
(b) Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed. System was dismantled in December 2003.
(c) Values rounded to the nearest whole number.
(d) Sr-90 removal expressed in mCi.
(e) EDB(ethylene dibromide) was not detected in the system influent in 2004. However, other low-level VOCs not attributable to BNL were detected; the results are potentially due to analytical lab contamination, and were all below MCLs.

ENVIRONMENTAL SURVEILLANCE (FACILITY) MONITORING RESULTS

During 2004, the Environmental Surveillance (ES) program monitored groundwater quality at 10 active research and support facilities. Groundwater samples were collected from 125 wells during 318 individual sampling events. Although no new impacts to groundwater quality were discovered during 2004, groundwater quality continues to be impacted at four facilities: continued high levels of tritium at the g-2/VQ-12 area of the Alternating Gradient Synchrotron (AGS) facility, tritium at the Brookhaven Linac Isotope Producer (BLIP), and low-level VOCs at the Motor Pool/Facility Maintenance area and the Upton Service Station. Highlights are as follows.

- Tritium continues to be detected in wells located approximately 150 feet downgradient of the g-2/VQ-12 source area, but at much lower concentrations than those observed in 2002, when tritium concentrations up to 3,440,000 pCi/L were observed. During 2003, tritium concentrations showed a steady decline from a maximum of 1,040,000 pCi/L in January to 113,000 pCi/L in October. During 2004, tritium concentrations continued to decline, dropping to a maximum of 93,200 pCi/L by October. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data suggest that the continued release of tritium appears to be related to the flushing of residual tritium from the vadose zone following significant natural periodic fluctuations in the local water table.

- In January 2004, tritium concentrations slightly exceeded the 20,000 pCi/L standard in one well immediately downgradient of BLIP, with a concentration of 24,900 pCi/L. Tritium concentrations declined to less than 20,000 pCi/L for the remainder of the year. Similar to the g-2/VQ-12 source area discussed above, the periodic release of tritium at the BLIP facility appears to be related to the flushing of residual tritium from the vadose zone following natural periodic fluctuations in the local water table.

- At the Motor Pool/Site Maintenance area, the solvents TCA and DCA continue to be detected at concentrations greater than the typical New York State Ambient Water Quality Standards (NYS AWQS) of 5 μg/L, but at concentrations that are lower than those observed during 2003. TCA was detected at concentrations up to 36 μg/L, and DCA was detected at concentrations up to 13 μg/L. The gasoline additive methyl tertiary butyl ether (MTBE) was also detected, with a maximum observed concentration of 18 μg/L. The NYS AWQS for MTBE is 10 μg/L. No floating petroleum was detected in the monitoring wells.

- At the Service Station, VOCs associated with petroleum products and solvents continue to be detected in several monitoring wells directly downgradient of the station, but at concentrations that are lower than those observed during 2003. Petroleum-related compounds included m/p xylene at 67 μg/L, o-xylene at 79 μg/L, 1,2,4-trimethylbenzene at 16 μg/L, and 1,3,5-trimethylbenzene at 24 μg/L. The solvent PCE was detected in several wells at a maximum concentration of 20 μg/L. The gasoline additive MTBE was also detected at a maximum concentration of 14 μg/L. No floating petroleum was detected in the monitoring wells.

- Monitoring of the leak detection systems at both vehicle maintenance facilities indicates that the gasoline storage tanks and associated distribution lines are not leaking. Furthermore, evaluation of current vehicle maintenance operations indicates that all waste oils and used solvents are being properly stored and recycled. Therefore, it is believed that the contaminants detected in groundwater at these facilities originate from historical vehicle maintenance activities, and are not related to current operations.

PROPOSED CHANGES TO THE GROUNDWATER PROTECTION PROGRAM

The data summarized in this report are the basis for several significant operational and groundwater monitoring changes to the groundwater protection and cleanup programs. A summary of those significant changes follows (more details of which are provided in Chapter 5).

- **OU I South Boundary System –** Reduce the flow rates of the extraction wells and implement in October periodic pulsing to optimize system performance. Install an additional permanent monitoring well upgradient of the extraction wells to continue to track the remaining plume concentrations as they migrate to the extraction wells.
- **Carbon Tetrachloride System** – Maintain system in standby mode and restart extraction well(s), if necessary.
- **Building 96** – Inject additional potassium permanganate, as needed in 2005, to treat the remaining VOCs in the silt zone area.
- **Middle Road System** – Install one or two temporary wells near the HFBR tritium extraction wells to monitor the high VOC concentration portion of the plume. Based on the results from the temporary wells, a monitoring well may be installed.
- **OU III South Boundary –** Install a temporary well into the Magothy aquifer downgradient of the Middle Road treatment system to enhance the monitoring well network. This will help determine the extent of VOCs in the Magothy aquifer between the Middle Road and South Boundary plume monitoring networks, as well as provide additional hydrogeologic data.
- **Western South Boundary** – Due to the steadily decreasing influent concentrations of VOCs, and because six out of seven plume core wells have reached the cleanup objective of 20 µg/L TVOCs, it is recommended to begin pulse pumping the extraction wells in October 2005.
- **Industrial Park System** – Shut down and place in standby mode treatment well UVB-1, which has had concentrations of VOCs below MCLs throughout 2004.
- **Chemical Holes Sr-90 Plume** – Install several temporary wells in the plume segment downgradient of the extraction well to further define the leading edge of the plume and evaluate the need for system changes.
- **Former Landfill Area Sr-90 Monitoring** – Install temporary wells to further define the Sr-90 plume (as defined by concentrations exceeding 8 pCi/L).
- **Industrial Park East** – Install an additional deeper monitoring well adjacent to well 000-495, to more accurately define the VOC plume.
- **Airport System –** Because no monitoring wells or extraction wells have VOC concentrations above MCLs, begin pulse pumping of treatment system wells in October 2005, while continuing to monitor for VOCs.
- **OU V Plume Monitoring –** It is recommended that eight monitoring wells (049-05, 049-06, 050-01, 050-02, 061-04, 061-05, 000-122, and 000-123) continue to be analyzed for perchlorate in 2005.

Table E-2.
Groundwater Restoration Progress.

Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
OU I	OU I South Boundary (RA V)	VOCs	Operational	Pump and Treat (P&T) with air stripping (AS)	313 lb of VOCs treated to date	8 of 14	The decline in VOCs leveled off. Mean total VOC concentration in monitoring wells down from ~ 55 µg/L in 1999 to 12 µg/L in 2004. Hot spot near the former HWMF showed a total VOC decrease in 2004 from 64 µg/L to 24µg/L.
	Current Landfill	VOCs tritium	Long Term Response Action	Landfill capping	Cap is maintained and stable	9 of 30	VOCs and tritium stable or slightly decreasing.
	Former Landfill	VOCs Sr-90 tritium	Long Term Response Action	Landfill capping	Cap is maintained and stable.	8 of 30	Continued decline in Sr-90. VOCs have been below NYS AWQS since 1998.
	Former HWMF	Sr-90	Long Term Response Action	Monitoring	NA	NA	Sr-90 detected at 7.5 pCi/L in well 088-26 in 2004, down from 21.6 in 2003.
OU III	Chemical/Animal Holes	Sr-90	Operational	P&T with ion exchange (IE)	1.27 mCi Sr-90 removed to date	2 of 10	Pilot Study completed. System operational since February 2003. Changed to clinoptilolite resin late 2004.
	Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Operational	P&T with carbon treatment	348 lb of VOCs treated to date	4 of 4	Petition for shutdown approved, system placed on standby August 2004. EW-15 restarted 4/05 to 5/05 due to increased concentrations.
	Building 96 source control	VOCs	Operational	Recirculation wells with AS	67 lbs of VOCs treated to date	3 of 2 (planned)	Treatment wells RTW-2, -3, and -4 were put in standby mode July 2004. Application of potassium permanganate performed for silt zone December 2004 and Jan 2005. Treatment well RTW-1 placed in stand-by 6/1/05.
	South Boundary	VOCs	Operational	P&T with AS	2,276 lbs of VOCs treated to date	7 of 13	Continued decline in monitoring well VOC concentrations at the site boundary with the exception of several wells in the vicinity of EW-4 and EW-5. EW-12 maintained in standby mode in 2004 due to low VOC concentrations.
	Middle Road	VOCs	Operational	P&T with AS	520 lbs of VOCs treated to date	3 of 25	Extraction wells RW-1 and -2 show moderate VOC levels. Eastern extraction wells showing low VOC concentrations. RW-4 and RW-5 remained in standby mode due to low VOCs.

continued

Table E-2 *(continued)***.**
Groundwater Restoration Progress.

Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
OU III (cont.)	Western South Boundary	VOCs	Operational	P&T with AS	32 lbs of VOCs treated to date	2 of 11	Extraction well VOC concentrations continue to remain low. Maximum total VOCs in monitoring well during 2004 was 57 µg/L.
	Industrial Park	VOCs	Operational	In-well stripping	838 lbs. of VOCs treated to date.	5 of 12	Generally decreasing VOC levels with the exception of fluctuating VOC concentrations in the eastern portion of system.
	Industrial Park East	VOCs	Operational	P&T with carbon treatment	17 lbs. of VOCs treated to date.	1 of 5	Began operations mid 2004. Concentrations in VOC plume in this area showed a decreasing trend in 2004.
	North Street	VOCs	Operational	P&T with carbon treatment	115 lbs. of VOCs treated to date.	1 of 4	Began operations mid 2004. VOC plume continued to migrate south with higher concentration portion of plume reaching Vita Dr. in 2004.
	North Street East	VOCs	Operational	P&T with carbon	5 lbs. of VOCs treated to date.	1 of 10	Began operations mid 2004.
	Long Island Power Authority (LIPA) Right of Way/ Airport	VOCs	Operational	P&T and recirculation wells with carbon treatment	62 lbs. of VOCs treated to date.	1 of 10	Began operations mid 2004. Low VOC concentrations continue at Airport.
	Magothy	VOCs	Operational	P&T with carbon treatment	NA	NA	Two additional Magothy extraction wells became operational at LIPA and IPE mid 2004. Significant mass removal seen at LIPA extraction well.
	HFBR Tritium	Tritium	The pump & recharge system remained in standby	Monitoring, Contingency of pump and recharge	0.2 Ci removed for off-site disposal. 180 lb of VOCs also removed from aquifer & treated.	NA	Temporary wells installed to support plume monitoring. High concentration area still migrating south, now south of Rowland St. Peak concentration observed in 2004 was 433,000 pCi/L, along Temple Place.
	BGRR/Waste Concentration Facility (WCF)	Sr-90	Construction /Startup Testing	P&T with IE	NA	0 of 10	Began operations early 2005.
OU IV	AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	35 lb of VOCs treated to date.	4 of 4	VOC concentrations in monitoring wells remain low. System decommissioned in Dec. 2003.
	AOC 6/650 sump outfall	Sr-90	Long Term Response Action	Monitored Natural Attenuation (MNA)	Plume slowly migrating south within monitoring-well network.	NA	Sr-90 plume still migrating slowly southwest from Bldg. 650 sump outfall. Highest Sr-90 detection was 24 pCi/L, in well 76-169 (Mar. 2004). Sr-90 concentrations in well 76-28 reached 15 pCi/L in March 2004.
OU V	STP	VOCs, tritium	Long Term Response	MNA	NA	NA	Low-level VOC plume concentra-tions remained stable during

Table E-2 *(continued)***.**
Groundwater Restoration Progress.

Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
			Action				2004. Tritium continues to be detected in monitor wells above detection limits but well below NYS AWQS, and continued to slowly decline.
OU VI	Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon treatment	<1 lb of VOCs treated to date (1)	1 of 10	Began operations mid 2004. The highest EDB concentration in a monitoring well in 2004 was 4.1 µg/L.

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
HWMF = Hazardous Waste Management Facility (former)
IE = Ion Exchange
MNA = Monitored Natural Attenuation
NA = Not Applicable
NYS AWQS = New York State Ambient Water Quality Standards
P&T = Pump and Treat
RA = Removal Action
STP = Sewage Treatment Plant

(1) EDB was not detected in the system influent in 2004. However, other low-level VOCs not attributable to BNL were detected; the results are potentially due to analytical lab contamination.

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1.0 INTRODUCTION AND OBJECTIVES

The mission of Brookhaven National Laboratory's Groundwater Protection Program is to protect and restore the aquifer system at BNL. The program is summarized in the *BNL Groundwater Protection Management Program Description* (Paquette et al. 2002). The program is built on four key elements:

- Pollution prevention–preventing the potential pollution of groundwater at the source
- Restoration–restoring groundwater that BNL operations have impacted
- Monitoring–monitoring the effectiveness of pollution-prevention efforts, as well as progress in restoring the quality of affected groundwater
- Communication–communicating the findings and results of the program to regulators and stakeholders

The *BNL Calendar Year 2004 Groundwater Status Report* is a comprehensive summary of groundwater data collected in 2004 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the eighth annual groundwater status report issued by the Laboratory. This document is unique in that it examines performance of the program on a project-by-project (facility-by-facility) basis, as well as comprehensively in a "watershed-like" analysis.

How To Use This Document. This document is a detailed technical report that includes analytical laboratory data, as well as data interpretations conducted by BNL's groundwater group. This technical document is intended for internal users, regulators, and other technically oriented stakeholders. Generalized summaries of this information can be obtained through BNL's website, and the Community Affairs Office. Data are presented in five key subject areas:

- Improvements to the understanding of the hydrogeologic environment and surrounding areas
- Identification of any new impacts to groundwater quality due to BNL's active operations
- Progress in cleaning contaminated groundwater
- Proposed changes to the groundwater protection program

This document satisfies BNL's requirement to report groundwater data under the Interagency Agreement and partially fulfills the commitment of the Groundwater Protection Program to communicate the program's findings and progress to regulators and stakeholders.

Chapter 1 discusses the drivers of the data collection work in 2004, the site's groundwater classification, and the objectives of groundwater monitoring. Chapter 2 discusses improvements to our understanding of the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2004. In Chapter 3, the groundwater cleanup data and progress towards achieving the site's cleanup goal are described. Chapter 4 outlines the groundwater surveillance data used to verify that operational and engineered controls are preventing further contamination from the site's active experimental and support facilities. Chapter 5 is a summary of the proposed recommendations to the Groundwater Protection Program identified in Chapter 3.

Appendices A and **B** include hydrogeologic data that support the discussions in Chapter 2. **Appendix C** contains the analytical results for each sample obtained under the Environmental Restoration monitoring program. **Appendix D** contains analytical results for each sample obtained under the Environmental Surveillance program. Due to the volume of these data, all of the report appendices are included on a CD ROM, which significantly reduces the size of this report in printed format. The CD ROM has a contents table with active links; by selecting the specific project and analytical suite, the user will be directed to the associated table of results. The results also can be printed from the CD ROM. The groundwater results are arranged by specific monitoring project and analytical group: Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, general chemistry, pesticides/PCBs, and radionuclides. The data are organized further by well identification (ID) and the date of sample collection. Chemical/radionuclide concentrations, detection limits, and uncertainties are reported, along with a data verification, validation, and/or usability qualifier (if assigned), and/or a laboratory data qualifier. If a data verification/validation qualifier was not assigned, the laboratory data qualifier is shown. Results exceeding the corresponding groundwater standard or guidance criteria (see **Section 1.1.2**) are identified by bold text. Including the complete results enables the reader to analyze the data in detail. **Appendix E** contains information on sample collection, analysis, and Quality Assurance/Quality Control. **Appendix F** consists of data supporting the remediation system discussions in Chapter 3, and **Appendix G** is a compilation of data usability report forms.

1.1 Groundwater Monitoring Program

Groundwater is monitored at BNL for two reasons:

1. To meet regulatory requirements.
2. Monitoring is an integral part of ISO 14001 Environmental Management Systems.

1.1.1 Regulatory Drivers

Activities at BNL are driven by federal and state regulations as well as DOE orders.

Comprehensive Environmental Response, Compensation and Liability Act

On December 21, 1989, BNL was included as a Superfund Site on the National Priorities List of contaminated sites identified for priority cleanup. DOE, EPA, and NYSDEC created a comprehensive Federal Facilities Agreement that integrated DOE's response obligations under CERCLA, RCRA (the Resource Conservation and Recovery Act), and New York State hazardous waste regulations. The interagency agreement that was finalized and signed by these parties in May 1992 (EPA 1992) includes a requirement for groundwater monitoring.

New York State Regulations, Permits, and Licenses

The monitoring programs for the Current Landfill and Former Landfill are designed in accordance with post-closure Operation and Maintenance requirements specified in 6 NYCRR (New York Code of Rules and Regulations) Part 360, *Solid Waste Management Facilities*.

BNL's Major Petroleum Facility (MPF) is operated under NYSDEC Bulk Petroleum Storage License No. 01-1700. This license requires BNL to routinely monitor the groundwater. Together with approved engineering controls, the groundwater-monitoring program verifies that storage operations for bulk fuel have not degraded the quality of the groundwater. The engineering controls and monitoring program for the MPF are described in the *BNL Spill Prevention, Control and Countermeasures Plan* (BNL 2001).

BNL's Waste Management Facility (WMF) is a hazardous waste storage facility operated under NYSDEC Permit No. 1-422-00032/00102-0. The permit requires groundwater monitoring as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls.

DOE Orders

DOE Order 450.1, Section 5-D-14, *Responsibilities*, states that DOE facilities are required to "Conduct environmental monitoring, as appropriate, to support the site's ISMS [Integrated Safety Management System], to detect, characterize, and respond to releases from DOE activities; assess impacts; estimate dispersal patterns in the environment; characterize the pathways of exposure to members of the public; characterize the exposures and doses to individuals, to the population; and to evaluate the potential impacts to the biota in the vicinity of the DOE activity" (DOE 2003).

1.1.2 Groundwater Quality and Classification

In Suffolk County, drinking water supplies are obtained exclusively from groundwater aquifers (e.g., the Upper Glacial aquifer, the Magothy aquifer, and, to a limited extent, the Lloyd aquifer). EPA designated the Long Island aquifer system as a sole source aquifer in 1978, pursuant to Section 1424(e) of the Safe Drinking Water Act (SDWA). Groundwater in the sole source aquifers underlying the BNL site is classified as "Class GA Fresh Groundwater" by the State of New York (6 NYCRR Parts 700–705); the best usage of Class GA groundwater is as a source of potable water. Accordingly, in establishing the goals for protecting and remediating groundwater, BNL followed federal Drinking Water Standards (DWS), NYS DWS, and NYS Ambient Water Quality Standards (AWQS) for Class GA groundwater.

For drinking water supplies, the applicable federal MCLs are set forth in 40 CFR (Code of Federal Regulations) 141 (for primary MCLs) and 40 CFR 143 (for secondary MCLs). In New York State, the SDWA requirements relating to the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code (10 NYCRR Part 5), enforced by SCDHS as an agent for the New York State Department of Health (NYSDOH). These regulations apply to any water supply that has at least five service connections or that regularly serves at least 25 individuals. BNL supplies water to approximately 3,500 employees and visitors and therefore must comply with these regulations. In addition, DOE Order 5400.5, *Radiation Protection of the Public and Environment* (DOE 1990), establishes Derived Concentration Guides (DCGs) for radionuclides not covered by existing federal or state regulations.

BNL evaluates the potential impact of radiological and nonradiological levels of contamination by comparing analytical results to NYS and DOE reference levels. Nonradiological data from groundwater samples collected from surveillance wells usually are compared to NYS AWQS (6 NYCRR Part 703.5). Radiological data are compared to the NYS AWQS for tritium, Sr-90, and gross beta; the NYS AWQS for gross alpha, radium-226, and radium-228; and the 40 CFR 141/DOE DCGs for determining the 4 mrem/yr dose for other beta- or gamma-emitting radionuclides.

Tables 1-1, 1-2, 1-3, and **1-4** show the regulatory and DOE "standards, criteria, and guidance" used for comparisons to BNL's groundwater data.

1.1.3 Monitoring Objectives

Groundwater monitoring is driven by regulatory requirements, DOE Orders, best management practice, and BNL's commitment to environmental stewardship. The Laboratory monitors its groundwater resources for the following reasons:

Groundwater Resource Management

- To support initiatives in protecting, managing, and remediating groundwater by refining the conceptual hydrogeologic model of the site and maintaining a current assessment of the dynamic patterns of groundwater flow and water table fluctuations.
- To determine the natural background concentrations for comparative purposes. The site's background wells provide information on the chemical and radiological composition of groundwater that has not been affected by BNL's activities. These data are a valuable reference for comparison with the data on groundwater quality from affected areas. The network of wells also can warn of any contaminants originating from potential sources that may be located upgradient of the BNL site.
- To ensure that potable water supplies meet all regulatory requirements.

Groundwater Surveillance

- To verify that operational and engineered controls effectively prevent groundwater contamination.
- To trigger early action and communication, should the unexpected happen (e.g., control failure).
- To determine the efficacy of the operational and engineered control measures designed to protect the groundwater.
- To demonstrate compliance with applicable requirements for protecting and remediating groundwater.

Groundwater Restoration

- To track a dynamic groundwater cleanup problem when designing, constructing, and operating treatment systems.
- To measure the performance of the groundwater remediation efforts in achieving cleanup goals.
- To protect public health and the environment during the cleanup period.
- To define the extent and degree of groundwater contamination.
- To provide early warning of the arrival of a leading edge of a plume, thereby triggering contingency remedies to protect public health and the environment.

The details of the monitoring are described in the *BNL Environmental Monitoring Plan* (BNL 2000a, 2003). This plan includes a description of the source area, description of groundwater quality, criteria for selecting locations for groundwater monitoring, and the frequency of sampling and analysis. **Figure 1-1** highlights BNL's OU locations designated as part of the CERCLA program, and key site features. Details on the sampling parameters, frequency, and analysis by well are listed in **Tables 1-5** and **1-6**. **Figure 1-2** shows the locations of wells monitored as part of the Laboratory's groundwater protection program.

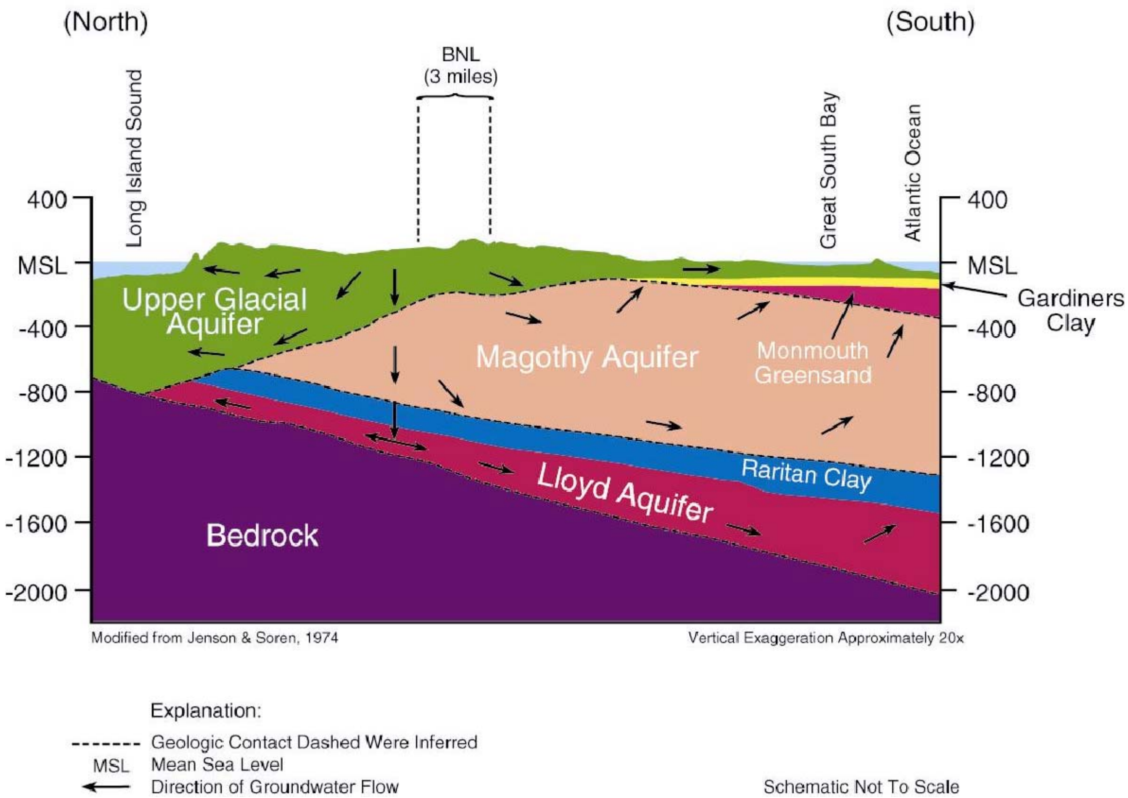
Since 2001, BNL has been using a structured Data Quality Objective (DQO) process to review and refine the groundwater monitoring and remediation projects. The results of the DQO reviews are documented annually in updates to the *BNL Environmental Monitoring Plan*.

2.0 HYDROGEOLOGY

This section briefly describes the improvements to our understanding of the hydrogeologic environment at BNL and the surrounding area. It also summarizes the dynamics of the groundwater flow system in 2004 along with on-site pumping rates and rainfall recharge.

Detailed descriptions, including the lithology and the geometry of the aquifer underlying BNL and its surrounding areas, are found in the U.S. Geologic Survey (USGS) report by Scorca and colleagues (1999), *Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, New York, 1994–97,* and the USGS report by Wallace deLaguna (1963), *Geology of Brookhaven National Laboratory and Vicinity, Suffolk County New York.* The stratigraphy below BNL consists of approximately 1,300 feet of unconsolidated deposits overlying bedrock (**Figure 2-1**). Among these unconsolidated deposits, the current groundwater monitoring program focuses on groundwater quality within the Upper Pleistocene deposits, and the upper portions of the Matawan Group-Magothy Formation.

Figure 2-1. Generalized Geologic Cross Section in the Vicinity of Brookhaven National Laboratory.



The Pleistocene deposits are about 100–200 feet thick and are divided into two primary hydrogeologic units: undifferentiated sand and gravel outwash and moraine deposits, and the finer-grained, more poorly sorted stratigraphic Upton Unit. The Upton Unit makes up the lower portion of the Upper Glacial aquifer beneath several areas of the site. It generally consists of fine- to medium-white to greenish sand with interstitial clay. In addition to these two major hydrogeologic units, there are several other distinct hydrogeologic units within the Upper Glacial aquifer. They include localized, near-surface clay layers in the vicinity of the Peconic River (including the STP area), and reworked Magothy deposits that characterize the base of the aquifer in several areas. The Gardiners Clay is a regionally defined geologic unit that is discontinuous beneath BNL and areas to the south. Typically, it is characterized by variable amounts of massive green silty clay, sandy, and gravelly green clay, and clayey silt. Where it exists, the

Gardiners Clay acts as a confining or semi-confining unit that impedes the vertical flow and migration of contaminants between the Upper Glacial aquifer and the underlying Magothy aquifer.

The Magothy aquifer is composed of the continental deltaic deposits of the Cretaceous Age that unconformably underlie the Pleistocene deposits. The Magothy aquifer at BNL is approximately 800 feet thick, and because it is composed of fine sand interbedded with silt and clay, it is generally less permeable than the Upper Glacial aquifer. The Magothy aquifer is highly stratified. Of particular importance at BNL is that the upper portion of the Magothy contains massive, locally continuous layers of grey-brown clay (referred to herein as the Magothy Brown Clay). Regionally, the Magothy Brown Clay is not interpreted as being continuous; however, beneath BNL and adjacent off-site areas, it acts as a confining unit (where it exists), impeding the vertical groundwater flow and movement of contaminants between the Upper Glacial and Magothy aquifers.

Regional patterns of groundwater flow near BNL are influenced by natural and artificial factors. **Figures 2-2 and 2-3** show the locations of pumping wells and recharge basins. Under natural conditions, recharge to the regional aquifer system is derived solely from precipitation. A regional groundwater divide exists immediately north of BNL near Route 25. It is oriented roughly east–west, and appears to coincide with the center line of a regional recharge area. Groundwater north of this divide flows northward, ultimately discharging to the Long Island Sound (**Figure 2-1**). Shallow groundwater in the BNL area generally flows to the south and east. During high water table conditions that groundwater can discharge into local surface water bodies such as the Peconic River and adjacent ponds. The BNL site is within a regional deep-water recharge area, where downward flow helps to replenish the deep sections of the Upper Glacial aquifer, the Magothy aquifer, and the Lloyd aquifer. South of BNL, groundwater flow becomes more horizontal and ultimately flows upward as it moves toward regional discharge areas such as Carmans River and Great South Bay. Superimposed on the natural regional field of groundwater flow are the artificial influences due to pumping and recharge operations.

2.1 Hydrogeologic Data

Various hydrogeologic data collection and summary activities were undertaken as part of the 2004 Groundwater Protection Program to evaluate groundwater flow patterns and conditions. This work is described in the following sections and includes the results of groundwater elevation monitoring, information on pumping and recharging activities on and off site, and precipitation data.

2.1.1 Groundwater Elevation Monitoring

Synoptic water levels are obtained quarterly from a network of on-site and off-site wells screened at various depths within the Upper Glacial aquifer and upper portions of the Magothy aquifer. These data are used to characterize the groundwater flow-field (direction and rate) and to evaluate seasonal and artificial variations in its flow patterns. Additional water level data from off-site wells are obtained from USGS.

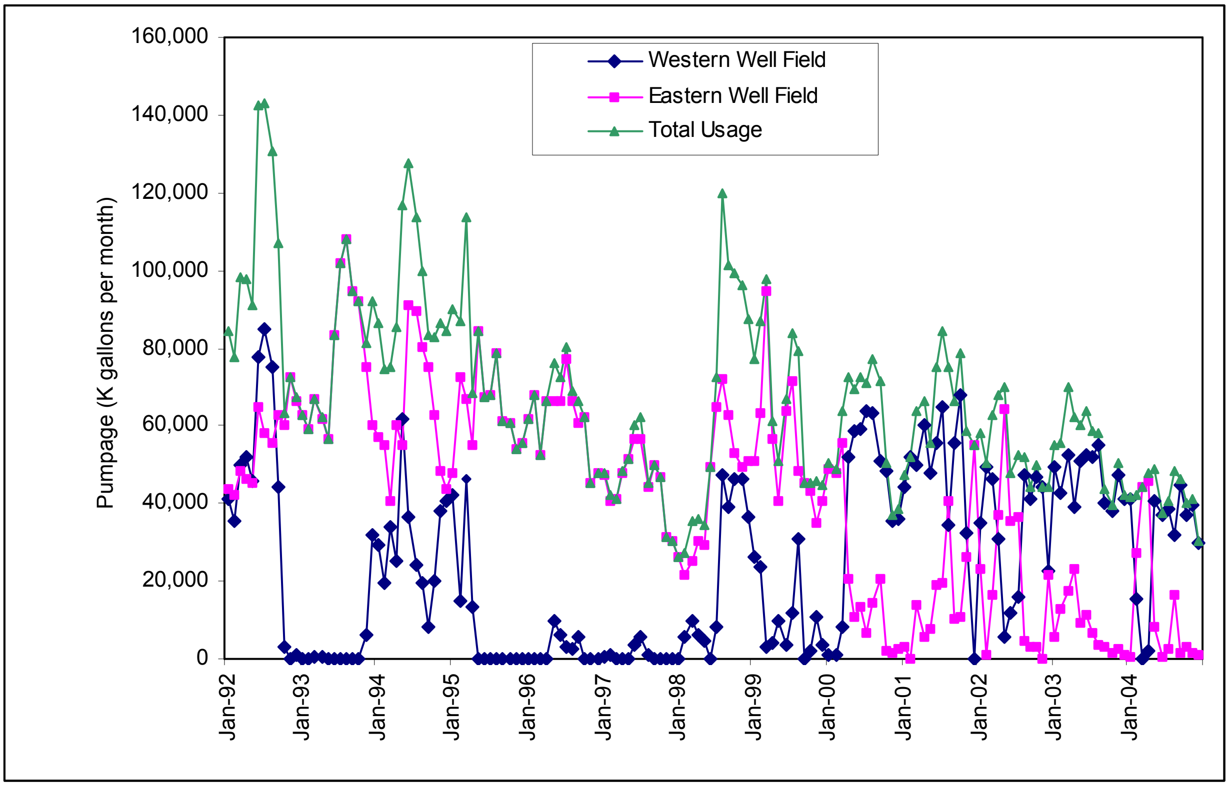
During 2004, water level data were collected during four synoptic events from March 15 to 17, June 14 to 16, September 20 to 23, and December 20 to 23, measuring 560 to 715 wells each period. Approximately 150 fewer wells were measured in March because an ice storm caused working conditions to become treacherous; the monitoring event was halted due to safety concerns. The number of wells monitored has remained below previous levels as a continued effort to improve cost efficiency of the water level monitoring program. Water levels were measured with electronic water level indicators following BNL's Environmental Management Standard Operating Procedure (EM-SOP)-300. **Appendix A** (on the companion CD-ROM) has the depth-to-water (DTW) measurements and the calculated groundwater elevations for these quarterly synoptic measurements. Long-term and short-term hydrographs for select wells are discussed in **Section 2.2**.

2.1.2 Pumpage of On-Site Water Supply and Remediation Wells

BNL operates six water supply wells to provide potable and process cooling water, and 40 active treatment wells and 12 treatment wells that are in standby mode to hydraulically contain and remediate contaminated groundwater. **Figures 2-2** and **2-3** show the locations of the water supply and remediation wells. The effects the groundwater withdrawals have on the aquifer system are discussed in **Section 2.2**.

Table 2-1 provides the monthly and total water usage for 2004 for the six on-site potable process supply wells (4, 6, 7, 10, 11, and 12). It includes information on each well's screened interval and pumping capacity. These wells primarily withdraw groundwater from the middle section of the Upper Glacial aquifer. The variation in monthly pumpage primarily reflects changes in water demand, and maintenance schedules for the water supply system. The western potable well field includes wells 4, 6, and 7; the eastern field contains wells 10, 11, and 12. The BNL Pump and Recharge Management Subcommittee currently prefers that the western well field be used as the primary source of water. Using the western well field minimizes the effects of supply well pumping on several segments of the groundwater contaminant plumes located in the center of the BNL site. **Figure 2-4** below summarizes monthly pumpage for the eastern and western well fields.

Figure 2-4.
Summary of BNL Supply Well Pumpage 1992 through 2004.



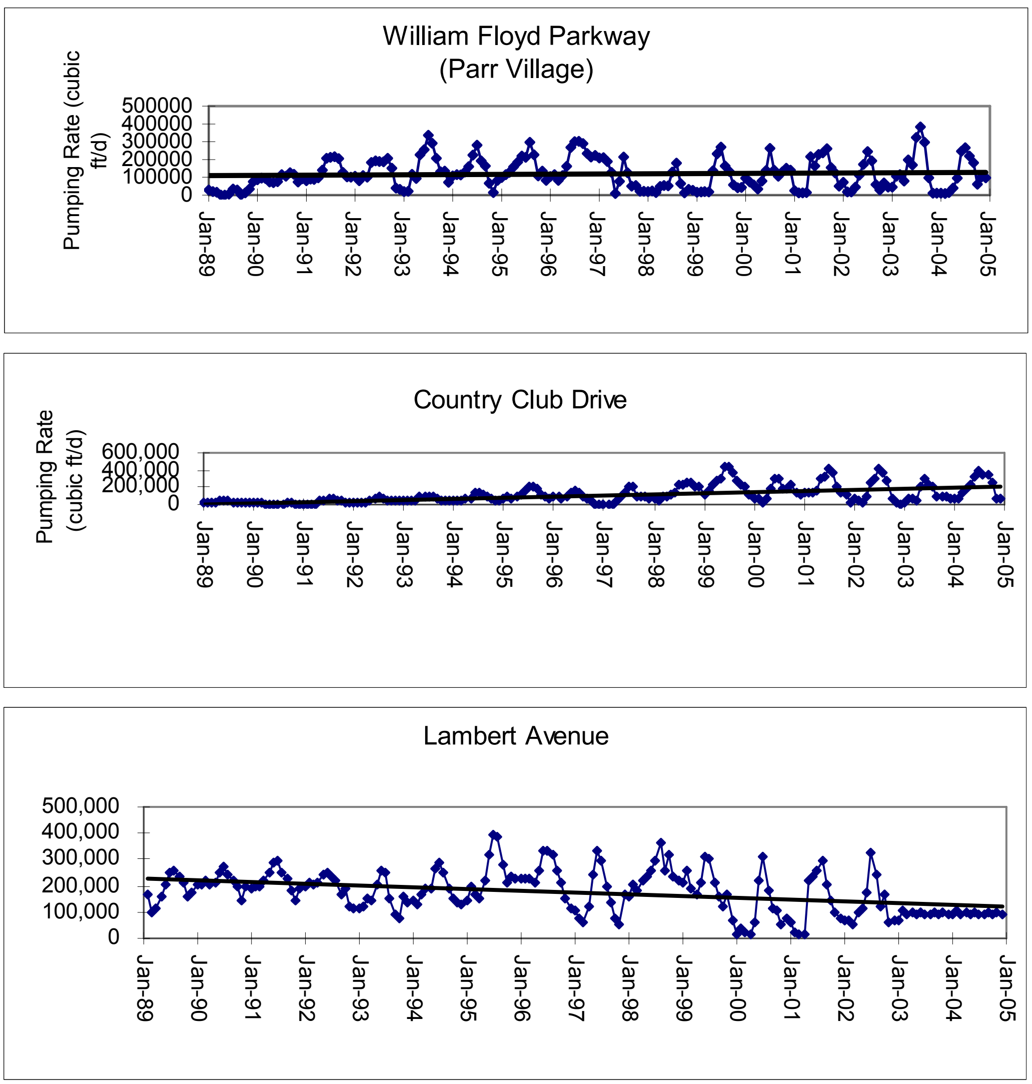
The western well field was the primary source of water for 2004. Overall, BNL's pumping of potable water generally decreased since 1999. This reduction is mainly due to water conservation measures throughout the Laboratory. Process water usage at BNL has been reduced to negligible levels due to water conservation measures. As a result, Process wells 101, 103, and 105 have been abandoned, and most of the remaining process water is supplied through the potable water system. **Table 2-2** summarizes the 2004 BNL process water usage. **Table 2-3** summarizes the 2004 monthly water pumpage for the groundwater remediation systems.

2.1.3 Off-Site Water Supply Wells

Several SCWA well fields are located near BNL. The two closest SCWA well fields are the William Floyd (Parr Village) Well Field and Country Club Drive Well Field (see **Figure 2-5** for locations of the SCWA well fields). Other SCWA well fields (e.g., Lambert Avenue) are sited south of Sunrise Highway.

The William Floyd Well Field is west/southwest of BNL (**Figure 2-5**), and consists of three water supply wells that withdraw groundwater from the mid Upper Glacial aquifer and the upper portion of the Magothy aquifer. Country Club Drive Well Field is south/southeast of BNL, and consists of three water supply wells that withdraw groundwater from the mid section of the Upper Glacial aquifer. Information for 1989 through 2004 is provided as **Figure 2-6.** In 2004, the William Floyd (Parr Village) and Country Club Drive Well Fields produced 421 and 372 millions of gallons per year, respectively. Lambert Avenue produced 366 million gallons in 2004. While there are seasonal variations, the pumpage rate at William Floyd has been reasonably steady for the past 10 years. However, pumpage at Lambert Avenue is decreasing and pumpage at Country Club Drive is increasing.

Figure 2-6.
Suffolk County Water Authority Pumping Near BNL.



2.1.4 Summary of On-Site Recharge and Precipitation Data

Components of this recharge include sources of artificial recharge (i.e., on-site recharge basins) and natural recharge from precipitation. **Table 2-4** summarizes the monthly and total flow of water through the 10 on-site recharge basins during 2004. Their locations are shown on **Figures 2-2 and 2-3**. **Section 2.2** (Groundwater Flow) provides a discussion on the effects associated with recharge. Seven of the basins (HN, HO, HS, HT-W, HT-E, HX, and HZ) receive stormwater runoff and water that was withdrawn by BNL's supply wells but not consumed or lost via evaporation. Flow into these basins is monitored monthly. Basin HP is no longer in use and has been removed form this report. Generally, the amount of water recharging to the groundwater system via these basins reflects supply well pumpage. Annual water supply flow diagrams show the general relationships between recharge basins and the supply wells, and are published in Volume I of the annual Site Environmental Report.

The remaining three basins (Removal Action V [RA V], OU III, and Western South Boundary) were constructed to recharge water processed through the groundwater remediation systems. Until September 2001, treated groundwater from the OU III South Boundary Pump and Treat System was discharged solely to the OU III basin, adjacent to former recharge basin HP along Princeton Avenue. After September 2001, groundwater from that system and the OU III Middle Road Pump and Treat System was discharged equally to the OU III and RA V basins. Treated groundwater from the OU I South Boundary is discharged to the RA V basin. **Table 2-4** gives estimates of flow to these basins. The discharge to these basins for 2004 (21 and 44 million gallons per month, average, for the OU III and RA V basins, respectively) is significantly greater than that from other individual on-site basins.

Other important sources of artificial recharge, not included in **Table 2-4**, include a stormwater retention basin referred to as HW (on Weaver Drive), and the sand filter beds at the STP. Basin HW causes localized mounding of the water table. At the sand filter beds, approximately 10 to 15 percent of the treated effluent (approximately 15 million gallons annually) seeps directly to the underlying water table via leaks in the underlying tile-drain collection system. The remaining treated effluent (approximately 130 million gallons annually) is discharged from the STP to the Peconic River. Most of it recharges the water table before reaching the BNL site boundary, except during times of seasonally high water levels, such as the spring.

Precipitation provides the primary recharge to the groundwater system at BNL. In an average year, approximately 24 inches of rainfall recharges the Upper Glacial aquifer. Under long-term conditions in undeveloped areas of Long Island, about 50 percent of precipitation is lost through evapotranspiration and direct runoff to streams; the other 50 percent infiltrates the soil and recharges the groundwater system (Aronson and Seaburn 1974; Franke and McClymonds 1972). In 2004, it is estimated that the recharge at BNL was approximately 18 inches. **Table 2-5** summarizes monthly and annual precipitation results from 1949 to 2004 collected on site by the BNL Meteorology Group. Variations in the water table generally can be correlated with the amount of precipitation. As depicted in **Table 2-5**, total annual precipitation in 2004 was 35.86 inches, well below the yearly average of 48.76 inches, and significantly less than the total annual precipitation in 2003, which was 63.11 inches. Monthly precipitation for 2004 ranged from 1.34 inches (June) to 5.14 inches (September).

2.2 Groundwater Flow

BNL routinely monitors horizontal and vertical groundwater flow directions and magnitudes within the Upper Glacial aquifer and uppermost Magothy aquifer by using water level data collected from a large network of on- and off-site monitoring wells. Short-term and long-term seasonal fluctuations of water levels are also evaluated using hydrographs for select wells, and trends in precipitation.

2.2.1 Water Table Contour Maps

Figure 2-2 shows groundwater elevation contour maps representing the configuration of the water table for December 2004. The contours were generated from the water level data collected during the December 2004 synoptic round from shallow glacial wells, assisted by a computer-aided contouring package (Quick SURF). Localized hydrogeologic influences on groundwater flow were considered, including on-site and off-site pumping wells, and on-site recharge basins (summarized in **Section 2.1**).

Groundwater flow in the shallow Upper Glacial aquifer in 2004 generally was characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly direction at the southern boundary and beyond. Flow directions in the eastern portion of BNL are predominately to the east and southeast (**Figures 2-2 and 2-3**). This pattern is consistent with comparable historical data published by SCDHS and USGS.

The highest water table elevations on site were in the northwestern section, (nearest the groundwater divide), varying from a high of approximately 52 feet above mean sea level (msl) in June, to a low of approximately 49 feet above msl in December. The lowest elevations were along the southern boundary, with a high of approximately 37 feet above msl in June and a low of approximately 34 feet above msl in December. Localized hydrogeologic disturbances are evident on the groundwater contour maps. They result primarily from active on- and off-site pumping wells, and on-site recharge basins. Influences from the pumping wells can be seen as cones of depressions, most notably near potable supply well 7 and near the groundwater treatment wells along the southern boundary (**Figure 2-2**).

Influences from water recharge activities can be observed as localized mounding of the water table, particularly around recharge basin HO and the RA V basin (in the central site), the OU III basins, and the STP. The degree of mounding is generally consistent with the monthly flows to recharge basins summarized in Section 2.1. However, mounding also reflects the ability of the underlying deposits to transmit water, which varies across the site. For example, the volume of recharged water at the STP sand filter beds typically is not as great as that at recharge basin HO or the RA V basin. However, the presence of near-surface clay layers underlying portions of the STP's sand filter beds results in an extensive groundwater mound.

Other noteworthy features are the influence that surface water bodies have on groundwater flow directions. **Figure 2-2** shows groundwater flowing towards the Carmans River in areas south/southwest of BNL. This pattern is consistent with the fact that the Carmans River is a significant discharge boundary.

2.2.2 Deep Glacial Contour Maps

Figure 2-3 shows the potentiometric surface contour maps of the deep zone of the Upper Glacial aquifer for December 2004. The contours were generated in the same manner as the water table contours, but using water level data from wells screened only within the deep glacial zone.

The patterns for groundwater flow in the deep Upper Glacial for 2004 are similar to those in the shallow (or water table) zone. They are characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly flow at the southern site boundary and beyond. In areas south/southwest of BNL, the deep glacial contour maps also show flow toward the Carmans River. The localized influences of pumping on the potentiometric surface configurations are evident as cones of depression. As with the water table configurations, variations in these localized hydrogeologic effects are attributed to the monthly variations in pumpage.

Although the localized influences of recharging on the potentiometric surface configurations are evident for the deep Upper Glacial aquifer, they are not as pronounced as those observed at the water table. Such hydrogeologic effects generally decrease with depth in the aquifer. Furthermore, mounding is not inferred beneath the STP sand filter beds because mounding is controlled by shallow, near-surface clay layers. Finally, the surface water/groundwater interactions along the Peconic River are not thought to influence the deep glacial zone.

2.2.3 Upper Magothy Aquifer Contour Map

The addition of deep wells installed as part of the Magothy Characterization in 2002 allow for an Upper Magothy potentiometric surface map to be generated (**Figure 2-5**). The patterns for groundwater flow in the Upper Magothy for 2004 are similar to those in the deep glacial zone. Groundwater flow directions were characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly flow at the southern site boundary and beyond.

2.2.4 Well Hydrographs

Groundwater hydrographs are useful in estimating recharge rates and the location of the water table relative to contaminant sources. Long-term (typically 1950–2004) and short-term (1997–2004) well hydrographs were constructed from water level data that were obtained for select USGS and BNL wells, respectively. These hydrographs track fluctuations in water level over time. Precipitation data also were compared to natural fluctuations in water levels. **Appendix B** contains the well hydrographs and precipitation- trend graphs, together with a map depicting the locations of these wells.

Seven long-term hydrographs were constructed from historical data on water level elevation obtained from wells installed and maintained by USGS and BNL. These wells provide reasonable areal coverage for historical trends in areas both on site and surrounding BNL (just south of the southern boundary). Changes in water level elevations indicate a long-term variability, with fluctuations from 8 to 14 feet. The maximum variation, 14 feet, reflects the fact that the period of record began in the early 1950s and subsequently encompassed the regional drought of the 1960s. The minimum variation of 8 feet is more indicative of the change in water level elevations since the late 1970s and early 1980s. These fluctuations correlate reasonably with long-term precipitation trends for a similar period.

Quarterly data on water levels collected during 2004 were used to construct nine short-term hydrographs from three well clusters (well cluster 75-39/-40/-41, 105-05/-07/-24, and 122-01/-04/-05). Generally, the highest groundwater elevations can be expected during March, based on long-term averages. This was not the case in 2004, which had less than normal precipitation early in the year, leading to a slightly lower water table in March and a relatively high water table elevation in June. The water table decreased to the expected seasonally lower elevations during September and December. This seasonal fluctuation, while slightly out of phase with historical trends, generally correlates to the short-term trends in precipitation given in **Table 2-5**.

2.3 New Geologic Data

The focus of the Environmental Restoration Program related to groundwater activities in 2004 was the construction of groundwater remediation systems as opposed to aquifer characterization. Incidental new data were collected during the installation of recovery and injection wells; specifically at the site of the Industrial Park East groundwater remediation system. However, these data did not alter the BNL site conceptual model.

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3.0 ENVIRONMENTAL RESTORATION GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during calendar year 2004. The chapter is organized first by Operable Unit, and then by the specific groundwater remediation system and/or monitoring program. **Figure 1-2** shows the locations of monitoring wells throughout the site and by project. Monitoring well location maps specific to particular monitoring programs are included throughout Chapter 3.

Report and Data on CD

Appendices C and D contain the analytical results for each sample. Due to the large volume of data, these appendices are included on a CD ROM; this significantly reduces the size of the hardcopy of this report. The CD ROM has a table of contents with active links, such that, by selecting the specific project and analytical suite, the user will be directed to the associated table of results. Users can print a hardcopy of the results from the CD ROM. The groundwater results are arranged by specific monitoring project and then by analytical group (VOCs, SVOCs, metals, chemistry, pesticides/PCBs, and radionuclides). The data are organized further by well ID and the date of collection of the sample. Chemical/radionuclide concentrations, detection limits, and uncertainties are reported, along with a data verification, validation, and/or usability qualifier (if assigned), and/or a laboratory data qualifier. If a data verification/validation qualifier was not assigned, the laboratory data qualifier is presented. Results that exceed the corresponding groundwater standard or guidance criteria (see **Section 1.1.1** [Regulatory Drivers]) are in bold text. Inclusion of the complete results allows the reader to analyze them in detail. In addition, this entire report is included on the CD-ROM with active links to tables and figures.

About the Plume Maps

Maps are provided that depict the areal extent and magnitude of the contaminant plumes. In most cases, the volatile organic compound (VOC) plumes were simplified by using the total VOC (TVOC) values for drawing the contours, except for those plumes that consist almost exclusively of one chemical, such as the OU III Carbon Tetrachloride plume and the OU VI Ethylene Dibromide (EDB) plume. TVOC concentrations are a summation of all the individual VOCs analyzed by EPA Method 524.2.

The extent of plumes containing VOC contamination was contoured to represent concentrations that were greater than the typical NYS AWQS of 5 micrograms per liter (μg/L) for most compounds. Most radionuclide plumes were contoured to their appropriate maximum contaminant levels. The exception to this is the High Flux Beam Reactor (HFBR) Tritium Plume, which is contoured to 1,000 pico Curies per liter (pCi/L), or one twentieth of the 20,000 pCi/L drinking water standard. **Figure 3.0-1** shows the VOC and radionuclide plumes as well as the locations and groundwater capture zones for each of the treatment systems.

Following the capping of the landfill areas and the beginning of active groundwater remediation systems in 1997, there have been significant changes in the size and concentrations of several of the VOC plumes. These changes can be attributed to the following:

- The beneficial effects of active remediation systems
- Source control and removal actions
- The impacts of BNL pumping and recharge on the groundwater flow system
- Radioactive decay, biological degradation, and natural attenuation

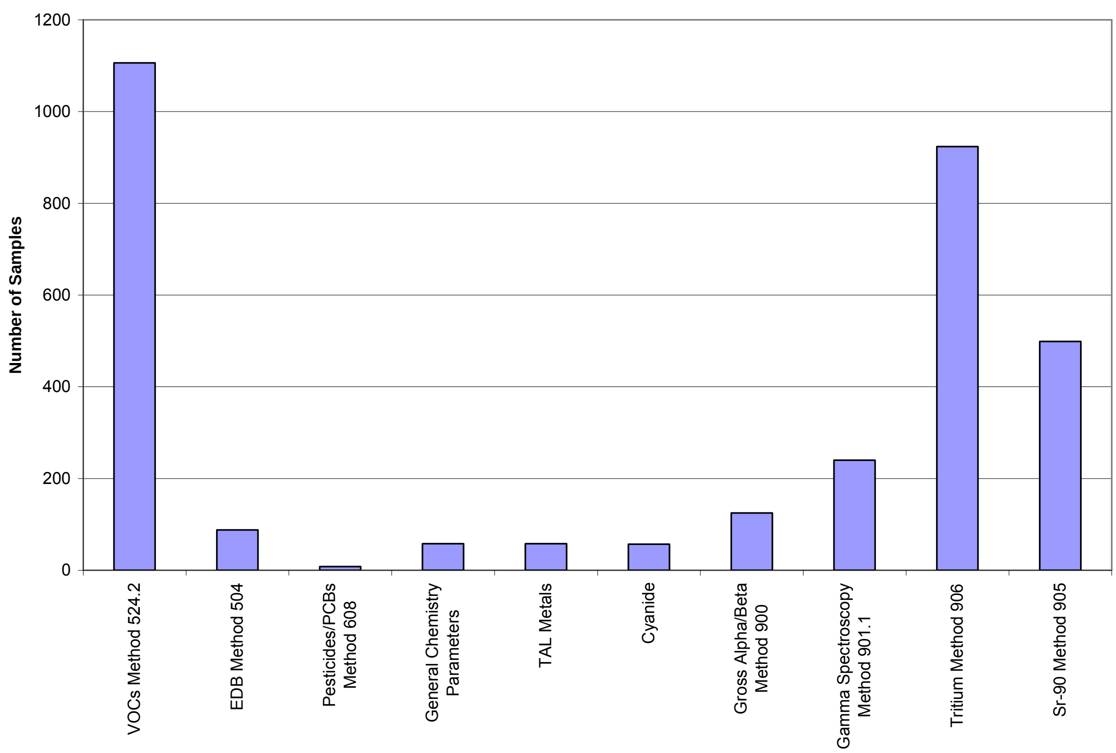
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by:

- The addition of permanent monitoring wells to the existing well networks
- The installation of temporary wells during groundwater characterization efforts that helped to fill in data gaps

During 2004, the contaminant plumes were tracked by collecting 1,889 groundwater samples obtained from 703 on-site and off-site monitoring wells. **Figure 3.0-2** provides a summary of the number of analyses performed, arranged by analytical method. Unless otherwise noted, the extent of contamination for a given plume is depicted by primarily using 2004 data from permanent monitoring wells. In several cases, data from early 2005 were utilized. Contaminant plumes associated with Building 96, HFBR Tritium, Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) Sr-90, and OU I South Boundary projects were further defined using temporary wells (i.e., direct push Geoprobes or vertical profiles).

A single representative round of monitoring data was chosen for each plume, typically from the last quarter of the year because it includes the most comprehensive sampling round for the year. This report also serves as the fourth quarter report for the remediation systems. Contaminant concentration trend plots for key monitoring wells in each plume are provided to identify significant changes. Data from monitoring wells sampled under BNL's Environmental Surveillance Monitoring Program are also evaluated.

Figure 3.0-2.
Summary of Laboratory Analyses Performed for the Environmental Management Program in 2004.



History and Status of Groundwater Remediation at BNL

Groundwater remediation systems have operated at BNL since 1997, beginning with the OU I South Boundary pump and treat system. The goal of groundwater remediation, as defined by the OU III Record of Decision, is, within 30 years or less, to prevent or minimize plume growth and not to exceed MCLs in the Upper Glacial aquifer. Based on additional information obtained during the Strontium-90 Pilot Study, the *OU III Explanation of Significant Differences, BNL 2005* identified changes to the cleanup goal timeframes for the Sr-90 plumes. For the BGRR/WCF and Chemical Holes Sr-90 plumes, MCLs must be reached within 65 years and 40 years, respectively. In addition, cleanup of the Magothy aquifer VOC contamination must meet MCLs within 70 years.

There are currently 12 groundwater remediation systems in operation, of which five began operation in 2004. Two systems are in standby mode (HFBR Tritium Pump and Recharge, and the Carbon Tetrachloride Pump and Treat). Another system has met its cleanup goals and has been abandoned: the OU IV, Area of Concern (AOC) 5, Air Sparge/Soil Vapor Extraction System, referred to as the OU IV AS/SVE. **Figure 3.0-1** shows the locations and groundwater capture zones for each of the treatment systems. In addition to the groundwater treatment systems, two landfill areas (Current and Former) were capped, which minimizes the potential for groundwater contamination.

BNL's Plant Engineering personnel perform routine maintenance checks on the treatment systems daily, in addition to their routine and nonroutine maintenance. BNL's Environmental and Waste Management Services Division (EWMSD) collects the treatment system performance samples (influent, midpoint, effluent). Full details of the maintenance checks are recorded in the system's operation and maintenance daily inspection logs. The daily logs are available at the treatment facility, or in the project files.

In general, BNL uses two types of groundwater remediation systems to treat VOC contamination: pump and treat with air stripping or carbon treatment, or recirculation wells with air stripping or carbon treatment. Pump and treat remediation consists of pumping groundwater from the plume up to the surface and piping it to a treatment system, where the contaminants are removed by either air stripping or granular activated carbon. Treated water then is introduced back into the aquifer via recharge basins, injection wells, or dry wells.

Table 3.0-1 summarizes both the operating and planned remediation systems. Groundwater remediation at BNL is proceeding as predicted. A graph of actual versus model predicted VOC mass removal is shown in **Figure 3.0-3**.

The groundwater monitoring well networks for each program are organized into background, core, perimeter, and bypass wells. The wells are designated as follows:

- Background –water quality results will be used to determine upgradient water quality
- Plume Core – utilized to monitor the high concentration or core area of the plume
- Perimeter – used to define the outer edge of the plume both horizontally and vertically
- Bypass Detection – used to determine whether plume capture performance is being met

Table 3.0-1. Summary of Groundwater Remediation Systems at BNL.

Operable Unit System	Type	Target Contaminant	No. of Wells	Years of Operation	Recharge Method	Pounds VOCs Removed (Year/Cum)
Operable Unit I						
South Boundary	P&T, AS	VOC	2	8	Basin	16 313
Operable Unit III						
South Boundary	P&T, (AS)	VOC	7	7	Basin	172 2276
HFBR Pump and Recharge	Pump and Recirculate	Tritium	3	Standby: 7	Basin	NA 180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	7	5	Recirculation Well	80 838
*Carbon Tet	P&T (Carbon)	VOC	3	Standby: 5	Basin	7 348
Building 96	Recirculation Well (AS/Carbon)	VOC	4	4	Recirculation Well	12 67
Middle Road	P&T (AS)	VOC	6	3	Basin	156 520
Western South Boundary	P&T (AS)	VOC	2	2	Basin	10 32
Chemical Holes	P&T, (IE)	Sr-90	1	2	Dry Well	0.388 1.27
North Street	P&T (Carbon)	VOC	2	1	Wells	115 115
North Street East	P&T (Carbon)	VOC	2	1	Wells	5 5
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	9	1	Wells and Recirculation Well	62 62
Industrial Park East	P&T (Carbon)	VOC	2	1	Wells	17 17
BGRR/WCF	P&T (IE)	Sr-90	5	NA	Dry Wells	NA
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	1	Wells	<1*** <1***

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
EDB = ethylene dibromide
IE = Ion Exchange
LIPA = Long Island Power Authority
NA = Not Applicable
P&T = Pump and Treat
Recirculation = Double screened well with discharge of treated water back to the same well in a shallow recharge screen
In-Well = The air stripper in these wells is located in the well vault.

* This system was shut down August 1, 2004 and put in standby mode.
** Sr-90 removal is expressed in mCi.
*** ***EDB was not detected in the system influent in 2004. Other low-level VOCs not attributable to BNL were detected; the results may be due to analytical lab contamination.

3.1 OPERABLE UNIT I

The two sources of groundwater contamination contained within the OU I project are the former Hazardous Waste Management Facility (HWMF) and the Current Landfill. The former HWMF was BNL's central RCRA Receiving Facility for processing, neutralizing, and storing hazardous and radioactive wastes for off-site disposal until 1997, when a new Waste Management Facility was constructed along East Fifth Avenue. Several hazardous materials spills were documented at the former HWMF. This facility has been characterized, and soil remediation began in October 2004.

The plumes from the Current Landfill and former HWMF become commingled south of the former HWMF. The commingling was partially caused by the pumping and recharge effects of the Spray Aeration System, which operated from 1985 to 1990. This system was designed to treat VOC-contaminated groundwater originating from the former HWMF. The commingled VOC plume is depicted in **Figure 3.1-1**. A segment of the plume extends off site, approximately 3,400 feet south of the site property boundary.

The on-site segment of the Current Landfill/former HWMF plume is being remediated by a groundwater pump and treat system consisting of two wells screened in the deep portion of the Upper Glacial aquifer at the site property boundary (OU I South Boundary Treatment System). The extracted groundwater is treated for VOCs by air stripping, and is recharged to the ground at the RA V basin, located northwest of the Current Landfill (**Figure 3.1-1**). A second system (North Street East System) was built to treat the off-site portion of the plume. The off-site groundwater remediation system began operations in June 2004 (see **Section 3.2.15**).

Tritium is detected in several monitoring wells, but at concentrations below the 20,000 pCi/L DWS. Sr-90 is detected in on-site wells, several of which exceed the 8 pCi/L DWS, as discussed in **Section 3.1.5.**

3.1.1 OU I South Boundary Pump and Treat System

This section summarizes the operational and monitoring well data for 2004 from the OU I South Boundary groundwater pump and treat system, and presents conclusions and recommendations for its future operation. This system began operating in December 1996.

Quarterly reports were prepared with the operational data from January 1, 2004 through September 30, 2004. Discharge Monitoring Reports for treated effluent water from the air-stripping tower were submitted to EPA and NYSDEC each month.

3.1.2 System Description

For a complete description of the OU I South Boundary Treatment System, see the *Operations and Maintenance Manual for the RA V Treatment Facility*, dated February 20, 1998.

3.1.3 Groundwater Monitoring

Well Network

The OU I South Boundary monitoring program uses a network of 57 monitoring wells (11 of which also are used for the Current Landfill and OU III North Street East monitoring programs, **Figure 1-2**). A discussion of monitoring well data specific to the Current Landfill source area is provided in **Appendix H**.

Sampling Frequency and Analysis

The wells are monitored semiannually for VOCs, tritium, Sr-90, and gamma spectroscopy (see **Table 1-5**).

3.1.4 Monitoring Well/Temporary Well VOC Results

Figure 3.1-1 shows the areal extent of TVOC contamination from the Current Landfill/former HWMF area based on the full round of samples collected in the third and fourth quarters of 2004 and from two temporary wells installed in the fall of 2004. The primary VOCs detected in the on-site segment of this plume include chloroethane and DCA, the signature contaminants for the Current Landfill. TCA, DCE, TCE, and chloroethane are prevalent in the off-site segment of the plumes (North Street East). The OU I South Boundary/North Street East plume (defined by TVOC concentrations greater than 5 µg/L) extends south from the Current Landfill to an area approximately 2,080 feet south of North Street (approximately 7,500 feet long as measured from the Current Landfill). Its maximum width is about 1,230 feet at the southern site boundary. The plume segments with higher TVOC concentrations (greater than 50 µg/L) are approximately 600 feet wide. The areas of the plume displaying the highest TVOC concentrations (greater than 100 µg/L) were approximately 1,200 to 2,800 feet downgradient of the former HWMF (107-38). Contaminant concentrations near wells 98-59 and 000-124 have declined significantly.

The off-site portion of the plume is discussed in **Section 3.2.15**.

Figure 3.1-2 shows the vertical distribution of VOCs. The transect line for cross-section A–A' is shown on **Figure 3.1-1**. DCA and chloroethane are primarily detected in the shallow zone of the Upper Glacial aquifer near the source areas, and in the deep Upper Glacial at the site boundary and off site. TCA, DCE, TCE, chloroethane, and chloroform are found in the mid to deep Upper Glacial aquifer off site, south of North Street.

The plume remains bounded by the current network of wells. **Figure 3.1-3** gives the historical trends in VOC concentrations for key plume core and bypass wells that monitor the plume. **Appendix C** has a complete set of 2004 analytical results for the 57 wells. Significant findings for 2004 include:

- There were no detections of VOCs above NYS AWQS in perimeter wells.
- Plume core well 098-59 (**Figure 3.1-3**) began to show a steadily decreasing trend in TVOC concentrations during 2002 after peaking at 371 µg/L in 1997, as a high-concentration slug of contaminants continues to migrate southward. The third-quarter 2004 result indicated that TVOC concentrations have dropped to 24 µg/L. This well is screened in the Upton Unit immediately above the Gardiners Clay.
- TVOC concentrations continued to decline in plume core well 115-36, which is between the firebreak road and the extraction wells. The TVOC concentration was 9 µg/L in the third quarter 2004, a marked decrease from concentrations greater than 100 µg/L before 1999.
- TVOC concentrations in plume core wells 115-14 and 115-31, both located adjacent to the extraction wells, continued to exhibit low concentrations, which ranged from 1.3 to 26 µg/L.
- TVOC concentrations in bypass wells 115-42 and 000-138 continued to decrease.
- The OU I South Boundary pump and treat system has created a break in the plume that is characterized by a region of low-level VOCs from south of the extraction wells to south of the Long Island Expressway (**Figure 3.1-1**).

3.1.5 Radionuclide Monitoring Results

The monitoring wells were analyzed for tritium and Sr-90 semiannually, and gamma spectroscopy annually. The complete results for these wells are provided in **Appendix C**.

During 2004, well 098-30 (located approximately 900 feet downgradient of the former HWMF), the only OU I on-site well that continued to show elevated tritium concentrations, exhibited a large decline from 19,400 pCi/L in 2003 to 2,050 pCi/L. In general, stable or decreasing tritium trends are observed for the remainder of the wells in which tritium has been detected historically. A plot of historical tritium results for well 098-30 and other select OU I South Boundary program wells is shown in **Figure 3.1-4**.

Well 108-12, located northeast of EW-2, is used to monitor the potential migration of tritium into the capture zone of the treatment system. Prior to February 2002, tritium levels in well 108-12 were generally less than 1,700 pCi/L, but then increased to levels above 2,000 pCi/L and reached a maximum of 6,910 pCi/L in August 2002. The tritium concentration declined to 410 pCi/L by September 2004.

There are 10 wells (including six that are also part of the OU I South Boundary Monitoring Program) used to monitor Sr-90 contamination from the former HWMF **(Table 1-5)**. The extent of Sr-90 concentrations is shown in **Figure 3.1-5**. Sr-90 has historically been detected in three wells located within and downgradient of the former HWMF (088-26, 098-21, and 098-30) at concentrations above the 8 pCi/L drinking water standard. These wells were all below the standard as of September 2004 but still elevated. None of the current data, including two temporary wells installed in 2005, show Sr-90 concentrations higher than 7.5 pCi/L. Sentinel monitoring wells were installed in 2002 downgradient of the leading edge of the plume. Sr-90 was detected in well 107-35 during the second half of 2004 at a maximum concentration of 2.6 pCi/L. The peak Sr-90 concentration observed during 2004 was 7.5 pCi/L, in well 088-26. Sr-90 concentration trends for key monitoring wells are provided in **Figure 3.1-6**.

3.1.6 System Operations

The extraction wells are currently sampled every two months. The influent and effluent of the air-stripper tower are sampled once per month. All samples are analyzed for VOCs. In addition, the influent and effluent samples are analyzed for pH weekly, and iron and manganese monthly. **Table 3.1-1** provides the effluent limitations for meeting the requirements of the State Pollution Discharge Elimination System (SPDES) equivalency permit. Although it is not a permit requirement, the effluent is sampled for metals, pesticides, PCBs, Sr-90, and gross alpha/beta annually.

The following is a summary of the OU I operations for 2004.

January–September 2004
EW-2 was off for January due to a motor failure. well maintenance, cleaning, and replacement of a pump.

October–December 2004
EW-2 was off from mid November and all of December due to motor failure.

Table 3.1-1.
OU I South Boundary Pump and Treat System 2004 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)*	Max. Measured Value (µg/L)
pH	6.0 – 9.0 SU	7.0 – 8.6 SU
Benzene	0.8	<0.50
Chloroform	7.0	<0.50
Chloroethane	5.0	<0.50
1,2-Dichloroethane	5.0	<0.50
1,1-Dichloroethene	5.0	<0.50
1,1,1-Trichloroethane	5.0	<0.50
Carbon tetrachloride	5.0	<0.50
1,2-Dichloropropane	5.0	<0.50
Methylene Chloride	5.0	<0.50
Trichloroethylene	5.0	<0.50
Vinyl Chloride	2.0	<0.50
1,2-Xylene	5.0	<0.50
Sum of 1,3- & 1,4-Xylene	10.0	<0.50

Notes:
*Maximum allowed by requirements equivalent to a SPDES Permit.
SU = Standard Units

3.1.7 System Operational Data

Extraction Wells

During 2004, 271 million gallons of groundwater were pumped and treated by the OU I system, with an average flow rate of 632 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells. VOC and tritium concentrations in samples from EW-1 (115-43) and EW-2 (115-27) are provided in **Table F-1** in **Appendix F** (on the CD-ROM). TVOC levels in both wells continued to show a slight decreasing trend with time (**Figure 3.1-7**). Year-end tritium levels were below detection limits in both wells.

System Influent and Effluent

VOC and tritium concentrations in 2004 for the air-stripper influent and effluent are summarized in **Tables F-2** and **F-3** in **Appendix F**. Radiological (gross alpha/beta and gamma spectroscopy), pesticide, and metals data for the effluent are shown in **Table F-4**. The concentrations of TCA and DCA generally have decreased over the eight years of OU I South Boundary System operation.

The air-stripper system effectively removed all contaminants from the influent groundwater. All effluent data were below the analytical methods detection limit and below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU I treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent, to calculate the pounds per month removed. The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.1-8**). During 2004, 15.7 pounds of VOCs were removed. Cumulatively, 312 pounds have been removed since 1997. The 1996 RA V Design modeling estimated that the system would remove 260 to 300 pounds by 2006 to 2011. Cumulative mass removal data for this system are summarized in **Table F-5**.

Air Discharge

Table 3.1-2 presents the VOC air emissions data for the year 2004 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operations. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from µg/L to pounds per gallon (lb/gal), which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. All VOC air emissions were well below allowable levels.

Air monitoring for tritium was suspended in the third quarter of 2001. It will be restarted if tritium levels in the air-stripper effluent rise above 1,000 pCi/L for three consecutive months.

Table 3.1-2
OU I South Boundary System
Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual** ERP* (lb/hr)
Carbon tetrachloride	0.016	<0.0002
Chloroform	0.0086	0.00019
1,1-Dichloroethane	10**	0.00064
1,2-Dichloroethane	0.011	<0.0002
1,1-Dichloroethene	0.194	<0.0002
Chloroethane	10**	0.00036
1,1,1-Trichloroethane	10**	<0.0002
Trichloroethene	0.119	<0.0002

ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

Recharge Basin

There are nine sentinel monitoring wells in the immediate area surrounding the RA V recharge basin (**Figure 1-2**). These wells are used to monitor water quality and water levels to assess the impact of the recharge basin on the aquifer. **Appendix C** (on the CD-ROM) contains the data for these monitoring wells. All tritium detections were below 1,000 pCi/L during 2004. The highest detection of tritium was 840 pCi/L in well 076-171. Beginning November 1, 2001, the RA V recharge basin began receiving 650 gpm of treated groundwater from the OU III South Boundary and Middle Road treatment systems. The OU III South Boundary SPDES equivalency permit was modified to include the Middle Road treatment system and their outfalls at the OU III and RA V recharge basins.

3.1.8 System Evaluation

The pump and treat system continued to maintain hydraulic control of contaminants originating from the Current Landfill and former HWMF, and to prevent further contaminant migration across the site's southern boundary. No equivalency permit limits have been exceeded, and no operating difficulties were experienced beyond normal maintenance. There have been no air emission problems and no observed interference with other BNL operations, such as the recharge to Basin HO or the OU III South Boundary Pump and Treat system.

The OU I South Boundary Pump and Treat system performance can be evaluated based on the five major decisions identified by applying the DQO process.

1. Was the BNL Contingency Plan activated?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the OU I South Boundary Pump and Treat System.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass wells reveals that there have been no significant increases in VOC concentrations during 2004; thus, the plume has not grown and continues to be controlled.

The groundwater contour maps are used to evaluate the capture zones of the OU I South Boundary Pump and Treat System (**Figures 2-2 and 2-3**). The capture zone for the OU I South Boundary Pump and Treat System is indicated in **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L isocontour that is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

Yes. The hydraulic capture performance of the system is operating as previously modeled and the system continues to be effective in removing VOCs from the deep Upper Glacial aquifer.

The 2002 and 2003 BNL Groundwater Status Reports raised concerns over the rate of cleanup of the aquifer relative to the cleanup goals. These reports concluded that some portions of the targeted cleanup area did not appear to be progressing as quickly as simulated in the groundwater modeling performed during the design of the system (CDM 1995, 1996). As a result of these concerns, the groundwater modeling was revisited in 2002 and the summer of 2004. This modeling is based on 6 years of operations and monitoring data and more up-to-date contaminant transport calibrations. The revised model results suggest that the cleanup goal of 30 years could be in jeopardy and that planning for an additional extraction well should be considered. The proposed location for a potential third extraction well was immediately downgradient of the former HWMF. However, this modeling also pointed out that there were significant data gaps near the core of the plume. The model was predicting relatively high concentrations of TVOCs in an area where there were no monitoring wells to verify it, making a prediction of cleanup duration uncertain.

Preliminary engineering estimates in 2004 suggested that adding a third extraction well provided some reduction in the operating duration of the pump and treat system and increased the confidence that cleanup goals could be achieved within 30 years. However, the installation of a third extraction well would significantly increase the life-cycle costs of the cleanup and would entrain a small Sr-90 plume emanating from the former HWMF.

Based on these model results and the concern over the cleanup goal, two vertical profile wells (107-38 and 107-39) were drilled in winter 2004 to verify the model predictions. These vertical profile results provided three key pieces of information that are pertinent to the management of the plume cleanup. They were:

- Sr-90 from the former HWMF has not co-mingled with the core area of the VOC plume.
- The less permeable Upton Unit was found to be absent in key areas downgradient of the former HWMF. The Upton Unit was previously believed to be retarding the movement of a portion of the core area of the VOC plume and therefore prolonging the pump and treat activities. The

absence of the Upton unit and more updated model calibration indicate that the plume is being remediated at a faster rate than believed in 2002 and 2003.

- The recent temporary well data matches the 2004 model predictions very well, which provides more confidence in the model predictions.

A comparison of the fourth-quarter 2004 TVOC plume map (which included the recent temporary well data) with refined model predictions for the same period is provided in **Figure 3.1.9**. This figure suggests that the refined groundwater model is better able to predict the duration of cleanup. The refined groundwater model suggests that by 2011, active pump and treat activities will have reduced the peak TVOC concentrations to approximately 100 µg/L and limited them to a very small area of the Upper Glacial aquifer within the BNL property limits. The 2002 model predicted a peak TVOC concentration of 218 µg/L, over a larger area of the aquifer. The predicted extent of TVOC contamination in 2011 is shown in **Figure 3.1.10**. This remaining contamination is predicted to naturally attenuate to levels below drinking water standards by 2025. This is within the cleanup goal time period in the OU III Record of Decision (ROD).

The model reasonably matches concentrations at six select monitoring wells over an 8-year period. In addition, the model assumes a dispersivity of zero in all directions and no biodegradation of the contamination. Based on these assumptions, it appears that the model predictions are conservative.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

Asymptotic conditions are demonstrated by analyzing the average trends in TVOC concentrations in the plume core wells. Asymptotic conditions have not yet been achieved. Aquifer cleanup continues to be demonstrated based on the continued decreasing slope to the trend of average TVOC concentrations in plume core wells, as shown in **Figure 3.1.11**. Changes in the makeup of the plume are shown in **Figure 3.1-12**, which compares the TVOC plume from 1997 to 2003. The cleanup goals for this system have not yet been achieved.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?

Yes, the mean TVOC concentration is currently less than 50 µg/L and continues a decreasing trend (**Figure 3.1-11**).

4c. How many individual plume core wells are above 50 µg/L?

None of 10 plume core wells continues to have TVOC concentrations exceeding 50 µg/L. Well 098-59, located south of the former HWMF, declined to 25 µg/L during 2004. However, one of the two temporary wells installed in the core of the plume indicated 99.7 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?

The OU I South Boundary System has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.1.9 Recommendations

The following are recommendations for the OU I South Boundary Pump and Treat System and groundwater monitoring program:

- The routine operation and maintenance monitoring frequency implemented in the fourth quarter of 2004 should be continued. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency.
- Implement reductions and pulsing of the pumping rates for the treatment system wells to optimize system performance. Beginning in October 2005, the system should be pulsed on and off on a monthly basis. The flow rates will be reduced from the current rates of 450 gpm and 250 gpm to about 375 gpm and 200 gpm.
- Install a permanent monitoring well downgradient of the 2004 vertical profile locations to continue to track the remaining plume concentrations as they migrate to the extraction wells.
- Maintain the current monitoring well sampling frequency.

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3.2 OPERABLE UNIT III

The OU III plumes, as depicted in **Figure 3.2-1,** are actually multiple commingled plumes originating from several sources defined in the OU III Remedial Investigation/Feasibility Study (RI/FS). Those sources include Building 96, Building 208, the Alternating Gradient Synchrotron (AGS), and the former carbon tetrachloride underground storage tank (UST). The eastern portions of the plume have sources in OU IV and the Former Landfill and Animal/Chemical Holes areas. **Figure 3.2-1** is a simplified representation of the plumes using TVOC concentrations. The eastern portion of **Figure 3.2-1** also includes the OU IV plume and the North Street (OU I/IV) plumes.

The primary chemical contaminants found in OU III groundwater are TCA, PCE, and carbon tetrachloride. These three chemicals are the primary VOCs detected in the OU III on-site monitoring wells. Off site, carbon tetrachloride and PCE are the main contaminants detected.

The OU III VOC plume extends from the AGS/WCF area in the northern part of the site, south to the vicinity of Flower Hill Drive off site (a distance of approximately 17,700 feet). The maximum width of its main body is about 5,800 feet, as defined by TVOC concentrations greater than 5 µg/L. The western lobe of the OU III plume is defined by discontinuous VOC contamination with concentrations less than 60 µg/L. This contamination most likely results from multiple small source areas in the northern and central portions of the site, and its distribution has been complicated by earlier changes in the on-site groundwater flow system resulting from changes in pumping and recharge patterns. The basis for this representation of the lobe of the plume is the extensive vertical profile characterization conducted under the OU III Remedial Investigation RI, in addition to data points from several existing monitoring wells.

The two most prominent source areas are the Building 96 area, and the former Carbon Tetrachloride UST. On-site portions of the plume displaying the highest VOC concentrations during 2004 were south of Building 96 with TVOC concentrations up to 2,506 µg/L, continuing south to the Middle Road with TVOC concentrations of 1,120 µg/L, and the south boundary with TVOC concentrations up to 695 µg/L. TVOC levels range up to 528 µg/L (primarily carbon tetrachloride and TCA) in the off-site industrial park area.

The transect lines for cross-sections B–B' (**Figure 3.2-2**), C–C' (**Figure 3.2-3**) and other project-specific cross sections are shown on **Figure 3.2-1**. Cross sections B–B' and C–C' are oriented in a north–south direction beginning in both the central industrial and OU IV areas of the site, and continuing through the high concentrations segments of the plumes. Data obtained from existing monitoring wells and the Magothy Aquifer Characterization Project identified significant VOC contamination of the upper Magothy aquifer in the industrial park, south into North Shirley. A comparison of the OU III plumes in 1997 and 2004 is provided in **Figure 3.2-4**.

Sections 3.2.1 through 3.2.17 summarize and evaluate the groundwater monitoring and system operations data for the OU III operational groundwater treatment systems and the monitoring-only programs.

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3.2.1 Carbon Tetrachloride Pump and Treat System

This section summarizes the operational data from the OU III Carbon Tetrachloride Pump and Treat System and offers conclusions and recommendations for future operation and monitoring. This system began operating on October 6, 1999 and was formally shut down on August 1, 2004 after receiving regulatory approval of the petition for shutdown. This summary is prepared annually and discusses the operational data from January 1, 2004 through December 31.

As was recommended in the petition to shut down the carbon tetrachloride system, two new monitoring wells (095-300 and -301) were installed in the vicinity of extraction well EW-15. Well 095-300 was installed to monitor the western edge of the plume in the vicinity of well EW-15, and well 095-301 was installed upgradient of well EW-15. In addition, one temporary well (095-302) was installed in the middle of the plume to determine concentrations of carbon tetrachloride in this area.

3.2.1.1 System Description

A complete description of the pump and treat system is contained in the *Carbon Tetrachloride Groundwater Removal Action Operations and Maintenance Manual* (BNL 2000d).

3.2.1.2 Groundwater Monitoring

Well Network

A network of 32 wells was designed to monitor the extent of the plume and the effectiveness of remediation.

Sampling Frequency and Analysis

The wells are sampled quarterly, and samples are analyzed for VOCs (see **Table 1-5**).

3.2.1.3 Monitoring Well Results

Carbon tetrachloride is the primary contaminant in this plume. The plume extends from the former UST southeast to the vicinity of the Weaver Drive recharge basin, a distance of approximately 1,300 feet (**Figure 3.2.1-1**). The width of the plume, as defined by the 50 μg/L isocontour, is approximately 120 feet[VGC1]. The complete 2004 analytical results from the monitoring of wells in the [VGC2]carbon tetrachloride program are provided in **Appendix C**. Significant findings for 2004 include:

- Plume core well 085-98, located just south of the former UST, had carbon tetrachloride concentrations greater than 150,000 μg/L in 1999. A decreasing trend has been observed in this well, beginning in 1999 with the start of groundwater pumping. The concentration of carbon tetrachloride was 63 μg/L in November 2004 (**Figure 3.2.1-2**).
- Plume core well 085-17 is sited next to the BNL service station on Rochester Avenue and downgradient of the source area. It has continued to show declining carbon tetrachloride trends from a peak of more than 4,000 μg/L in 2000 to a concentration of 84 μg/L in November 2004 **(Figure 3.2.1-2)**.
- Plume core well 85-161 is approximately 120 feet downgradient from the source area. Concentrations in this well have remained low throughout 2004, with a concentration of 15 μg/L in November 2004 **(Figure 3.2.1-2)**.
- Plume core well 095-183 is approximately 450 feet downgradient of the source area. Carbon tetrachloride concentrations in this well have decreased from greater than 2,000 μg/L in 2000, to 18 μg/L in November 2004 **(Figure 3.2.1-2)**.
- Plume perimeter wells 095-300, and core well 095-301 and temporary well 095-302 were installed in 2004 as recommended in the *Petition to Shutdown the Carbon Tetrachloride*

System. Well 095-300 was installed west of EW-15 to confirm the western edge of the carbon tetrachloride plume. The analytical results for this well show concentrations below NYS AWQS, thus confirming the western edge of the plume. Well 095-301 was installed to monitor concentrations of the plume immediately upgradient of well EW-15. Concentrations of carbon tetrachloride were 230 µg/L in this well in November 2004. This is consistent with concentrations of 420 µg/L, observed upgradient of this well in temporary well 095-302.

3.2.1.4 System Operations

Operating Parameters

The influent, midpoints, and effluent of the carbon vessels were sampled twice a month until August 2004. The extraction wells were sampled monthly. All samples are analyzed for VOCs. In addition, the pH of the influent and effluent samples was measured monthly. The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. All effluent samples during this period of operation were below the permit levels (**Table 3.2.1-1**). The system operations are summarized below.

Table 3.2.1-1
Carbon Tetrachloride Pump & Treat System
2004 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Measured Value (µg/L)
pH (range)	5.5 – 8.5 SU**	6.0 – 6.4 SU
bromodichloromethane	50.0	<0.50
carbon tetrachloride	5.0	<0.50
chloroform	7.0	<0.50
methylene chloride	5.0	2.8
tetrachloroethylene	5.0	<0.50
toluene	5.0	<0.50
trichloroethylene	5.0	<0.50
xylene (0-isomers)	5.0	<0.50
xylene (sum of M&P isomers)	10.0	<0.50

Notes:

SU = Standard Units

*Maximum allowed by requirements equivalent to a SPDES permit.
**pH value lowered by NYSDEC to 5.5 in September, 2000.

January – July 2004

During this period, wells EW-13 and EW-15 operated normally. EW-14 was off.

August – December 2004

The system was put in standby mode August 2 in accordance with the *Petition to Shut Down*, which was approved by DOE, EPA, and NYSDEC. Sampling for the SPDES equivalency permit was stopped and will be resumed if the system is restarted.

3.2.1.5 System Operational Data

System Influent and Effluent

Analytical results indicate that all parameters were below the regulatory limit specified in the SPDES equivalency permit.

The overall influent water quality to the carbon vessels continued to show a decrease in the concentrations of carbon tetrachloride. The influent carbon tetrachloride concentration at the beginning of system operations in October 1999 was 11,000 µg/l. The concentration was 26 µg/l at the end of July 2004, before system shutdown. **Tables F-6** through **F-9** in **Appendix F** (on the CD-ROM) summarize carbon tetrachloride concentrations in the influent, effluent, and midpoint samples.

Cumulative Mass Removal

The mass of carbon tetrachloride removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system. **Table 2-3** lists monthly pumpage rates for 2004. These rates were used in determining mass removal of carbon tetrachloride.

Table F-9 in **Appendix F** gives total pounds of carbon tetrachloride removed by the treatment system. **Figure 3.2.1-3** plots mass removal vs. time. Approximately 7 pounds of carbon tetrachloride were removed during 2004, with a cumulative total of 349 pounds since the system started in 1999.

3.2.1.6 System Evaluation

The system was placed in a standby mode in August 2004 after approval of the petition for shutdown. The groundwater extraction wells will remain on a monthly sampling schedule to monitor for any significant rebound in concentrations of carbon tetrachloride. The OU IIII Carbon Tetrachloride Pump and Treat System performance can be evaluated based on the five major decisions identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no detections of either carbon tetrachloride or any other contaminants in wells associated with this monitoring network during 2004 that triggered the BNL Groundwater Contingency Plan.

2. Were the cleanup goals met?

Yes. The groundwater cleanup goals for the system have been met. The system was shut down in August 2004.

3. If not, has the plume been controlled?

Yes. The plume has been controlled.

4. Is the system operating as planned?

The system is currently shut down and being maintained in standby mode. Shutdown of the system at these concentrations is consistent with meeting the OU III ROD cleanup objectives by 2030.

5. Is an engineering evaluation needed to modify the Middle Road treatment system to ensure the capture and remediation of the carbon tetrachloride plume?

Based on data from bypass and Middle Road tracking wells, no engineering study is required at this time.

3.2.1.7 Recommendations

The following are recommendations for the OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- Continue sampling of the extraction wells on a monthly basis.
- The monitoring well network is adequate and no modifications are necessary at this time.
- If significant concentrations of carbon tetrachloride are detected, the system will be turned on.

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3.2.2 Building 96 Air Stripping System

This section summarizes the 2004 operational data from the OU III Building 96 Source Control System, which consists of recirculation wells with air stripping and vapor phase carbon treatment, and presents conclusions and recommendations for future operation. The system began operation in February 2001. The analytical information from monitoring wells and characterization work is evaluated in detail. An evaluation of the shutdown of this system was conducted and the information presented in the *OU III Building 96 Groundwater Treatment System Shutdown Petition (AOC 26B)* (BNL 2005c), which is attached as **Appendix H**.

3.2.2.1 System Description

The Building 96 groundwater treatment system consists of four recirculation treatment wells (RTW-1 through RTW-4). Contaminated groundwater is drawn from the aquifer via a submersible well pump in a lower well screen that is set near the base of the contaminant plume. The groundwater then is pumped into a shallow stripping tray adjacent to the well, and after treatment is recharged back to the shallow portion of the plume through the upper screen. A complete description of the system is included in the *Building 96 Groundwater Source Control Treatment System Operations and Maintenance Manual* (BNL 2002e).

3.2.2.2 Groundwater Monitoring

The monitoring network of 21 wells was designed to monitor the VOC plume and the effectiveness of the groundwater remediation system (**Figure 1-2**). The wells are sampled quarterly, and samples are analyzed for VOCs (see **Table 1-5**). The three downgradient extraction wells (RTW-2, -3, and -4) were placed in standby in July 2004 and are currently monitored quarterly.

3.2.2.3 Monitoring Well Results

Complete VOC results are provided in **Appendix C** (on the CD-ROM). The fourth-quarter 2004 plume is shown on **Figure 3.2.2-1**. Core plume monitoring wells downgradient of extraction well RTW-1 shown in **Figure 3.2.2-2** continued to show very low VOC concentrations less than 1 μg/L . Extraction wells in standby mode (RTW-2, -3 and -4) also continue to show VOC concentrations less than the DWS. Perimeter monitoring wells on the west side of the plume have shown increased concentrations followed by decreases. **Figure 3.2.2-1** shows that the current TVOC concentrations in these wells range from 27 μg/L to 77 μg/L . This contamination will not be treated by RTW-2, 3, or 4 but is expected to be captured by the OU III Middle Road system**.**

Additional monitoring was performed in the high-concentration area upgradient of RTW-1 as described in the *Building 96 Site Source Reduction Chemical Oxidation Scope of Work* (BNL 2004d). A full description of the monitoring results is attached as Appendix H.

3.2.2.4 System Operations

Operating Parameters

The influent, midpoint and effluent air samples from the carbon vessels were sampled quarterly and analyzed for VOCs by EPA Method TO-14A. These samples monitor the efficiency of the granular activated carbon (GAC) units and are used to demonstrate when a carbon changeout is required. Air sampling results are included in **Table F-10** in **Appendix F**.

Influent and effluent water samples were collected monthly from each of the four recirculation wells; all samples were analyzed for VOCs by EPA Method 524.2. These samples determine the well's removal efficiency and performance. Based on these results, operational adjustments can be made to optimize the system's performance. The system operations for 2004 are summarized below.

January –September 2004

Due to extremely cold weather, excess condensate was observed in the air lines and the system was deactivated from January 14 to 22. Otherwise the system operated normally.

On June 17, 2004, the *OU III Building 96 Operations and Maintenance Manual Modification* (BNL 2004c) was submitted to the regulatory agencies to place the three downgradient extractions wells in standby mode. As recommended, on July 13, wells RTW-2, -3, and -4 were placed offline due to reduced VOC concentrations in the plume. The system continued to operate utilizing well RTW-1 only. Influent samples from wells RTW-2, -3, and -4 continued to be collected quarterly. Due to the high concentrations remaining upgradient of extraction well RTW-1, an engineering evaluation of additional treatment technologies was also performed as part of the recommendation to place the three downgradient wells in standby. The proposed remedy resulting from the screening process was chemical oxidation by *in situ* permanganate injection.

During June 2004, a temporary well investigation was performed in the saturated silty zone upgradient of RTW-1. Results of this investigation were utilized to further delineate the extent of contamination in this high-concentration area and to help determine the details of the permanganate injection as discussed in *Building 96 … Scope of Work* (BNL 2004d).

October –December 2004

The system was operational throughout the last quarter of 2004 utilizing RTW-1 only. In December 2004, the additional remedial measure of permanganate injection was initiated. Results of this effort are discussed in the *OU III Building 96 … Shutdown Petition (AOC 26B),* (BNL 2005c, also **Appendix H**).

3.2.2.5 System Operational Data

Recirculation Well Influent and Effluent

Table F-11 in **Appendix F** lists the influent and effluent VOC concentrations for each of the four recirculation wells. Until they were placed in standby in July 2004, effluent concentrations in all recirculation wells were less than the DWS or were nondetectable.

Cumulative Mass Removal

Mass-balance calculations were made to determine the mass of VOCs removed from the aquifer by the pumping wells. For each RTW, the gallons of water pumped during each month were used, in combination with the influent TVOC concentrations, to calculate the pounds removed. The pumpage and mass removal data are summarized in **Table F-12** in **Appendix F**. During 2004, the treatment system removed approximately 12 pounds of VOCs. Since February 2001, the system has removed approximately 67 pounds of VOCs. **Figure 3.2.2-3** plots the total pounds of VOCs removed vs. time. A comparison of the plume from 2000 to 2004 is shown in **Figure 3.2.2-4**.

Air Treatment System

Air samples were collected monthly from the GAC vessels before treatment (influent), between the two vessels (midpoint), and after the second vessel (effluent). The findings are utilized to monitor the efficiency of the GAC units and to determine when a carbon changeout is required (**Table F-10** in **Appendix F**). Airflow rates, measured for each air-stripping unit inside the treatment building, show that they typically range between 250 and 450 cubic feet per minute (cfm) for each of the four wells. Assuming a total airflow rate of 1,200 cfm, all compounds detected in the carbon effluent during the operating year were much lower than the New York State DAR-1 Air Toxics Assessment limits for the worst-case potential impacts to the public (**Table 3.2.2-1**).

Although the concentrations in the GAC air effluent have been well within the DAR-1 Toxics Assessment, the presence in the influent, midpoint, and effluent of benzene compounds not present in the groundwater monitoring wells is a concern. As long as the concentrations are below the DAR-1 levels, the situation only requires monitoring. The system was designed such that the carbon would not have to be changed out during its operational life.

3.2.2.6 System Evaluation

The system is operating as designed and removed 12 pounds of VOCs during 2004. Discharge concentrations to the aquifer have been less than the drinking water standard. Approximately 24.6 million gallons of groundwater were treated during the year. A full description of the system evaluation is contained in Appendix H.

The OU III Building 96 source control system performance can be evaluated based on the two major decisions identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual detections of PCE, TCA, or any other contaminants in wells associated with the monitoring network during 2004 that would have triggered the BNL Groundwater Contingency Plan. The high concentrations that were upgradient of extraction well RTW-1 had been considered a possibility during the design of the system and were previously detected in monitoring wells 085-293 and 085-335.

2. Have the source control objectives been met?

Based on the goals established in the *Building 96 Groundwater Source Control … Operations and Maintenance Manual* (BNL 2002e), the source control goals for this system have been met. The plan for this system was to remove approximately 57 pounds of VOCs, and 67 have been removed to date **(Figure 3.2.2-3).** Source remediation, as measured by mass removal, has exceeded its original intent except for the effects of the high-concentration silty zone upgradient of extraction well RTW-1. The change in the plume distribution from 2000 to 2004 is shown in **Figure 3.2.2-4**. This figure shows that a cutoff of the plume has occurred as a result of the extraction wells.

Table 3.2.2-1.
OU III Building 96
VOC Emission Rates, 2004 Average

Parameter	Allowable ERP*	Actual** ER
dichlorodifluoromethane	0.0000187	0.00000250
acetone	0.000674	N/D
methylene chloride	0.000749	0.00000240
2-butanone	0.000187	N/D
benzene	0.000112	0.0000222
tetrachloroethene	0.000165	N/D
m,p-xylene	0.0000116	N/D
isopropylbenzene	0.000243	N/D
n-propylbenzene	0.0000599	N/D
1,3,5-trimethylbenzene	0.000375	0.00000814
1,2,4-trimethylbenzene	0.000225	0.00000257
4-isopropyltoluene	0.00000749	N/D
naphthalene	0.0000225	N/D
carbon disulfide	0.0000487	N/D
styrene	0.00000637	N/D
trans-1,3-dichloropropane	0.0000157	N/D

ER = Emissions Rate
ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
N/D = Analyte Not Detected.

3.2.2.7 Recommendations

The following are recommendations for the OU III Building 96 groundwater remediation system and monitoring program:

- Based on the information gathered during the previous year, the Building 96 RTW-1 recovery well can now be shut down and placed in standby mode on June 1, 2005.
- An integral part of the shutdown of the Building 96 recovery well RTW-1 is the continued monitoring of VOC concentrations in the groundwater beneath the Building 96 former scrap yard. The monitoring program currently in place for the previously shut down recovery wells RTW-2, -3, and -4 will be expanded to include RTW-1 and the 12 new monitoring wells installed in the silty zone injection grid. The 16 wells that are being monitored as part of the permanganate injection program, including RTW-1, will be sampled monthly, while all other Building 96 wells will be monitored quarterly, including RTW-2, -3, and -4. Monthly monitoring will change to quarterly when concentration trends have stabilized. Prior to implementation, any schedule change will be discussed in the *BNL Annual Groundwater Status Report*.
- If, after shutdown of the system, up to two years of groundwater monitoring data indicate that TVOC contaminant concentrations in all monitoring wells are consistently below the cleanup goal of 380 μg/L for each chemical, then a formal petition for closure of the remediation system, system decommissioning, and termination of post-closure monitoring may be submitted to the regulatory agencies for review and approval.
- In addition to monitoring, the Building 96 silt zone area will have repeat injections of permanganate on an as-needed basis in locations where concentrations are not declining. This activity will be repeated until it is clear, due to the VOC concentrations less than 380 μg/L , that the OU III ROD cleanup objectives will be met. The results of the injection(s) and any further recommendations will be reported in the quarterly operations reports and *BNL Annual Groundwater Status Report*.

3.2.3 Middle Road Pump and Treat System

The Middle Road Groundwater Pump and Treat System began operating on October 23, 2001. This section summarizes the operational data from the Middle Road system for 2004, and presents conclusions and recommendations for future operation. The analytical data from the monitoring wells also are evaluated in detail.

3.2.3.1 System Description

The Middle Road system was designed with six extraction wells and air-stripping technology to remove VOCs from the groundwater. On September 30, 2003, extraction wells RW-4 and -5 were placed in standby mode due to low concentrations of VOCs. The system is currently operating at a pumping rate of approximately 400 gpm. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1*, dated July 18, 2003.

3.2.3.2 Groundwater Monitoring

The Middle Road Monitoring Program consists of a network of 23 monitoring wells located along the road between the Princeton Avenue firebreak road and the OU III South Boundary Pump and Treat System (**Figure 1-2**).

The 23 Middle Road wells are monitored and the samples are analyzed for VOCs. Nine of the wells are sampled quarterly, and the others are sampled semiannually. Several wells are also utilized in the OU III HFBR Tritium Monitoring Program (**Table 1-5**).

3.2.3.3 Monitoring Well Results

The complete VOC results are shown in **Appendix C** (on CD-ROM). The highest plume concentrations are found between extraction wells RW-1 and -3, based on influent data for these wells and available monitoring well data (**Figure 3.2-1**). TVOC concentrations in monitoring wells east of RW-3 are below 100 µg/L. Results for key monitoring wells are as follows.

- The highest TVOC concentration detected was in bypass detection well 113-17 at slightly greater than 1,100 µg/L. VOC concentrations have continued to decline in 2004 (**Figure 3.2.3-1**). The VOCs in this bypass well were present prior to the operation of the pump and treat system, and are expected to be captured by the OU III South Boundary System.
- Plume core well 105-23 is approximately 2,000 feet upgradient of RW-1 near Princeton Avenue. TVOC concentrations have decreased from 1,794 µg/L during 2001, to 144 µg/L in the fourth quarter of 2004 (**Figure 3.2.3-1)**.
- TVOC concentrations in plume core wells further to the east along Princeton Avenue were generally below 100 µg/L in 2004. TVOC concentrations decreased in well 105-44, from 423 µg/L in 2001 to less than 20 µg/L in the fourth quarter of 2004 (**Figure 3.2.3-1)**.

Figure 3.2.3-2 shows the vertical distribution of contamination running along an east–west line through the extraction wells; the location of this cross section (D–D') is given in **Figure 3.2-1**. VOC contamination in the western portion of the remediation area (RW-1 through RW-3) extends into the Upper Magothy aquifer, as does the screen on well RW-3.

3.2.3.4 System Operations

Beginning in April 2003, a SPDES equivalency modification was approved, reducing the system VOC and pH sampling from twice a month to monthly. The effluent sampling parameters for pH and VOCs follow the requirements of the SPDES permit equivalency. In addition, system influent samples are analyzed for tritium during each system-sampling event. Tritium remains below detection limits in all samples. All effluent concentrations from the treatment system during this period of operation were below permit equivalency levels (**Table 3.2.3-1**).

Approximately 194 million gallons of water were pumped and treated in 2004 by the OU III Middle Road System. The following paragraphs summarize the Middle Road System operations for 2004.

January–September 2004

Recovery well RW-6 was offline from January 22–February 13, due to a pump motor failure. The system was shut down from June 15–21 for painting of the interior piping at the South Boundary well house.

October 2004

The system pumped and treated approximately 16 million gallons of water in October. The average flow rate for the system was 364 gpm.

November 2004

The Middle Road system pumped and treated approximately 18 million gallons of water in November. The average flow rate for the system was 407 gpm.

December 2004

Approximately 17 million gallons of water were pumped and treated in December. The average flow rate for the system was 385 gpm.

Table 3.2.3-1.
Middle Road Air Stripping Tower
2004 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH (range)	6.5–8.5 SU	6.9 – 7.7 SU
carbon tetrachloride	5	ND
chloroform	7	ND
dichlorodifluoromethane	5	ND
1,1-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
methyl chloride	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
1,1,2 trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units

3.2.3.5 System Operational Data

System Influent and Effluent

All parameters in the SPDES equivalency permit limits were within the specified ranges during 2004. The effluent data were either below the method detection limit, or below the regulatory limit specified in the equivalency permit.

The influent's overall water quality showed a slight decrease in VOC concentrations over the reporting period. The average TVOC concentration in the influent during 2004 was 96 µg/L (see **Table F-14, Appendix F**). The system influent was also sampled for tritium. Tritium was not detected above the reporting limit in any sample during 2004. The results from sampling the influent and effluent are summarized in **Tables F-14** and **F-15**, respectively.

Cumulative Mass Removal

Mass balance was calculated for the period of operation to determine the mass removed from the aquifer by the pumping wells. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to determine the pounds removed. Flow averaged 368 gpm during 2004 (**Table 2-3**, and **Table F-11**). The cumulative total of VOCs removed was approximately 520 pounds since the system began startup testing on October 23, 2001. The cumulative total of TVOCs removed vs. time is plotted in **Figure 3.2.3-3**. For 2004, approximately 150 pounds of VOCs were removed.

Air Discharge

Table 3.2.3-2 shows the air emissions data from the system for the OU III Middle Road tower during 2004, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for all water treated during that time (**Table F-13**). The concentration of each constituent was averaged for 2004, and those values were used in determining the emissions rate. All air emissions were below allowable levels.

Table 3.2.3-2.
Middle Road Air Stripper
VOC Emission Rates, 2004 Average

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0009
chloroform	0.0031	0.0002
1,1-dichloroethane	10***	0.000005
1,2-dichloroethane	0.008	0.000022
1,1-dichloroethylene	0.034	0.0006
cis-1,2-dichloroethylene	10***	0.0001
trans-1,2-dichloroethene	10***	0
tetrachloroethylene	0.387	0.0213
1,1,1-trichloroethane	10***	0.0025
trichloroethylene	0.143	0.0005

Notes:
ERP = Emission Rate Potential. Reported in lb/hr.
*ERP based on NYSDEC Air Guide 1 Regulations.
** Rate reported is the average rate for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

Extraction Wells

Beginning in October 2003, the extraction well sampling schedule was reduced from monthly to quarterly. In addition, on September 30, 2003, extraction wells RW-4 and -5 were shut down and placed on standby due to low concentrations of VOCs. The wells are sampled quarterly, including wells RW-4 and RW-5.

3.2.3.6 System Evaluation

The system has been operating since October 24, 2001. Groundwater level mapping indicates that hydraulic control has been achieved.

The OU III Middle Road Pump and Treat System performance can be evaluated based on the five major decisions identified for this system from the groundwater DQO process.

__1. Was the BNL Contingency Plan triggered?__

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III Middle Road Pump and Treat System during 2004.

__2.Has the plume been controlled?__

Yes. VOC concentrations in plume perimeter wells remained stable at low concentrations during 2004, indicating that the plume is being controlled. High VOC concentrations in bypass wells were present before the system was operational and not within the capture zone of the extraction wells. It will take several additional years before the contaminants migrate to the south boundary system. Groundwater elevation data are obtained from many of the OU III Middle Road monitoring program wells, in addition to wells located throughout the BNL on-site and off-site areas on a quarterly basis. Groundwater contour maps are generated using these data (**Figures 2-2** and **2-3**). The capture zone for the OU III Middle Road System is depicted in **Figure 3.0-1**. The capture zone includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?

Yes. The system is operating as planned based on the mass removal of VOCs. Monitoring wells continue to show decreasing concentration trends during 2004.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see 4a through 4b).

4a. Have asymptotic VOC concentrations been reached in core wells?

No. Groundwater remediation for this system is still in the early stages. Mann-Kendall tests were not performed at this time. Monitoring and extraction wells have shown generally decreasing concentration trends since 2002 and these trends have continued.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?

No. Groundwater remediation for this system is still in the early stages.

4c. How many individual plume core wells are above 50 µg/L?

Three of the 14 plume core wells contain TVOCs greater than 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The OU III Middle Road System has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.3.7 Recommendations

The following recommendations are made for the OU III Middle Road Pump and Treat System and groundwater monitoring program:

- Maintain the routine operation and maintenance monitoring frequency that was begun in 2003.
- Continue extraction wells RW-4 and RW-5 in standby mode during 2005. Restart the wells restarted if extraction or monitoring well data indicate that VOC concentrations are showing significant rebound.
- Install one or two temporary wells near HFBR tritium extraction wells EW-9, EW-10, and EW-11 (**Figure 3.2.3-1**) to monitor the high-concentration portion of the plume. Based on the results from the temporary wells, a monitoring well may be installed.

3.2.4 South Boundary Pump and Treat System

This section summarizes the operational data from the OU III South Boundary groundwater pump and treat system for 2004, and gives conclusions and recommendations for future operation. Also included within this section is an evaluation of the system and extraction well monitoring and sampling data.

3.2.4.1 System Description

This system began operation on June 17, 1997, utilizing air-stripping technology for treatment of extracted groundwater from seven extraction wells. The system is currently operating at a pumping rate of approximately 600 gpm, utilizing six extraction wells. Extraction well EW-12 was placed offline during October 2003, due to low VOC concentrations. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1*, dated July 18, 2003.

3.2.4.2 Groundwater Monitoring

The monitoring well network consists of 38 wells and was designed to monitor the VOC plume(s) in this area of the southern site boundary, as well as the efficacy of the groundwater remediation system (**Figure 3.2.4-1**). The South Boundary wells are sampled and analyzed for VOCs at frequencies detailed in **Table 1-5**.

3.2.4.3 Monitoring Well Results

The south boundary segment of the OU III VOC plume continued to be bounded by the existing monitoring well network. VOC concentrations in the plume perimeter wells were less than 5 µg/L (**Figure 3.2.4-1**). VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary, as depicted in **Figures 3.2-2 and 3.2.4-1. Appendix C** (on CD-ROM) has the complete groundwater monitoring results for 2004.

The plume core wells continued to show the same trend of decreasing VOC concentrations that were observed following the startup of the pump and treat system in 1997, with several exceptions. Instances in which VOC concentration increases were observed are most likely due to slugs of contamination migrating to the site boundary area. The bulk of the VOC contamination in this area is currently located between EW-3 and EW-6, as can be seen in **Figure 3.2.4-2,** which is a cross-section (E–E') drawn along the south boundary and incorporating the extraction wells. The VOC concentration trends for specific key plume core wells are shown in **Figure 3.2.3-1.** Results for key monitoring wells are as follows:

- Plume core well 114-07 is located just upgradient of EW-12. Increasing VOC concentrations in this well during 1998 prompted the addition of EW-12, which began pumping in December 1999. TVOC concentrations in 2004 remained below the NYS AWQS, with no VOCs exceeding NYS AWQS since 2001. EW-12 was placed on standby in October 2003.
- Plume core well 122-22 is located just east of EW-8. A sharp drop in TVOC concentrations was observed during 1997 and 1998 from its pre startup concentration of 1,617 µg/L. VOC concentrations have remained very low, with no VOC exceedances of NYS AWQS since 2002.
- Plume core well 122-19 is located directly downgradient of EW-8. TVOC concentrations were as high as 367 µg/L in 1997, and have not been detected since 2002.
- Plume core well 122-04 is located between EW-7 and EW-8. TVOC concentrations have remained below 20 ppb (parts per billion) during 2004.
- Plume core well 121-23 is located immediately downgradient of EW-5. During 2004, the concentrations of TVOCs ranged between 590 and 690 µg/L. The spikes in TVOC concentrations

are the result of either higher concentration slugs of VOCs arriving at the site boundary or contamination being pulled back from the downgradient capture zone. The primary contaminant observed is PCE. This is consistent with the contaminant distribution in EW-4 and EW-5.

- Plume core well 121-13 is located immediately upgradient of, and between, EW-4 and EW-5. TVOC concentrations in this well have fluctuated somewhat since 1997, peaking at 1,098 µg/L in 1999. TVOC concentrations have stabilized at less then 35 µg/L since 2002. Samples from well 121-14 (located in the same cluster but screened deeper) showed a TVOC concentration spike to 1,471 µg/L during the fourth quarter of 2002, before falling back to between 51µg/L and 71µg/L in 2003. They remained below 50 µg/L during 2004. PCE is the primary compound in wells 121-13, 121-14, 121-23, EW-4, and EW-5. This contamination is being captured by the treatment system.
- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations decreased from a high of 275 µg/L in October 2003 to approximately 80 µg/L in November 2004.
- Bypass detection well 122-35, located south of EW-8, continued to show little to no detectable levels of VOCs. VOC concentrations in well 122-34, clustered with 122-35, were below NYS AWQS in 2003 and 2004.
- Plume core well 122-05 is a Magothy monitoring well located west of EW-8. TVOC concentrations had remained stable at approximately 50 µg/L since October 2001; however, a slight decrease was observed in November 2004, to approximately 33 µg/L.
- Magothy wells 121-40, 121-44, and 122-41 showed no detectable levels of VOCs during 2004.

3.2.4.4 System Operations

Beginning in April 2003, a SPDES equivalency modification was approved, which reduced the system VOC and pH sampling to once monthly. Prior to April 2003, influent and effluent to the air stripper tower were sampled twice a month for VOCs and weekly for pH. The individual extraction wells are sampled quarterly. All samples are analyzed for VOCs. The effluent sampling parameters of pH and VOCs are done in accordance with SPDES permit equivalency requirements (**Table 3.2.4-1**). In addition, samples are analyzed for tritium with each system-sampling event. In all samples, tritium continues to remain below reporting limits. All effluent concentrations from the treatment system during this period of operation were below permit equivalency requirements.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower 2004 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH (range)	6.5 – 8.5 SU	6.6-7.7 SU
carbon tetrachloride	5	ND
chloroform	7	ND
dichlorodifluoromethane	5	ND
1,1-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
methyl chloride	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
1,1,2 trichloroethane	5	ND
trichloroethylene	10	ND

*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.

OU III South Boundary System Operations

The following summarizes system operations for 2004. Approximately 310 million gallons of water were pumped and treated in 2004 by the OU III South Boundary System.

January–September 2004

The system was shut down June 15–21 for painting of the interior piping at the South Boundary well house.

October 2004
The South Boundary System pumped and treated approximately 26 million gallons of water in October. The average flow rate for the system was 577 gpm.

November 2004
The South Boundary system pumped and treated approximately 28 million gallons of water in November. The average flow rate for the system was 656 gpm.

December 2004
Approximately 27 million gallons of water were pumped and treated in December. The average flow rate for the system was 607 gpm.

Table 3.2.4-2.
South Boundary Air Stripper
VOC Emission Rates, 2004 Average

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0021
chloroform	0.0031	0.0005
1,1-dichloroethane	10***	0.000018
1,2-dichloroethane	0.008r	0.0006
1,1-dichloroethylene	0.034	0.0006
cis-1,2-dichloroethylene	10***	0.0002
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.129
1,1,1-trichloroethane	10***	0.0020
trichloroethylene	0.143	0.0005

ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual rate reported is the average for the year.
*** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

3.2.4.5 System Operational Data

System Influent and Effluent
All parameters in the SPDES equivalency permit conditions were within the specified ranges during 2004. The effluent data were either below the method detection limits, or below the regulatory limit specified in the equivalency permit.

Figure 3.2.4-3 plots the concentrations of TVOCs in the extraction wells versus time. The overall influent water quality and the individual extraction wells show a general leveling off of concentrations. The average TVOC concentration in the influent for this operational period was 66 µg/L, which remains consistent with the average of 66 µg/L for the same period last year. The system was also sampled monthly for tritium. Tritium was not detected above the reporting limit in any sample during 2004. System influent and effluent sampling results are summarized in **Tables F-17** and **F-18**, respectively.

Cumulative Mass Removal
Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to calculate the mass removed. Flow averaged 589 gpm from January 1, 2004 through December 31, 2004 (see **Table 2-3** and **Table F-20**). The cumulative total of TVOCs removed by the treatment system versus time is plotted in **Figure 3.2.4-4**. The total for 2004 was approximately 172 pounds. Cumulatively, the system removed approximately 2,276 pounds since it was started on June 17, 1997.

Air Discharge
Table 3.2.4-2 shows the air-emission data from the OU III South Boundary Tower for the operational period, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for all water treated during that time (**Table F-18**). The concentration of each constituent was averaged for the year, and that value was used in the calculation. All air emissions were below allowable levels.

Extraction Wells
In general, the extraction wells continued to show slowly decreasing VOC concentrations during 2004, (**Figure 3.2.4-3**). **Table F-17** in **Appendix F** summarizes the data for the extraction wells.

3.2.4.6 System Evaluation

The pump and treat system continued to establish hydraulic control of contaminants originating from source areas in the central portion of the BNL site and continues to prevent further migration across the southern site boundary. Plume core and bypass wells continued to show stable or decreasing VOC concentrations. The system operated at an average of 589 gpm during 2004. There was some minor downtime due to electrical problems and scheduled maintenance. No permit equivalency standards were exceeded and no operating difficulties were experienced beyond normal maintenance. There have been no air emission exceedances.

The OU III South Boundary Pump and Treat system performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III South Boundary Pump and Treat System during 2004.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass wells reveals that there have been no significant VOC concentration increases in these wells during 2004.

The capture zone for the OU III South Boundary Pump and Treat System is depicted in **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

Yes. The OU III South Boundary System continues to be effective in removing VOCs from the deep portions of the Upper Glacial aquifer. Actual mass removal is tracking very closely to the projections using the groundwater model (**Figure 3.2.4-4**). **Figure 3.2-4** compares the OU III plume from 1997 to 2004. The overall reduction in the high-concentration areas of the plume near the south boundary is evident.

The OU III South Boundary system is planned to operate for a total duration of 10 to 15 years; at the end of 2004, it had operated for approximately 7.5 years. The system is removing contamination at the expected rate and hydraulic control of the plume was demonstrated; hence, it is operating as planned. However, the duration of operation could be closer to 15 years rather than 10 years. The duration of operation for the OU III South Boundary system is dependent on the partition coefficient of the contamination, the rate of desorption (i.e., linear or nonlinear), and the effectiveness of the Middle Road Groundwater Treatment System. The Middle Road system started operation approximately 4.5 years after the OU III South Boundary system. The contaminant travel time from Middle Road to the OU III South Boundary system is about 5 to 10 years. Therefore, the high concentrations observed in the vicinity of well 113-17 will likely determine the remaining operating period of this system (**Figure 3.2-1 and 3.2-2**).

The trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is a declining one; however, there is significant variability in the mean from quarter to quarter. This is indicative of the expected capture of pulses (or slugs) of higher concentration contamination. The target contamination in this area is the result of periodic historical releases, and not continuous sources of contamination. As a result, the nature of the high-concentration portion of the plume is rather discontinuous and exists as a series of contamination pulses or slugs. This is the likely explanation of the significant variability in the mean from quarter to quarter. This variability makes it difficult to estimate the mass of contamination in the aquifer requiring treatment, and the duration of treatment that will be required.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

No. The average TVOC concentrations of the OU III South Boundary wells resumed a decreasing trend in 2003 and 2004 after showing a marked increase at the end of 2002 (**Figure 3.2.4-5**).

4b. Is the TVOC concentration in core wells less than 50 µg/L?

No. Three core wells, 121-11, 121-13, and 121-23, have TVOC concentrations above 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The OU III South Boundary System has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. Based on modeling results, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.4.7 Recommendations

The following are recommendations for the OU III South Boundary and Treat System and groundwater monitoring program:

- A routine operations and maintenance monitoring frequency was implemented in the fourth quarter of 2003. This frequency should be maintained during the Operations and Maintenance (O&M) phase.
- Continue to monitor the OU III South Boundary Magothy wells (121-40, 121-44, 122-41, and 122-05) at a quarterly (startup mode) frequency in 2005.
- Extraction well EW-12, which was installed in 1999 to address a slug of contamination that was to the east of the original capture zone of the South Boundary system, achieved VOC concentrations below NYS AWQS in 2003. This well was placed in standby mode in 2003. This well will continue in standby mode during 2005. The well will be restarted should monitoring well data indicate that VOC concentrations are showing significant rebound.
- Install temporary and permanent wells in the Magothy aquifer downgradient of the Middle Road treatment system to enhance the monitoring well network. This will help determine the extent of VOCs in the Magothy aquifer between the Middle Road and South Boundary plume monitoring networks, as well as provide additional hydrogeologic data.

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3.2.5 Western South Boundary Pump and Treat System

The Western South Boundary pump and treat system was designed to capture the VOCs in the Upper Glacial aquifer along the western portion of the BNL south property boundary. This system will capture the highest VOCs observed at the western south boundary and remediate a portion of the OU III VOC plume to reduce additional off-site migration of the contamination, and potential impacts of the VOC plume to the Carmans River. The system began operating in September 2002.

3.2.5.1 System Description

A complete description of the Western South Boundary Treatment System is contained in the *Operations and Maintenance Manual for the Western South Boundary Treatment System,* dated December 2002.

3.2.5.2 Groundwater Monitoring

A network of 17 wells is used to monitor this portion of the OU III plume. Their locations are shown in **Figure 1-2**. Starting with the third quarter 2004, the sampling frequency changed from startup phase (quarterly sampling) to the O&M phase (semiannual for plume core wells and quarterly for perimeter and sentinel wells). The wells are analyzed for VOCs. For details, see **Table 1-5**.

3.2.5.3 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are dichlorodifluoromethane (freon), TCA, TCE, and chloroform. VOC contamination in the monitoring wells is located in the mid to deep Upper Glacial aquifer. Groundwater monitoring for this system was initiated in 2002. **Figure 3.2-1** presents fourth-quarter 2004 monitoring well concentrations. A summary of key monitoring well data for 2004 is below:

- Maximum TVOC concentrations during 2004 were found in perimeter well 130-03, at 58 μg/L during the fourth quarter, with dichlorodifluoromethane as the highest VOC, at 38 μg/L. This is slightly higher than 2003, when the maximum TVOC concentration was 48 μg/L and dichlorodifluoromethane was 23 μg/L. Dichlorodifluoromethane, which was first detected in this well in mid 2001, has been increasing slightly each year. The capture zones of the Western South Boundary extraction wells were not intended to include this area.
- Plume core wells 121-42, 126-11, 126-13, 126-14, 127-04, and 127-06 have been steadily decreasing in concentrations since the treatment system was started in 2002. TVOC concentrations in core well 126-15, located midway between the two extraction wells and not within the capture zone, have remained consistently low at less than 5 μg/L.
- TVOC concentrations in plume bypass wells 126-16, 127-07, and 130-08 have remained steady between 20 μg/L to 45 μg/L since the system started. If any of these wells starts showing increasing trends, we will evaluate the need to take further action.
- Plume perimeter wells 119-03 and 125-01 monitor the groundwater quality in the vicinity of the OU III Western South Boundary recharge basin. There were no detections of VOCs exceeding NYS AWQS for these wells in 2004.

3.2.5.4 System Operations

During 2004, the extraction wells were sampled monthly. The influent and effluent of the air-stripper tower were sampled twice per month. All samples were analyzed for VOCs. In addition, the effluent sample was analyzed for pH and tritium twice a month. **Table 3.2.5-1** provides the effluent limitations for meeting the requirements of the SPDES permit equivalency. All effluent discharges met the SPDES equivalency permit requirements. The system operations are summarized as follows:

January–September 2004

The treatment system operated normally from January to April. In May, the system was shut down so the recharge basin could be drained and scraped of scaling.

From June to September the system operated normally, with only two shutdowns recorded. These were due to blower problems, maintenance, electrical, and communications problems.

October–December 2004

The system operated normally for the entire quarter. Minor shut downs for blower maintenance occurred as part of the system's preventative maintenance schedule.

Table 3.2.5-1.
Western South Boundary Pump & Treat System
2004 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)*	Max. Measured Value (µg/L)
pH (range)	6.5–8.5 SU	6.7–8.1 SU
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

* Maximum allowed by regulations equivalent to SPDES permit.

3.2.5.5 System Operational Data

Extraction Wells

During 2004, 144 million gallons were pumped and treated by the OU III Western South Boundary system, with an average flow rate of 270 gpm. **Table 2-3** gives monthly pumping data for the two extraction wells. VOC and tritium concentrations for extraction wells WSB-1 (126-12) and WSB-2 (127-05) are provided in **Table F-21** in **Appendix F** (on the CD-ROM). TVOC levels in both wells continued to show a slight decreasing trend with time (**Figure 3.2.5-1)**.

System Influent and Effluent

All influent TVOC concentrations were less than 13 µg/L , and individual VOC concentrations were less than the DWS. These levels are consistent with the 2003 influent concentrations. The influent consists primarily of dichlorodifluoromethane, TCA, TCE, and chloroform (**Tables F-22** and **F-23**, **Appendix F**).

The air-stripper system effectively removed all elevated contaminants from the influent groundwater. All effluent data were below the analytical method's detection limit and below the regulatory limit specified in the permit equivalency conditions.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper's influent, to calculate the pounds removed per month (**Table F-24, Appendix F**). The cumulative mass of VOCs removed by the treatment system is provided in **Figure 3.2.5-2**. During 2004, 10 pounds of TVOCs were removed; a total of 32 pounds has been removed since the startup of the system in 2002.

Air Discharge

Table 3.2.5-2 presents the VOC air emission data for the year 2004 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for all water treated during operation. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from µg/L to lb/gal, which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. All VOC air emissions were well below allowable levels.

Table 3.2.5-2.
Western South Boundary
Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	<0.0002
chloroform	0.0086	0.00027
1,1-dichloroethane	10**	<0.0002
1,2-dichloroethane	0.011	<0.0002
1,1-dichloroethene	0.194	0.0002
chloroethane	10**	<0.0002
1,1,1-tichloroethane	10**	0.0003
trichloroethene	0.119	0.00018

ERP = Emissions Rate Potential, stated in lb/hr.
* Based on NYSDEC Air Guide 1 Regulations.
** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 lb/hr without controls.

3.2.5.6 System Evaluation

The system has been fully operational since September 2002. The Western South Boundary Pump and Treat System performance can be evaluated based on the five major decisions identified for this system from the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the Western South Boundary Treatment System during 2004.

2. Has the plume been controlled?

Yes. VOC concentrations in most of the plume perimeter wells remained stable at or less than the drinking water standard during 2004, indicating that the plume is being controlled. However, perimeter well 130-03, still with relatively low concentrations, has been slowly increasing over the last few years. As noted above, low VOC concentrations in the bypass wells were present before the system was operational and not within the capture zone of the extraction wells. The capture zone for the treatment system is depicted in **Figure 3.0-1**.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

Yes. The system is operating as planned based on the mass removal of VOCs. Plume core monitoring wells began showing decreasing concentration trends since 2002.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements; however, it is recommended that the extraction wells be pulse-pumped (see 4a through 4b).

4a. Have asymptotic VOC concentrations been reached in core wells?

Yes. As noted in Section 3.2.5.3 above, all core wells have been steadily decreasing since the system became operational in mid 2002. Mann-Kendall tests were not performed at this time. The extraction wells have shown generally decreasing concentration trends since 2002.

4b. Is the mean TVOC concentration in core wells less than 20 µg/L?

No. Six out of seven core wells have been below 20 µg/L TVOCs for the past two quarters.

4c. How many individual plume core wells are above 20 µg/L TVOC's?

One of seven core wells was above the 20 µg/L TVOC concentration. Well 126-14, just upgradient of extraction well WSB-2, still shows TVOCs up to 31 µg/L for the past two quarters.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?

The Western South Boundary System has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in all plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.5.7 Recommendations

The following are recommendations for the OU III Western South Boundary Treatment System and groundwater monitoring program:

- Due to the steadily decreasing low influent concentrations and because six out of seven plume core wells have reached the cleanup objective of 20 µg/L TVOCs, it is recommended that pulse pumping the extraction wells begin. The wells will be shut down as of October 2005 and kept off for 2 months, then turned back on for 1 month. This process will continue for approximately 1 year to evaluate any changes to the VOC concentrations in the influent and the monitoring wells. The extraction wells will continue to be sampled monthly during pulse pumping.
- Complete the connection of communications to central on-site location.
- Monitoring well sampling will be changed to shutdown frequency to collect data for submittal of a petition for shutdown in the future.

3.2.6 Industrial Park In-Well Air Stripping System

This section summarizes the operational data from the OU III Industrial Park In-Well Air Stripping System for 2004, and presents conclusions and recommendations for its future operation. The system began operation on September 27, 1999. The OU III Industrial Park system was designed to contain and remediate the portion of OU III plume existing between BNL's southern boundary and the southern boundary of the Parr Industrial Park. **Figure 3.2-1** illustrates the extent of the OU III contaminant plume in the vicinity of the Industrial Park.

3.2.6.1 System Description

The OU III Industrial Park system consists of a line of seven in-well air stripping treatment wells. Each treatment well is constructed with two well screens separated by an inflatable packer. Contaminated groundwater is withdrawn from the aquifer via submersible pump through a lower screen (extraction screen) set at the base of the treatment well. The groundwater is pumped to a stripping tray located in a belowground vault over the wellhead. After passing through the stripping tray, treated groundwater flows back down the well and is recharged to a shallower portion of the aquifer through an upper screen (recharge screen). Some of the treated groundwater that is recharged through the upper screen re-circulates through the cell and is drawn back into the extraction screen for further treatment, while the balance flows in the direction of regional groundwater flow.

A closed-loop air system through a single blower keeps the vault under a partial vacuum. This vacuum draws air from below the stripping tray as contaminated groundwater is discharged on top. VOCs are transferred from the liquid phase to the vapor phase as contaminated groundwater passes through the stripping tray. The contaminated air stream is carried from the vault to a treatment and control building, where it is passed through two granular activated carbon (GAC) units in series to remove the VOCs. Treated air is then recirculated back to the wellhead. The carbon units, system blower, and system control panel are all housed in a one-story, masonry treatment building. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Off-Site Removal Action* (BNL 2000e).

3.2.6.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 40 wells and is designed to monitor the VOC plumes in the vicinity of the industrial park south of the site, and also the effectiveness of the in-well air stripping groundwater treatment system on this part of the high-concentration OU III VOC plumes. The wells are located throughout the industrial park, and on Carleton Drive, shown in **Figure 3.2.1.** Screen depths vary, to capture water levels at multiple levels and to obtain water quality data as follows: 1) above the treatment well effluent depth, 2) at the effluent depth, and 3) at the treatment well influent depth.

Sampling Frequency and Analysis

In general, plume core and perimeter wells are sampled either annually or semiannually and analyzed for VOCs. Bypass detection and Magothy wells are sampled quarterly and analyzed for VOCs (**Table 1-5**).

3.2.6.3 Monitoring Well Results

The complete results are included in **Appendix C** (on the CD-ROM). VOC concentrations in the plume perimeter wells that monitor the width of the plume (000-245 and 000-272) remained below NYS AWQS during 2004. Based on these data, the plume is effectively bounded by the current well network. **Figure 3.2.4-1** shows the plume distribution based on fourth-quarter 2004 data. The vertical extent of contamination is shown in **Figure 3.2.6-1**. The location of this cross section (F–F') is illustrated in **Figure 3.2-1**.

The highest TVOC concentrations in the industrial park area observed in 2004 were between remediation wells UVB-6 and UVB-7: 527 µg/L in well 000-268, in April 2004. This is down from the 2003 maximum concentration of 772 µg/L in well 000-249, which is located between UVB-4 and UVB-5 in the center of the industrial park system. VOC concentrations showed a significant reduction in the industrial park monitoring wells during 2004. Results for key monitoring wells are as follows.

- Plume core wells 000-253 (just east of UVB-1), 000-256 (between UVB-1 and UVB-2), and 000-259 (between UVB-2 and UVB-3) showed stable or decreasing VOC concentrations during 2004 (**Figure 3.2.6-2**).
- There had been a steady decline in VOC concentrations in plume core well 000-112 (immediately upgradient of UVB-1 and -2) from 1999 through early 2002, before a spike in concentrations during the latter portion of 2002. TVOC concentrations resumed a decreasing trend since then, and were at 23 µg/L in November 2004 (**Figure 3.2.6-2**).
- Plume core well 000-262 (between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002; this trend continued in 2004 (**Figure 3.2.6-2**). TVOC concentrations in this well peaked at 2,175 µg/L in 2001 and were at 224 µg/L in the fourth quarter of 2004.
- VOC concentrations in 000-268 (between UVB-6 and UVB-7) fluctuated between 132 µg/L and 527 µg/L during 2004 (**Figure 3.2.6-2**). The data indicate that a higher concentration slug is migrating through this area.
- VOC concentrations in bypass monitoring wells located near Carleton Drive were stable or decreasing during 2004. Wells 000-431 and 000-432 serve as bypass monitoring points downgradient of UVB-2. Well 000-432 has shown TVOC concentrations between 4 µg/L and 7 µg/L since sampling began in 2003. TVOC concentrations in 000-431 varied from 4 µg/L to 15 µg/L during 2004. The low VOC concentrations in these wells indicate that the system is effective in hydraulically controlling the plume.
- The remaining bypass wells for the OU III Industrial Park System are wells 000-273, 000-274, 000-275, 000-276, 000-277, and 000-278. TVOC concentrations in these wells are all below the capture goal of 50 µg/L, indicating that the system is effective in capturing the plume. The highest concentration observed was 23 µg/L (April 2004), in well 000-274.
- VOC concentrations for individual constituents remained below NYS AWQS (5 µg/L) in each of the shallow wells screened to monitor the adjacent UVB effluent wells.

3.2.6.4 System Operations

In 2004, approximately 177 million gallons of groundwater were pumped and treated.

Operating Parameters

Water samples are obtained monthly from each of the seven wells before air stripping in each UVB tray and after treatment. All samples are analyzed for VOCs. These samples determine the wells' removal efficiency and performance. Based on these results, operational adjustments are made to optimize the system's performance.

System Operations

The following summarizes the system operations for 2004.

January – September 2004

Well UVB-7 was off the entire month of February waiting for repair (delayed due to weather). It was repaired and started on March 10. Well UVB-3 was off from April 7–30 for repair. Well UVB-5 was off for approximately two weeks in May for electrical repairs. Well UVB-2 was off from June 16–30 for a high water level. Well UVB-2 was off the entire month of July waiting for a replacement variable speed drive. Well UVB-5 was off from July 1–19, and well UVB-6 was off from July 1–14, both with electrical problems.

October – December 2004
Well UVB-5 was down from October 4–18 with an electrical problem. Well UVB-2 was off from October 13 through December 1 with a leaking inflatable packer. It was repaired and placed back on-line December 2. However, it was down from December 13–30 with an electrical problem.

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent
During 2004, influent TVOC concentrations in all treatment system wells remained stable (**Figure 3.2.6-3**). The corresponding effluent well concentrations (**Figure 3.2.6-4**) showed decreasing and stable TVOC concentrations for the year. The concentrations in UVB-1 have decreased significantly since startup in 1999.

During the fourth quarter of 2004, the average removal efficiency for VOCs was 90 percent. Overall for 2004, the average removal efficiency was 86 percent (**Table F-25**, **Appendix F**).

Cumulative Mass Removal
Calculations were performed to determine the VOC mass removed from the aquifer by the remediation wells during the year. The average estimated flow rates for each monthly monitoring period were used, in combination with the influent and effluent TVOC concentrations, to calculate the pounds per month removed. **Table F-26** summarizes these data and they are included in **Appendix F**. Flow averaged approximately 48 gpm for the wells during 2004. **Figure 3.2.6-5** plots the total pounds of TVOCs removed by the treatment system vs. time. During 2004, 80 pounds were removed from the aquifer.

Air Treatment System
Air samples were collected quarterly from the GAC vessels prior to treatment, between the two vessels, and after the second vessel (effluent). The samples were used to determine when a GAC changeout is needed. In addition, airflow rates were recorded to optimize the efficiency of individual recirculation wells.

Airflow rates are measured for each in-well air-stripping unit inside the treatment building. These rates averaged 503 cfm for the seven wells in the fourth quarter, and 480 cfm during 2004 (**Table F-27, Appendix F**).

3.2.6.6 System Evaluation

The OU III Industrial Park In-Well Air Stripping system performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the OU III Industrial Park System during 2004.

2. Has the plume been controlled?
Yes. An analysis of the plume perimeter and bypass well data reveals that there have been no significant VOC concentration increases in these wells during 2004. Therefore, we conclude that there has been no plume growth and the plume continues to be controlled.

The capture zone for the OU III Industrial Park System is depicted in **Figure 3.0-1**. The capture zone depicted includes the TVOC 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?

Yes. The treatment system is effectively removing contamination. The current estimate for treatment system operations is 12 years, which is significantly longer than the design estimate (7 to 9 years). The OU III Industrial Park System continues to effectively remove VOCs from the deep Upper Glacial aquifer. Actual mass removal is within approximately 10 percent above projections using the groundwater model (**Figure 3.2.6-5**). **Figure 3.2-4** compares the OU III plume from 1997 to 2004. The overall reduction in the high-concentration areas of the plume near the south boundary is evident. This is an indication that concentrations of VOCs approaching the Industrial Park System will decrease over time.

The OU III Industrial Park System is currently planned to operate for 12 years; at the end of 2004, it had operated for 5 years. The trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is a declining one (**Figure 3.2.6-6**). The system is removing contamination at the expected rate and hydraulic control of the plume is demonstrated; hence, it is operating as planned.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

No. During 2004, concentrations showed an overall decreasing trend.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?

No, the mean TVOC concentration in the plume core wells was 51 µg/L by fourth-quarter 2004.

4c. How many individual plume core wells are above 50 µg/L?

Two of the nine plume core wells have TVOC concentrations exceeding 50 µg/L, as of the fourth quarter 2004.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The OU III Industrial Park System has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. Based on model results, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.6.7 Recommendations

The following are recommendations for the Industrial Park In-Well Air Stripping System and groundwater monitoring program:

- The current routine operations and maintenance monitoring frequency should be maintained during 2005.
- The system should continue operations at 60 gpm per well except for well UVB-1, which is to be shut down and put in a standby mode in October 2005. This well had concentrations below MCLs throughout 2004. Monthly sampling will continue and if higher concentrations are observed, well UVB-1 will be restarted.

3.2.7 Off-Site Monitoring

The OU III Offsite Groundwater Monitoring Program consists of 12 wells that were installed primarily during the OU III RI. Three of the wells (000-97, -98, and -99) were installed as part of the Sitewide Hydrogeologic Characterization Program. The wells installed during the OU III RI were meant to track the plume core, or perimeter in off-site areas, or to serve as sentinel wells for the leading edge of the plume. The three wells installed as part of the Sitewide Hydrogeologic Characterization are used as plume perimeter wells. Eight wells that were part of the OU III Offsite Program during 2003 were incorporated into the groundwater monitoring programs associated with the LIPA and Brookhaven Airport ("Airport") OU III off-site remediation systems during 2004.

3.2.7.1 Groundwater Monitoring

Well Network
The network has 12 wells that monitor the off-site, downgradient extent of the OU III VOC plumes (**Figure 1-2**). Some wells downgradient of the leading edge of the plumes serve as sentinel wells. Their locations and screen depth, in the deep portions of the Upper Glacial aquifer, were selected using BNL's Groundwater Model.

Sampling Frequency and Analysis
The wells are sampled semiannually, and samples are analyzed for VOCs (**Table 1-5**).

3.2.7.2 Monitoring Well Results

The complete results for the monitoring wells in this program can be found in **Appendix C**. The horizontal and vertical extents of the off-site segment of the OU III VOC plume are shown in **Figure 3.2-1** and **Figure 3.2-2**.

The monitoring wells remaining in the OU III Off-site program, which are perimeter and sentinel wells, continue to have VOC concentrations below standards.

3.2.7.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2004 that would have triggered the *BNL Groundwater Contingency Plan* (BNL 2000c). The plume remained within the boundaries of the perimeter wells that are currently in place.

3.2.7.4 Recommendations

No changes to the monitoring program are warranted at this time.

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3.2.8 North Street Pump and Treat System

The North Street Pump and Treat System (formerly known as OU I/IV) addresses a VOC plume that originated at the Former Landfill/Chemical Holes area. The VOC plume is primarily located south of the site boundary. The leading edge extends south to the vicinity of the Brookhaven Airport. The monitoring program also addresses radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 Sump Outfall areas). The groundwater pump and treat system began operating in May 2004.

Groundwater treatment consists of two extraction wells operating at a combined pumping rate of 450 gpm. This pumping will capture the higher concentration portion of the VOC plume (i.e., TVOC concentrations greater than 50 to 60 μg/L) in the Upper Glacial aquifer, and minimize the potential for VOC migration to the Magothy aquifer. Details on the groundwater treatment system design can be found in the *OU III North Street Groundwater Remediation System Final Design* (BNL 2003g).

The North Street plume has been divided into segments for remediation purposes. The area north of Moriches–Middle Island Road is being addressed by the remediation system on North Street, whereas the Airport Recirculation System handles the area to the south (**Figure 3.0-1**). The Airport System was constructed to address the leading edge of this plume and satisfy the cleanup objectives defined in the OU III ROD (minimize plume growth and meet MCLs in the Upper Glacial aquifer in 30 years or less). Details on the remediation system and pre-design characterization activities can be found in the *OU III Airport Groundwater Treatment System 90% Design Documents* (Holzmacher 2002a).

3.2.8.1 System Description

The North Street system consists of two extraction wells. Extracted groundwater is piped through two 20,000-pound GAC units and discharged to two of four injection wells. Both the North Street and North Street East Systems share the four injection wells. Extraction well NS-1 is designed to operate at a rate of approximately 200 gallons per minute (gpm), while extraction well NS-2 is designed for 250 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004f).

3.2.8.2 Groundwater Monitoring

Well Network

A network of 30 wells monitor the downgradient portion of the OU IV, Former Landfill, Chemical/Animal Pits, and Glass Holes VOC plumes and the potential radiological contamination originating from these areas (**Figure 1-2**). Wells sampled under the OU III South Boundary and Industrial Park Programs are also utilized for mapping this plume. Thirteen of the 30 wells were installed during 2004 in association with the construction of the groundwater treatment system.

Sampling Frequency and Analysis

Twenty-four of the 30 wells are sampled and analyzed quarterly for VOCs, three wells are sampled semi-annually for VOCs, and three wells are analyzed annually for VOCs. Twenty-seven wells are sampled and analyzed annually for gross alpha/beta, gamma spectroscopy, and Sr-90. All wells are sampled and analyzed annually for tritium (**Table 1-5**).

3.2.8.3 Monitoring Well Results

The primary VOCs associated with this plume are carbon tetrachloride, PCE, and TCA. **Figure 3.2-1** depicts the TVOC plume distribution and includes data from all the monitoring wells. The complete groundwater monitoring well data for 2004 are included in **Appendix C**. A hydrogeologic cross section (G–G') running through the spine of the plume is provided in **Figure 3.2.8-1.** The location for the cross section is shown on **Figure 3.2-1**. Monitoring well 000-154 has historically shown the highest VOC concentrations (primarily carbon tetrachloride) in the North Street area. TVOC concentrations greater than 1,000 μg/L were observed in 1997 and 1998, but have steadily declined since then, as illustrated in **Figure 3.2.8-2**. The leading edge of the high-concentration area (>100 µg/L) now appears to be migrating south of 000-153 based on the peaking of TVOC concentrations in this well during 2002 and early 2003, followed by a sharp decline in the last two quarters of 2003. During 2004, however, the concentrations appear to have increased to about 100 µg/L. The increased concentrations in well 800–63 have stabilized in 2004 (**Figure 3.2.8-2**) and suggest that the leading edge of this higher concentration segment has reached this location.

Historically, tritium has been detected in localized off-site areas roughly within the area covered by the North Street VOC plume. Potential sources for this tritium as well as other radionuclides are located in the Former Landfill/Chemical/Animal Holes and OU IV Building 650 areas of the site. Tritium has been detected in the deep Upper Glacial aquifer at concentrations well below the DWS of 20,000 pCi/L.

Historically, the highest tritium concentration was detected in 2001 in temporary well 000-337, at 9,130 pCi/L. This location is approximately 300 feet north of well 000-153. Tritium has been detected historically in well 000-153. In 2004, the tritium concentration in this well declined to 970 pCi/L from 1,570 pCi/L in 2003.

3.2.8.4 System Operations

Weekly laboratory analyses were performed on samples from the extraction wells and samples of the influent, midpoint, and effluent from the GAC units. All samples are analyzed for VOCs, and the influent and effluent samples are also analyzed for pH. In addition, the system effluent is analyzed for tritium. **Table 3.2.8-1** provides the effluent limitations for meeting the requirements of the SPDES permit equivalency.

Table 3.2.8-1
OU III North Street
2004 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH (range)	5.5 – 8.5 SU	5.8 - 6.4 SU
carbon tetrachloride	5	ND
chloroform	5	ND
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.

June–September 2004
System startup and testing were done in June. Routine operations continued through September.

October–December
Routine operations continued from October–December. Carbon changeouts were successfully completed on December 9, 2004 and the system was restarted.

3.2.8.5 System Operational Data

The North Street System startup phase began in April 2004. The system went into full-time operation in May 2004. A pump test was performed during June 2004. The system was operational from June to December 2004, with only minor shutdowns due to electrical outages, programmable logic controller (PLC) issues, scheduled maintenance, and GAC changeouts.

Extraction Wells
Table F-28 contains the monthly pumping data and mass removal data for the system. VOC concentrations for the extractions wells are provided in **Table F-29** in **Appendix F** (on the CD-ROM). Well NS-1 declined from 599 to 109 µg/L over the period and well NS-2 remained unchanged at 18 µg/L TVOC.

System Influent and Effluent
VOC concentrations in 2004 for the NS carbon influent and effluent are summarized in **Tables F-30** and **F-31** in **Appendix F**. The combined influent declined from 260 µg/L in June to 75 µg/L in December 2004.

The carbon vessels for the system effectively removed all contaminants from the influent groundwater. All effluent data were below the analytical method's detection limit and below the regulatory limit specified in the equivalency permit conditions except for 111-TCA and carbon tetrachloride, at less than 1 µg/L in October.

Cumulative Mass Removal
The mass of TVOCs removed from the aquifer by the OU III North Street treatment system was calculated using the average flow rates for each monthly monitoring period, in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds per month removed. The cumulative mass of TVOCs removed by the treatment system vs. time was then plotted (**Figure 3.2.8-3**). During 2004, approximately 143 million gallons of groundwater were pumped and treated by the North Street System, and approximately 115 pounds of VOCs were removed. The data for this figure are summarized in **Table F-31.**

3.2.8.6 System Evaluation

Construction of the OU III North Street System and installation of additional monitoring wells was completed in May 2004. **Figure 3.2.8-4** compares the TVOC plume from 1997 to 2004. The following significant changes were observed in the plume over this period:

- The trailing edge of the plume has migrated south of the Former Landfill, Chemical/Animal Holes areas.
- The high-concentration area (> 100 µg/L) has moved south from well 000-154 and is located within the two extraction wells' combined zone of influence (**Figure 3.2.8-5**).
- A small area of TVOC greater than 50 µg/L was noted in 2003 south of the site boundary crossing to the south of North Street. Due to the lack of recent well data, the movement of this plume segment was estimated from groundwater modeling.
- The leading edge of the plume, as defined by a TVOC of 5 µg/L, remains in the vicinity of Flower Hill Drive and is addressed in **Section 3.2.17**, LIPA/Airport Pump and Treat System.

The OU III North Street Monitoring Program can be evaluated from the five decision rules identified from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2004.

2. If not, has the plume been controlled?
Yes. Since the cleanup goals have not been met, it must be verified that the plume is not growing. An analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2004; thus, we conclude that that plume has not grown and continues to be controlled.

The leading edge of the plume was defined at Flower Hill Drive at concentrations below the NYS AWQS for individual VOCs. The Airport pump and treat system is designed to capture any contaminants migrating south of Flower Hill Drive. All but seven homes in the residential area overlying the plume have been connected to public water. These seven homes are offered annual well sampling.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

The hydraulic capture performance of the system is operating as modeled in the system design and the system has been removing VOCs from the deep Upper Glacial aquifer. It is too early in the system's life cycle to determine whether the aquifer cleanup is proceeding as planned.

4. Are there off-site radionuclides that would trigger additional actions?

No. Based on monitoring well data, radionuclide contamination appears to be limited to isolated occurrences of tritium, primarily in the deep Upper Glacial aquifer, at concentrations below the DWS of 20,000 pCi/L.

5. Can the groundwater treatment system be shut down?

No, the system has only been operating for 8 months and has not met all shutdown requirements.

5a. Have asymptotic TVOC concentrations been reached in core wells?

No. Asymptotic conditions have not yet been achieved.

5b. Are there individual plume core wells above 50 μg/L TVOC ?

There are currently several plume core wells showing concentrations greater than 50 *μg/L.*

5c. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The North Street system has not been pulsed to date.

5d. Have the groundwater cleanup goals been met? Have MCLs been achieved by 2030?

No. MCLs have not been achieved for individual VOCs in plume core wells.

3.2.8.7 Recommendations

The following are recommendations for the North Street System and groundwater monitoring program:

- Continue to monitor the wells and system on the current schedule.
- Continue routine operations as per the *O&M Manual*.

3.2.9 OU III Central Monitoring

The OU III RI identified several low-level (less than 50 µg/L) VOC source areas and nonpoint contaminant sources within the developed central areas of the BNL site. These sources include spills within the AGS Complex, the Bubble Chamber spill areas, Building 208 vapor degreaser, and the storage area for site maintenance equipment. Because these sources are not large enough to warrant a dedicated monitoring program, they are monitored under the OU III Central monitoring program. In addition, this program includes wells 109-03 and 109-04, which are located near the BNL site boundary. They were installed by the Suffolk County Department of Health Services to serve as sentinel wells for the SCWA William Floyd Parkway well field.

3.2.9.1 Groundwater Monitoring

Well Network
The monitoring well network is comprised of 19 wells (**Figure 1-2**). The locations aid in defining the VOC plumes, which extend downgradient from the central areas of the site. This network also is supplemented by data from Environmental Surveillance (ES) program wells that monitor active research and support facilities (**Table 1-6**). Results from the ES programs are provided in **Section 4**.

Sampling Frequency and Analysis
The wells are sampled and analyzed annually for VOCs, and select wells are analyzed semiannually for gross alpha/beta, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**). Select ES wells in the AGS Complex are typically sampled annually for VOCs in order to complete the northern portion of the OU III VOC plume configuration.

3.2.9.2 Monitoring Well Results

VOC concentrations detected in most of the OU III Central wells are near or below NYS AWQS. The primary constituent in many of the wells in the north-central developed portion of the site is TCA. The following wells displayed significant changes in VOC concentrations in 2004 or were otherwise noteworthy:

- Wells 065-04 and 065-05 are screened in the shallow Upper Glacial aquifer and are located in the vicinity of Building 811. TVOC concentrations in well 065-05 had a peak concentration of 123 µg/L in September 2000. Since that time the concentrations have decreased, remaining below 1 µg/L during the past two years. TVOC concentrations peaked in well 065-04 and have decreased from a high of 99 µg/L in 1997 to less than 10 µg/L since 2002. The primary constituent in these wells is TCA. TVOC concentrations in well clusters 065-39 and 065-40, located approximately 800 feet downgradient of well 065-05, increased from concentrations of 3 µg/L during 2001, up to 22 µg/L in well 065-39 in 2004. The primary constituent in these wells is also 1,1,1 TCA and the wells are screened in the mid Upper Glacial aquifer. Based on this trend, a small slug of VOC contamination appears to be migrating south.
- TVOC concentrations (primarily TCA) in deep Upper Glacial aquifer well 085-02 have demonstrated an increasing trend since the first sampling event in 1999 detected 1 µg/L TVOC. The TVOC concentration in 2004 was 34 µg/L. This well is located on Brookhaven Avenue and is directly downgradient of TCA contamination discussed above.
- Well 083-02 is near the intersection of Brookhaven Avenue and Upton Road and is screened in the mid to deep Upper Glacial aquifer. This well consistently has contained 10 to 25 µg/L of chloroform since 1997. Potential sources of this contamination may be in the AGS area of the site.
- SCDHS wells 109-03 and 109-04 serve as sentinel wells for the SCWA William Floyd Well Field and are near the eastern BNL property boundary. Toluene was detected in well 109-03

(screened in the deep Upper Glacial aquifer) at 5.3 µg/L in a sample obtained on September 2002. There were no VOC detections in this well exceeding NYS AWQS or guidance values prior to this sampling event. The well was resampled on October 29, 2002 and sent to two different analytical laboratories. Methyl tertiary butyl ether (MTBE) was detected by both laboratories at concentrations ranging from 4.8 µg/L to 7 µg/L, as well as trace amounts of toluene (0.2 µg/L). The well was sampled again in December 2002. No VOCs were detected in these samples. SCDHS sampled the well in early January 2003 and also did not detect any VOCs. Routine BNL monitoring detected MTBE at 67 µg/L in a sample collected on February 21, 2003. Benzene, m/p xylene, and toluene were also detected, at concentrations of 1.4 µg/L, 6.2 µg/L, and 8.7 µg/L, respectively. BNL sampled the well again on April 3, 2003 and detected MTBE at 5 µg/L and toluene at 1 µg/L. The well was sampled by both BNL and SCDHS on April 23, 2003 and no VOCs were detected in these samples. There have been no detections of VOCs in either well during the remainder of 2003 and throughout 2004. No radionuclides were detected in either well in 2004.

3.2.9.3 Groundwater Monitoring Program Evaluation

The evaluation of the OU III Central Monitoring program is based on four major decision rules established for this program using the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered during 2004?

No. There were no unusual or unexpected VOC or Radionuclide concentrations in the monitoring wells associated with this program during 2004.

2. Are there potential impacts to the SCWA William Floyd Parkway well field from on-site contamination?

No. There were no detections of contaminants in the sentinel monitoring wells during 2004.

3. Are the performance objectives met?

No. Individual wells continued to contain VOC concentrations exceeding the NYS AWQS during 2004; therefore, the OU III ROD objectives have not been met.

4. If not, are observed conditions consistent with the attenuation model?

Yes. In the areas of the site where the wells of the OU III Central Monitoring Program are located, the observed TVOC concentrations generally agree with the model-predicted concentrations, with respect to both the plume extent and contaminant concentrations.

3.2.9.4 Recommendation

No changes to the monitoring program are warranted at this time.

3.2.10 Magothy Aquifer

This section provides a brief summary of the Magothy aquifer groundwater monitoring program and the proposed remedial approach for addressing the VOC contamination. The 37 monitoring wells used to characterize the Magothy are shown on **Figure 3.2.10-1**. Two of these monitoring wells were installed in January 2004.

Detailed descriptions of the monitoring well data results and remediation progress are presented in the following sections of this report: Western South Boundary, Middle Road, Airport/LIPA, North Street, North Street East, OU III South Boundary, Industrial Park, Industrial Park East, and Central Monitoring. A brief summary of the results is provided in **Table 3.2.10-1**. Further details of the investigation results are in the *Final Magothy Aquifer Characterization Report* (BNL 2003c).

Table 3.2.10-1. Magothy Aquifer Contamination.

Location	Max. TVOC[a] (ppb[b])	Primary VOCs	Results
Western boundary on site	<5.0	NA	Magothy not impacted. Two monitoring wells serve as adequate outpost/sentinel wells for Suffolk County Water Authority William Floyd wellfield.
Middle Road and south boundary on site	340	PCE, CCl4	VOCs identified in upper 20 to 40 feet of Magothy at Middle Road area where brown clay is absent. TVOCs also detected at approximately 2,000 ppb in 1999 in lower portion of Upper Glacial. VOCs not detected at south boundary beneath the clay.
North Street off site	50	TCE	Low TVOC concentrations have been detected in localized areas in the upper 30 feet of Magothy below hole in brown clay and downgradient near Vita Drive where clay exists. Leading edge of contamination is around Moriches Middle Island Road.
North Street East off site	30	1,1-DCA; 1,1-DCE	Low TVOC concentrations have been detected at the BNL south boundary to North Street below the brown clay at approximately 40 to 150 feet into the upper Magothy. Tritium also co-located with VOCs upwards of 4,660 picoCuries/liter (pCi/l) (13,600 pCi/l detected in 1998).
Industrial Park East off site and south boundary	570	TCA, CCl4	Lower VOC concentrations on-site (less than 50 ppb) and higher (more than 500 ppb) off-site in the Industrial Park, where brown clay is absent. Magothy and Upper Glacial contamination is contiguous in Industrial Park.
South of Carleton Drive off site	7,200	CCl4	High VOC concentrations just south of Carleton Drive where brown clay is absent. Contamination is contiguous between Magothy and Upper Glacial Aquifer.

[a] Total Volatile Organic Compounds
[b] parts per billion

The Magothy Remedy identified in the *Explanation of Significant Differences* (ESD) document calls for the following:

1. Continued operation of the existing three extraction wells as part of the Upper Glacial treatment systems that provide capture of Magothy VOC contamination (Middle Road, South Boundary, and Airport)
2. Two additional off-site Magothy extraction wells on Stratler Drive (south of Carleton Drive) and at the Industrial Park East location were recently installed to prevent migration of high concentrations of VOCs through the hole in the brown clay and into the Magothy aquifer

3. Data from the monitoring wells will continue to be evaluated to ensure protectiveness. **Table 3.2.10-2** describes how each of the Magothy investigation areas is addressed by the DOE's selected Magothy aquifer remedy.
4. Institutional controls and 5-year reviews

Data for all Magothy monitoring wells are presented in Appendix C.

Table 3.2.10-2. Magothy Remedy

	Area Investigated	Alternative 2 Selected Remedy
1	Western boundary onsite area	Good well network in place. Continue monitoring and evaluate data.
2	Middle Road and south boundary on-site area	Continue operation of the Magothy extraction well at Middle Road, as well as the two Upper Glacial systems. Continue to monitor the three Magothy monitoring wells at Middle Road and three at the south boundary. An additional monitoring well (121-44) at the south boundary was installed in 9/03.
3	North Street off-site area	Continue operation of the two existing Upper Glacial extraction wells on Sleepy Hollow Drive and North Street to prevent further Magothy contamination. Four additional wells (M-2, O-1, O-2, Q) were installed in 2003 to help integrate the North Street and Airport system's monitoring well network. Continue monitoring and evaluate data.
4	North Street East off-site area	Good well network in place. Continue monitoring and evaluate data.
5	Industrial Park East off-site area and south boundary	Continue operation of the partial Magothy extraction well at the southeast boundary. Include an additional extraction well at the interface of the Upper Glacial and Magothy aquifers for the Industrial Park East treatment system. This will prevent migration of high concentrations of VOCs through the hole in the brown clay and into the Magothy aquifer. The extraction well was installed January 2004. Continue monitoring and evaluate data.
6	South of Carlton Drive off-site area	Modify the LIPA/Airport treatment system to include an additional extraction well at the interface of the Upper Glacial and Magothy aquifers on Stratler Drive. This will prevent migration of high concentrations of VOCs through the hole in the brown clay and into the Magothy aquifer. The extraction well was installed in March 2004. Three additional monitoring wells (Mag-1, Mag-2, Mag-3) were installed in 12/03 and 1/04. Continue monitoring and data evaluation.

3.2.11 HFBR Tritium Monitoring

In late 1996, tritium was detected in monitoring wells near the HFBR. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed and the spent fuel pool was drained. In May 1997, a three-well groundwater pump and recharge system was constructed on Princeton Avenue approximately 3,500 feet downgradient of the HFBR to capture tritium and assure that the plume would not move off site. Extracted water was recharged at the RA V recharge basin. Groundwater modeling projected that the tritium plume would attenuate naturally to below DWS (20,000 pCi/L) before reaching the site boundary. The extraction system was placed on standby status in September 2000, as groundwater monitoring data demonstrated that the plume was not growing.

As described in the OU III ROD, the selected remedy to address the HFBR tritium plume included implementing monitoring and low-flow extraction programs to prevent or minimize the plume's growth. Beginning in June 2000 and ending April 2001, 20 low-flow extraction events removed 95,000 gallons of tritiated water with concentrations greater than 750,000 pCi/L. This water was sent off site for disposal. The trigger level for low-flow extraction has not been exceeded since April 2001. Plume growth is defined as a detection of tritium above 25,000 pCi/L in monitoring wells at the Chilled Water Plant Road, or above 20,000 pCi/L in monitoring wells along Weaver Drive. Exceedances of these activities will necessitate implementing the specific contingencies described in the ROD, including possible reactivation of the Princeton Avenue pumping system.

Groundwater flow in the vicinity of the HFBR is variable, due to BNL pumping and recharge operations in the area. In general, groundwater flow is toward the south or southeast (**Figures 2-2** and **2-3**). Evaluation of groundwater flow and quality data indicates that the downgradient portion of the tritium plume (south of Brookhaven Avenue) has shifted east since 1997 in response to changing flows to the HO recharge basin, the OU III recharge basin, and the reduced pumping of BNL supply wells 10, 11, and 12.

3.2.11.1 Groundwater Monitoring

Well Network

A monitoring well network of 159 wells was designed to evaluate the extent of the plume, monitor the source area, and verify the predicted attenuation of the plume (**Figure 1-2**). Due to the closeness of the HFBR to pumping and recharge operations, the plume is subjected to changing hydraulic stresses, which have warranted an extensive monitoring network.

Sampling Frequency and Analysis

The wells associated with the high concentration portion of the plume (core wells) are sampled for tritium quarterly. Sampling details for the complete well network are contained in **Table 1-5**. Select wells are also analyzed for VOCs as part of the Carbon Tetrachloride and Middle Road programs.

3.2.11.2 Monitoring Well/Temporary Well/Geoprobe Data

The extent of the tritium plume is shown on **Figure 3.2.11-1**. This figure summarizes data collected during the fourth quarter of 2004, including monitoring well and temporary well data. Monitoring well data were supplemented with data obtained from 11 temporary wells installed during May through July 2004 and two temporary wells installed in February 2005. Five of the temporary wells were installed east of Rowland Street in the vicinity of Railroad Street, to track the high-concentration segment of the plume (**Figure 3.2.11-2**). Two temporary wells were installed just west of Grove Street and east of the Chilled Water Facility to determine the southern extent of the 20,000-pCi/L tritium isocontour. Six temporary wells were installed along the eastern segment of Weaver Drive and along Grove Street south of Weaver Drive. **Appendix C** has the complete set of monitoring well data. Data from temporary wells installed in 2004 is summarized in **Table 3.2.11-1**.

HFBR to Brookhaven Avenue

The plume in the area immediately south of the HFBR shifted east in 2004, as evidenced by:

- Increased tritium concentration in the two eastern well clusters on Cornell Ave. (**Figure 3.2.11-3**)
- The highest tritium concentration along Cornell Avenue was in well 075-245, in the easternmost well cluster on Cornell Avenue.

Concentrations in well 075-43 were 378,000 pCi/L during the first quarter of 2004. Tritium in this well spiked between the fourth quarter of 2003 and the second quarter of 2004. Concentrations have since declined to just above detectable levels. The increase corresponded with a significant elevation in the water table from July 2003 to July 2004, which apparently mobilized tritium residing in the vadose zone beneath the HFBR (**Figure 3.2.11-3**). This leaching mechanism results in relatively small slugs of tritium that migrate south from the HFBR in groundwater (**Figure 3.2.11-4**). Tritium concentrations at Temple Place spiked to 433, 000 pCi/L with the passage of a slug in 2004.

Brookhaven Avenue to Weaver Drive

During 2004, the high-concentration segment (south of Brookhaven Avenue) of the plume was located in the vicinity of Grove Street and Rowland Street, with a maximum concentration of 55,000 pCi/L observed in temporary well 85-344 (**Figure 3.2.11-2**).

Tritium concentration trend plots are shown for key wells located along the spine of the plume in **Figure 3.2.11-4**. The high-concentration core of the plume passed through the vicinity of well 75-294 early in 2001, then through well 75-418 north of Brookhaven Avenue during the middle to latter part of 2001. The high-concentration segment reached Rowland Street in late 2003 and is currently south of Rowland Street along Grove Street, as determined by the temporary well results. The vertical extent of contamination along the spine of the plume is depicted in cross section I–I' (**Figure 3.2.11-5**).

The fourth-quarter 2004 HFBR tritium plume distribution is shown in **Figure 3.2.11-1**. The leading edge of the 20,000-pCi/L isocontour is estimated to be just north of the Chilled Water Plant Road in the mid to deep Upper Glacial aquifer. This estimate is based on an average groundwater velocity for this area of 1 ft/day. During 2004, concentrations in well 096-84, located approximately 400 feet south of Weaver Drive, increased from non detect to 3,680 pCi/L. There were no detections of tritium in excess of 1,000 pCi/L during 2004 in the sentinel wells on Weaver Drive.

3.2.11.3 Groundwater Monitoring Program Evaluation

The OU III HFBR Tritium Monitoring Program can be evaluated based on five major decision rules established for this program using the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. The BNL Groundwater Contingency Plan was not triggered during 2004. High tritium concentrations detected in temporary wells, geoprobes, and monitoring wells were consistent with our understanding of the HFBR tritium plume. The increased concentrations of tritium observed at Cornell Avenue in 2004 are consistent with previous slugs of tritium moving through this area following significant rises in water table elevations.

2. Is the tritium plume growing?

No. A comparison of the plume distribution between 1997 and 2004 is shown in **Figure 3.2.11-6**. This figure also illustrates that significant plume growth is not occurring. Tritium concentrations above 25,000 pCi/L in wells at the Chilled Water Plant Road or above 20,000 pCi/L in wells along Weaver Drive were not observed. Tritium detections were observed in several of the temporary wells along Weaver Drive. The highest concentration in this area was 8,740 pCi/L, in temporary well 096-90. Similar tritium levels have been observed in wells south of the Chilled Water Plant Road over the past several years, but concentrations in particular wells have varied and none have exceeded 10,000 pCi/L.

3. Are observed conditions consistent with the attenuation model?

Yes. Since the HFBR tritium plume discovery in 1997, groundwater models have been used to assess the fate and transport of the plume and aid in making plume management decisions. The groundwater modeling objectives have evolved to support the remedial action process. The *Groundwater Flow and Tritium Transport Modeling Report* (AG&M 1998) supported the initial plume characterization, aided in the design of the HFBR pump and recharge system, and supported comparisons on remedial alternatives for the OU III Feasibility Study (FS). The *HFBR Groundwater Model Update Report* (BNL 2001a) addressed model calibration and the design and performance of a low-flow pumping system and estimated future tritium concentrations at the Weaver Road location. The *2002 BNL Groundwater Status Report* (BNL 2003d) was used to document the latest model assessment, which examined fourth-quarter 2002 monitoring data relative to earlier predictions. Observed conditions during 2004 remained consistent with these model predictions and did not warrant a groundwater modeling update.

4. Is the tritium plume migrating toward the zone of influence of BNL water supply wells 10, 11, and 12?

No. Groundwater flow in this area was to the south throughout 2004. Tritium was detected at up to 3,080 pCi/L during the last three quarters of 2004 in monitoring well 065-40, located upgradient of the HFBR. Based on groundwater flow conditions, this tritium is originating from the AGS area to the north. Tritium was not detected in any of the other monitoring wells located north of the reactor that serve as sentinel wells for the supply wells during times when the groundwater flow gradient is flat or reversed in this area. A trace amount of tritium was detected in supply well #12 in 2004. This tritium was not associated with the HFBR plume (see **Section 4.9**).

5. Has any segment of the plume migrated beyond the current monitoring network?

No. Although the plume shifted to the east along Cornell Avenue, the eastern edge of the plume is contained by the monitoring network. The southern segment of the plume also remains bounded by both monitoring and temporary wells (**Figure 3.2.11-1**).

3.2.11.4 Recommendations

The following are recommendations for the HFBR groundwater monitoring program.

- Several temporary wells will be installed in 2005 to track the high-concentration portion of the plume south of Rowland Street along Grove Street as outlined in the *HFBR Tritium Low Flow Pumping Evaluation Report* (BNL 2001b).
- The frequency in perimeter monitoring well 096-84 and outer perimeter monitoring wells 105-22, 105-23, and 105-42, located on Princeton Avenue, will remain quarterly. There will be no change to the monitoring parameters or frequency for the remainder of the network of wells. Extraction wells EW-9, -10, and -11 will also be sampled quarterly.

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3.2.12 BGRR/WCF Strontium-90 Monitoring Program

The OU III BGRR/WCF project monitors the extent of Sr-90 plumes in groundwater downgradient of these facilities. Some of the wells included in the OU III BGRR/WCF network also are monitored as part of the OU III AOC 29 HFBR and Building 801 (see **Section 3.2.11** and **4.10**) programs. These wells are sampled concurrently for both programs to avoid duplication of effort.

A predesign groundwater characterization effort was conducted in late 2003/early 2004 to increase definition of the Sr-90 plumes and source areas. The additional data were used to prepare the *OU III Explanation of Significant Differences* (BNL 2005), in accordance with CERCLA and Section 300.435 (c)(2)(i) of the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP). The BGRR/WCF remedy calls for:

1. Installation of extraction wells using ion exchange to remove Sr-90 from the extracted groundwater, and on-site discharge of the clean water
2. Operation of the system to minimize plume growth and meet DWS within 70 years
3. Continued monitoring and evaluation of data to ensure protectiveness
4. Institutional controls and five-year reviews

The analytical results indicate three areas of elevated Sr-90, one emanating from the WCF area, an area south of the BGRR Below Ground Ducts (BGD) and Canal House, and an area south of the Pile Fan Sump (PFS) (**Figure 3.2.12-1**). Variability in groundwater flow directions due to changes in pumping and recharge patterns in the plume vicinity over time have resulted in spreading of the contamination.

3.2.12.1 System Description

The Sr-90 BGRR/WCF groundwater treatment system construction started during the summer of 2004 and was completed in December 2004. Startup testing for the new treatment system began in January of 2005. Once operational, this system is planned to extract and treat contaminated groundwater at an average rate of 25 gallons per minute (gpm). For flexibility, the system has been designed to treat up to 75 gpm. Groundwater will be extracted from five wells, transported through pipelines to an ion exchange treatment system located within Building 855. The effluent will be recharged to the Upper Glacial aquifer via three on-site dry wells approximately 850 feet west of Building 855. In addition, a tray aeration unit (air stripper) will be operated, if necessary, to address low-level concentrations (less than 10 ppb) of VOCs that have been detected during startup testing. A New York SPDES Equivalency Permit will regulate the discharge to the dry wells. The Sr-90 BGRR/WCF system was designed so that the entire filter vessel can be changed out, thus avoiding on-site handling of spent radioactive filter media and potential waste issues associated with regeneration.

The treatment system consists of five extraction wells that feed into one pipeline that goes into Building 855, where the treatment system is located. There are two extraction wells (SR-1 and SR-2) located south of the WCF, and three extraction wells (SR-3, SR-4, and SR-5) located south of the BGRR. Extraction wells SR-1 and SR-2, located south of the WCF, consist of a 6-inch diameter steel riser pipe with 20 feet of 6-inch 20-slot screen. The screens are located 33 to 53 and 33.5 to 53.5 feet below grade, respectively. Extraction well SR-3, located south of the BGRR, consists of a 6-inch diameter steel riser pipe with 20 feet of 6-inch 20-slot screen. That screen is located 51 to 71 feet below grade. Extraction wells SR-4 and SR-5, south of the BGRR and south of Building 901 (in the parking lot) consist of a 6-inch diameter steel riser pipe with 20 feet of 6-inch 40-slot screen. Those screens are located 35 to 75 and 35 to 75 feet below grade, respectively. The five extraction wells are finished in belowgrade vaults with pressure gauges and flow meters. Additional meters and electrical and mechanical components for the water pumped by all of the wells are contained within the former HWMF (Building 855). Water captured by the five extraction wells will be piped to the treatment building via two pipelines. The first pipeline connects wells SR-1 and SR-2 and runs east along an unpaved access road from Building 811 to Railroad Avenue. The second pipeline runs east (parallel to Cornell Avenue) from wells SR-3, SR-4, and SR-5 to Railroad Avenue, then north until it connects with the Well SR-1/SR-2 pipeline. The combined pipeline runs north and east until it enters Building 855. In addition to the five extraction wells, 22 monitoring wells were also installed to help monitor Sr-90 plumes. The 22 new monitoring wells were installed from September 2004 through March 2005.

The ion exchange media filled vessels are designed to treat the Sr-90 contaminated groundwater to below the 8 pCi/L requirements of 6 NYCRR Chapter X, Part 703.6: *Groundwater Effluent Limitations for Discharges to Class GA Waters*. It is understood that the treated groundwater discharge criteria must meet the substantive requirements of NYSDECs wastewater regulations. The discharge criteria have been incorporated into the long-term groundwater monitoring program specified in the *Operation and Maintenance Manual for the Sr-90 BGRR/WCF/PFS Groundwater Treatment System* (BNL 2005).

Treatment Facility

The following process overview includes a general description of equipment and components of the Sr-90 BGRR/WCF treatment system. The treatment system consists of the following unit operations:

- Groundwater extraction
- Tray Air Stripper
- Equalization
- Bag filtration
- Zeolite resin treatment
- Treated water discharge

The extracted groundwater is pumped through a tray air stripper, then to an influent tank before being pumped through a series of bag filters. Extracted groundwater is pumped using the influent pump from the influent tank, through the bag filters, and then to the zeolite feed tank (ZE Feed Tank). The zeolite feed pump pumps the filtered water through the zeolite adsorbers, then through a second set of bag filters, and then to the treated water discharge tank. The water is pumped through a 3 x 3 array of adsorbers filled with a natural occurring zeolite (clinoptilolite), for removal of Sr-90. After the zeolite treatment, the water enters a set of bag filters for a final removal of suspended solids. The treated water then enters the treated water discharge tank, where it is pumped from the treated water discharge tank to the dry wells.

3.2.12.2 Groundwater Monitoring

Well Network

A network of 63 existing monitoring wells and 22 new monitoring wells, for a total of 85 wells, is used to monitor the Sr-90 plumes associated with the BGRR, WCF, and PFS areas (**Figure 1-2**).

Sampling Frequency and Analysis

The wells are monitored semiannually, and the samples are analyzed for Sr-90 (**Table 1-5**).

3.2.12.3 Monitoring Well/Temporary Well Data

A ground water characterization effort was performed for the Sr-90 BGRR/WCF treatment system between September 2003 and June 2004. The plume distribution map is shown in **Figure 3.2.12-1**. The distribution of Sr-90 throughout the BGRR, WCF, and PFS areas is depicted based on groundwater data obtained from this characterization effort and the fourth-quarter 2004 sampling of the monitoring well network. The highest Sr-90 concentration seen in 2004 was 1,240 pCi/L, from a geoprobe installed immediately south of Building 901. Groundwater data from the OU III RI characterization effort was also considered, although it is not shown on this figure. The following cross-sectional views are also provided:

- **Figure 3.2.12-2** (I–I') – A north–south cross section from the BGRR south to Brookhaven Ave.
- **Figure 3.2.12-3** (J–J') – North–south cross section from Building 801 south of Cornell Ave.
- **Figure 3.2.12-4** (K–K') – North to south cross section from WCF south to HFBR stack area.

In addition, historical Sr-90 concentration trend plots for key wells are plotted on the plume distribution map in **Figure 3.2.12-5**.

3.2.12.4 Groundwater Monitoring Program Evaluation

The OU III BGRR/WCF Strontium-90 Monitoring program can be evaluated in the context of four basic decisions established for this program using the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected Sr-90 concentrations observed in the monitoring wells to trigger the BNL Groundwater Contingency Plan during 2004.

2. Is the extent of the Sr-90 plume still defined by the existing monitoring well network?

Yes. The current well network is sufficient to monitor the plume.

3. Can Sr-90 contamination impact existing or planned groundwater remediation systems?

No. The nearest operating groundwater remediation systems are the Carbon Tetrachloride and Building 96 Systems, which are located more than 2,000 feet south of the leading edge of the plume and are not expected to be effected. Potential Sr-90 plume impacts would have to be evaluated should the need for g-2 tritium plume remediation or additional HFBR tritium remediation occur.

4. Are the Sr-90 plumes migrating toward BNL supply wells 10, 11, and 12?

No. Sr-90 was not detected in the sentinel wells upgradient of the WCF area. There is no evidence at this time of Sr-90 moving toward the BNL supply wells.

3.2.12.5 Recommendations

The following are recommendations for the BGRR/WCF groundwater monitoring program:

- Maintain the southerly groundwater flow direction by managing the pumping of BNL supply wells.
- Abandon the monitoring of wells 085-299, 085-300, and 085-311 due to the construction of the new Nanocenter. These wells will be replaced once the construction has been completed.

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3.2.13 Chemical/Animal Holes Strontium-90 Treatment System

This section summarizes the operational data from the OU III Chemical/Animal Holes Strontium-90 (formerly called the Sr-90 Pilot Study) treatment system for 2004, and gives conclusions and recommendations for future operation. This system began operation on February 26, 2003.

3.2.13.1 System Description Background

The Chemical/Animal Holes were located in the south-central portion of the BNL property (**Figure 3.2.13-1**). The area consisted of 55 pits located east of the Former Landfill and were used for the disposal of a variety of laboratory chemicals and animal carcasses. The buried waste was excavated in 1997.

Following the excavation, a Sr-90 plume was characterized. The plume is approximately 565 feet long and 100 feet wide, with a maximum thickness of 15 feet. It is approximately 22 to 45 feet below ground surface (bgs). To date, the highest Sr-90 concentration observed in groundwater in this area was 2,540 pCi/L, at well 106-16 in November 1999. The area of higher concentrations appears to be a very narrow band approximately 330 feet long and 30 feet wide (**Figure 3.2.13-1).**

The objective of the Sr-90 Pilot Study was to evaluate the effectiveness of extraction and treatment of Sr-90 in groundwater prior to implementation of the final remedy specified in the *Operable Unit III Record of Decision* (BNL 2000b). Details of the pilot study are provided in the *Strontium-90 Pilot Study Report* (BNL 2004a). The selected remedy for Sr-90 contamination in groundwater was groundwater extraction, treatment using ion exchange, and on-site discharge of the treated water. Based on the results from the pilot study, an ESD for the Sr-90 remediation was developed. The *OU III Explanation of Significant Differences* (BNL 2005) was developed in accordance with CERCLA and Section 300.435 (c)(2)(i) of the NCP. For the Sr-90 remediation at the Chemical/Animal Holes it calls for the following.

1. Installation of extraction well using ion exchange to remove Sr-90 from the extracted groundwater, and for on-site discharge of the clean water
2. Operation of the system to minimize plume growth and meet DWS within 40 years
3. Continue to monitor and evaluate the data to ensure protectiveness
4. Institutional controls and five-year reviews and details of operations are provided in the *Strontium-90 Pilot Study Treatment System Operation and Maintenance Manual* (BNL 2004b).

3.2.13.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 36 monitoring wells. **Figure 1-2** shows the monitoring well locations.

Sampling Frequency and Analysis

Six of the 36 monitoring wells were sampled quarterly for Sr-90 and the remainder were sampled semiannually. All of the wells were sampled annually for VOCs.

3.2.13.3 Monitoring Well Results

Figure 3.2.13-1 shows the Sr-90 plume distribution. The plume depiction is derived from the fourth-quarter monitoring well data. The highest Sr-90 concentration observed in 2004 was 1,050 pCi/L, in well 106-16 during the third-quarter sampling round. This well is immediately south of the Chemical/Animal Holes and historically has shown the highest concentrations in this area (**Figure 3.2.13-2**).

A high-concentration plume segment of greater than 50 pCi/L Sr-90 extends from approximately 35 feet northwest of well 106-16 to just south of the Sr-90 Extraction well (EW-1). The 50-pCi/l contour extends from approximately well 106-105 to approximately 275 feet south. The leading edge of the plume, as defined by the NYS DWS of 8 pCi/L, is approximately 180 feet south of well 106-49, which is on the south side of the firebreak road.

A second, smaller plume occurs south of the Former Landfill. The leading edge of the plume exceeding 8 pCi/L is estimated to be approximately 210 feet south of well 106-64, which is on the south side of the Princeton Avenue firebreak road. The estimated location of the plume exceeding 8 pCi/L is shown on **Figure 3.2.13-1**. There are no monitoring wells that can monitor the current location of this plume.

Selected monitoring wells in this program are also analyzed annually for VOCs to monitor low-level VOC contamination originating from the Chemical/Animal Holes. The highest concentration of VOCs was detected in well 106-25, with a TVOC concentration of 15 μg/L. The complete results are in **Appendix C**.

3.2.13.4 System Operations

The Strontium-90 Chemical/Animal Holes treatment system influent, effluent, and midpoint locations were collected at least once a week, in accordance with the SPDES Equivalency Permit. All samples are analyzed for Sr-90. In addition, the influent and effluent samples are analyzed for pH values on a weekly basis (**Table 3.2.13-1**). The treatment system consists of one extraction well. Sr-90 concentrations in 2004 for the system influent and effluent are summarized in **Tables F-32** and **F-33** in **Appendix F**. **Table F-34** contains the monthly Sr-90 removal for the system.

Table 3.2.13-1.
Sr-90 Pilot Study Treatment System
2004 SPDES Equivalency Permit Levels

Parameter	Permit Level*	Max. Measured Value
pH (range), SU	6.5–8.5	6.7-7.9
Sr-90 (pCi/L)	8	ND

* Max. effluent allowed by requirements equivalent to a SPDES permit.
ND = Not detected above minimum detectable activity.
SU = Standard Units

System Operations

The following summarizes the systems operations for 2004. Details are given in the operation and maintenance manual for this system.

January–September 2004

System operated normally from January through March 15, 2004 when system was shut down due to Sr-90 detection past the first row of adsorber vessels. The system was restarted on May 21, 2004 after it was decided to operate the system with minor breakthrough of Sr-90 past the first row of adsorber vessels (the system has three rows of adsorber vessels) The system operated normally until July 19, 2004 when the system shut down due to the failure of the extraction well pump. The pump was replaced and the system was restarted on October 12, 2004.

October–December 2004

The extraction well pump was replaced and the system restarted October 12, 2004. The system was operated until October 15, 2004 and was then shut down due to high pressure in the first row of vessels. The system was restarted after the first row of vessels were changed out on November 17, 2004 and the bag filters where changed out on November 18, 2004.The system operated sporadically during December due to automatic shutdowns from siphoning effects.

3.2.13.5 System Operational Data

The analytical data for the period January 1–December 31, 2004 show that Sr-90 in the influent ranged from 31.3 to 218 pCi/L. All effluent samples were non-detect for Sr-90. During this period, approximately 1.2 million gallons of groundwater were processed through the system. The highest concentrations were influent samples collected during December 2004 (218 pCi/l).

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 concentration, to calculate the number of millicuries removed. Flow averaged 6 gpm from January 1 through December 31, 2004. The cumulative total was approximately 0.388 mCi of Sr-90 removed during 2004 (**Figure 3.2.13-3**).

Extraction Well

The Strontium-90 Pilot Study was designed to operate at a maximum of 50 gpm. Based on the results of the initial startup testing during 2003, the treatment system is currently operating at an approximate rate of 6 gpm. This pumping rate was selected after a capture zone analysis was performed that showed a pumping rate of 5 gpm would have a capture zone width of approximately 35 feet ,which is capable of capturing the highest concentrations of Sr-90.

3.2.13.6 System Evaluation

The Chemical/Animal Holes Treatment System performance can be evaluated based on the four major decisions identified for this system as part of the DQO process that was used to design the monitoring program.

1. Was the BNL Contingency Plan activated?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the Chemical/Animal Holes Treatment System.

2. Has the plume been controlled?

The monitoring data and updated model predictions indicate the plume upgradient of the extraction well is controlled by the single extraction well pumping at 6 gpm. However, monitoring data collected down gradient of the extraction well during 2004 showed significant concentrations (up to 631 pCi/L of Sr-90). This Sr-90 was already downgradient of the pilot study extraction well when the well went into operation (**Figure 3.2.13-1**). The significance of the downgradient contamination was further evaluated using the groundwater model discussed below.

3. *Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate identified in the Explanation of Significant Difference to the OU III Record of Decision?*

The groundwater extraction well is removing contamination at a rate comparable to prior predictions. Probably 1 to 2 more years of groundwater monitoring data will be required to better evaluate the probable Sr-90 desorption isotherm for the aquifer (e.g., linear desorption vs. nonlinear). The period of monitoring data collected to date is rather short to perform a definitive analysis of this phenomenon.

As mentioned above, the significance of the downgradient contamination not captured by the treatment system was evaluated using the groundwater model. A more refined groundwater model grid and starting contamination concentrations were used for this modeling. The refined model grid size was 20' x 20' x 20'. The model was used to help evaluate whether this downgradient contamination would leave the BNL property above drinking water standards and whether it would naturally attenuate (via advection, radioactive decay, and dispersion) to less than DWS in less than approximately 40 years. The model was run with and without dispersivity assumptions similar to those experienced at the HFBR tritium plume. The model also assumed a partition coefficient (Kd) value of 2.8 cm^3/gm. The model parameter assumptions are the same as model predictions used for the pilot study. The grid size and the starting concentrations (reflecting the latest data) were changed. The model predictions are summarized in **Table 3.2.13-2**.

The model predictions suggest that the contamination downgradient of the extraction well may present a risk to achieving the cleanup goal of 40 years. This warrants careful monitoring, as these predictions are sensitive to the starting concentrations in the model.

4. *Have the cleanup goals been met? Can the groundwater treatment system be shut down?*

No. Significant contamination remains upgradient of the extraction well. Left untreated, this contamination would threaten achieving the cleanup goal of within 40 years.

3.2.13.7 Recommendations

The following are recommendations for the Chemical/Animal Holes treatment system and groundwater monitoring program:

- Continue evaluating the use of Clinoptilolite, a natural occurring zeolite.
- Continue operating the treatment system at 6 gpm.
- Sample all wells in the monitoring well network semiannually for Sr-90.
- Install several geoprobes in the plume segment downgradient of the extraction well and particularly in monitoring well 106-49, to better define downgradient concentrations and evaluate the data.
- Install several geoprobes downgradient from monitoring well 106-64 to better define the downgradient concentrations of the Sr-90 plume form the Former Landfill.
- Move future discussion of the Sr-90 concentrations downgradient of monitoring well 106-64 to the Former Landfill section, since that is the source of this plume.

Table 3.2.13-2.
Summary of Model Predictions

	Pilot Study (12/03), no dispersivity	2004 GSR Model Update, no dispersivity	2004 GSR Model Update, with dispersivity
Year	--------------Peak Sr-90 Concentration (pCi/L)------------		
10	54	110	60
30	16	30	10
40	DWS (<8)	15	DWS (<8)
60	<8	DWS (<8)	<8
85	<1	<4	<1

Notes:

DWS = Drinking Water Standard

GSR = Groundwater Status Report

85 years is the approximate transport time of the plume to the BNL south property boundary.

The refined model predicts that the pilot extraction well pumping at 6 gpm controls the contamination upgradient of the extraction well. It also uses a Sr-90 migration rate of 29 ft/year.

3.2.14 South Boundary Radionuclide Monitoring Program

The South Boundary Radionuclide Monitoring Program was initiated to confirm that groundwater impacted by radionuclides is not migrating off the southwestern sections of the BNL site. Samples are tested annually for tritium, gamma spectroscopy, and Sr-90. The sampling was conducted in conjunction with the OU III South Boundary and Western South Boundary programs, to eliminate additional costs of collecting samples. The south boundary of the eastern portions of the site is monitored for radionuclides as part of the OU I South Boundary, EDB, and OU V STP groundwater monitoring programs.

3.2.14.1 Groundwater Monitoring

A network of 54 monitoring wells is used to monitor radionuclides from the OU III South Boundary and OU III Western South Boundary programs. The well locations along the southern property boundary are shown in **Figure 3.2.14-1**.

Sampling Frequency and Analysis

The OU III South Boundary Radionuclide Monitoring Program wells were sampled annually for tritium, Sr-90, and gamma spectroscopy (**Table 1-5**).

3.2.14.2 Monitoring Well Results

The radionuclide analytical results for the wells can be found in **Appendix C**. There were no detections during 2004.

3.2.14.3 Groundwater Monitoring Program Evaluation

The OU III South Boundary Radionuclide Monitoring Program can be evaluated based on the one decision rule identified for this program resulting from applying the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unexpected results during 2004 to trigger the *BNL Groundwater Contingency Plan*.

3.2.14.4 Recommendations

No changes are recommended for the OU III South Boundary Radionuclide Monitoring Program. The wells will continue to be sampled on an annual basis for radionuclides.

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3.2.15 North Street East Pump and Treat System

This section summarizes the operational and monitoring well data for 2004 for the OU III North Street East (NSE) groundwater pump and treat system, and presents conclusions and recommendations for its future operation. The system began operation in June 2004 to provide capture and control of the downgradient portion of the OU I VOC plume, which has migrated beyond the BNL site boundary.

3.2.15.1 NSE System Description

The North Street East treatment system consists of two extraction wells piped through two 20,000-gallon GAC units and discharged to two of four injection wells. Both the North Street and North Street East systems share the four injection wells. Extraction well NSE-1 is designed to operate at a rate of approximately 200 gpm; extraction well NSE-2 is designed for 100 gpm. A complete description of the system is contained in the *Operations and Maintenance Manual for the North Street/North Street East Offsite Groundwater Treatment Systems* (BNL 2004f).

3.2.15.2 NSE Groundwater Monitoring

The monitoring network consists of 14 wells. It was designed to monitor the VOC plume off site, south of the OU I South Boundary System, as well as the efficiency of the NSE groundwater remediation system (**Figure 1-2**).

3.2.15.3 NSE Monitoring Well Results

Figure 3.1-1 shows the extent of the VOC plume. The plume originated from the Current Landfill and former HWMF (sources in OU I). The on-site segment of the plume is being treated by the OU I South Boundary Remediation system. The off-site segment of the plume located south of BNL is being addressed by the NSE Remediation system. This segment of the plume extends from the vicinity of North Street to south of the LIPA right of way, a distance of approximately 7,000 feet. The maximum width of this segment of the plume is approximately 500 feet. The higher concentrations in this segment of the plume (greater than 50 μg/L) are located between the LIPA right of way and extraction well NSE-1.

Figure 3.1-2 depicts the vertical distribution of VOCs (primarily TCA, DCE, TCE, choroethane, and chloroform) within the deep Upper Glacial aquifer. The transect line for cross-section A–A' is shown on **Figure 3.1-1**. **Figure 3.1-3** gives the historical trends in VOC concentration for key core and bypass wells along the Current Landfill/HWMF/NSE plume. **Appendix C** contains a complete set of 2004 analytical results for the 14 NSE program wells. Significant findings for 2004 include:

- The plume continues to be bounded by the current network of wells.
- VOC concentrations in well 000-137 continued to decline during 2004, with detections from all four quarters remaining below 1 μg/L. This signifies that the trailing edge of the shallower lobe of this plume has migrated south of North Street (**Figure 3.1-2**). The slug of deeper VOCs also continued migrating south during 2004, as evidenced by the continuing decrease of concentrations in well 000-138. Concentrations in this well have dropped from 253 μg/L in 1999 to 11 μg/L during the last two quarters of 2004.
- The core of this plume continues to migrate south of the LIPA right-of-way. The maximum TVOC concentration in well 000-124 dropped to less than 10 μg/L in 2004, down from a high of 487 μg/L in 1998.
- TVOC concentrations in well 000-478 were as high as 205 μg/L in 2004. NSE-1 is well positioned to capture the core of the plume represented by this well.

3.2.15.4 System Operations

The extraction wells were sampled weekly, as well as the influent, midpoint, and effluent from the GAC units. All samples are analyzed for VOCs. In addition, the influent and effluent samples are analyzed for pH. The system effluent is also analyzed for tritium. **Table 3.2.15-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit.

Table 3.2.15-1.
OU III North Street East
2004 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Observed Value (µg/L)
pH (range)	5.5–8.5 SU	5.9– 6.6 SU
carbon tetrachloride	5	ND
chloroform	5	0.61
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	3.4
trichloroethylene	10	ND

*Max. effluent allowed by requirements equivalent to a SPDES permit.
ND = Not Detected above method detection limit of 0.50 µg/L.

3.2.15.5 System Operational Data

The North Street East system began startup phase in April 2004 and went into full-time operation in June 2004. A pump test was performed from June 29 –July 2, 2004 and the *Pump Test Report* was submitted on August 24, 2004. The system was operational throughout 2004 with only minor shutdowns due to electrical outages, PLC issues, and scheduled maintenance. During 2004, approximately 4.8 pounds of VOCs were removed.

Extraction Wells

During 2004, 84 million gallons were pumped and treated by the NSE system, with an average monthly flow of approximately 13 million gallons. **Table 2-3** contains the monthly pumping data for the two extraction wells. VOC concentrations for NSE-1 (000-487) and NSE-2 (000-483) are provided in **Table F-35** in **Appendix F** (on the CD-ROM). Declining TVOC trends are noted for both wells during 2004, with concentrations below 10 µg/L reported in both wells during the fourth quarter.

System Influent and Effluent

VOC concentrations for 2004 for the carbon treatment influent and effluent are summarized in **Tables F-36** and **F-37** in **Appendix F**. The carbon treatment system effectively removed most of VOCs from the influent groundwater. All effluent concentrations were below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal

The mass of VOCs removed form the aquifer by the NSE treatment system was calculated. Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the system influent, to calculate pounds per month removed. The cumulative mass of VOCs removed by the treatment system versus time was then plotted (**Figure 3.2.15-1**). It shows that 4.8 pounds of VOCs were removed since system startup in April 2004. The data for this figure are provided in **Table F-38**.

3.2.15.6 System Evaluation

The NSE system was designed to remediate the off-site segment of the VOC plume originating at the Current Landfill and former HWMF. This segment of the plume had migrated off site prior to the OU I South Boundary system startup in 1996. The system began operations in June 2004 and is planned to run for approximately ten years. The system is operating as designed. No operating difficulties were experienced beyond normal maintenance, and system effluent concentrations did not exceed SPDES equivalency permit requirements.

1. Is the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the NSE treatment system.

2. If not, has the plume been controlled?

Yes. The system has been in operation for only 6 months, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2004; thus, we conclude that plume has not grown and is controlled.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing VOCs from the deep Upper Glacial aquifer. Due to the fact that the system has been operating for 6 months, it is still too early to determine if the aquifer is being restored at the planned rate.

4. Can the groundwater treatment system be shut down?

No, the system has only been operating for 6 months and has not met all shutdown requirements.

4a. Have asymptotic TVOC concentrations been reached in core wells?

No. Asymptotic conditions have not yet been achieved. These conditions are not expected to be achieved for several years.

4b. Are there individual plume core wells above 50 µg/L TVOC ?

There is currently one plume core well, 000-478, that shows TVOC concentrations greater than 50 µg/L.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?

The NSE system has not been pulsed to date.

4d. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?

No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.15.7 Recommendation

The system will continue to operate in its present configuration. No changes to the monitoring well network or the sampling schedule are recommended.

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3.2.16 Industrial Park East Pump and Treat System

This section summarizes the operational and monitoring well data for 2004 for the OU III Industrial Park East (IPE) groundwater pump and treat system, and presents conclusions and recommendations for its future operation. The system began full operation in June 2004 to provide capture and control for a downgradient portion of the OU III VOC plume, which has migrated beyond the BNL site boundary.

3.2.16.1 System Description

The treatment facility is located at the Industrial Park immediately east of the already constructed Industrial Park Groundwater Treatment System. This system includes two extraction wells and one recharge well. Extraction well EW I-1 will is screened in the Upper Glacial aquifer, near the high-concentration core of the plume, and EW I-2 is screened in the upper portion of the Magothy aquifer to address contiguous contaminants. Extraction well EW I-1 is designed to operate at a maximum rate of approximately 120 gallons a minute (gpm); and extraction well EW I-2 is designed for approximately 100 gpm.

The treated water is recharged to the Upper Glacial aquifer through a recharge well located nearby the extraction wells and designated as DW I-1. A complete description of the system is contained in the *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System* (BNL 2004i).

3.2.16.2 Groundwater Monitoring

The monitoring network consists of 12 wells (**Figure 1-2**). The last two wells were installed in late 2004 to help improve the monitoring of the western edge of the plume. The wells are sampled quarterly and analyzed for VOCs. These wells monitor the VOC plume south of the LIE to Astor Drive in the East Yaphank residential area, as well as the effectiveness of the groundwater treatment systems.

3.2.16.3 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are TCA, Trichloroethylene, and 1,1-Dichloroethylene. Groundwater monitoring for this system was initiated in 2004, however, three of the wells have been monitoring the plume since 1999. Fourth-quarter well data is posted on **Figure 3.2-1, 3.2.4-1 and 3.2.6-1**. The complete results are in **Appendix C.** Results for key monitoring wells are as follows:

- Maximum TVOC concentrations during 2004 were found in plume core well 122-24, at 139 µg/L during the first quarter, with TCA as the highest VOC, at 71 µg/L. This well is located upgradient but within the capture zone of the extraction wells (to the northwest). The TVOC concentrations in this well continued to decline over the year to a low of 46 µg/L in the fourth quarter.
- Recently installed plume core well 000-514, located just to the west of the extraction wells, detected TVOCs in the fourth quarter up to 80 µg/L.
- VOCs in plume bypass wells 000-493, 000-494, and 000-495 have remained below the Maximum Contaminant Level (MCL) since they were installed in June.

3.2.16.4 System Operations

Operating Parameters

The influent, midpoint, and effluent of the carbon vessels were sampled twice a month during startup. Since there was no combined influent sampling port until January 2005, the extraction well sample data was used to determine VOC concentrations entering the carbon vessels. The extraction wells were sampled monthly. All samples are analyzed for VOCs. In addition; the pH of the influent and effluent samples is measured monthly. The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. All effluent samples during this period of operation were within the permit levels (**Table 3.2.16-1**).

Table 3.2.16-1.
Industrial Park East Pump & Treat System
2004 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Measured Value (µg/L)
pH (range)	5.5–8.5 SU	5.8–6.4 SU
bromoform	50	<0.50
carbon tetrachloride	5	<0.50
chloroform	5	<0.50
methylene chloride	5	<0.50
tetrachloroethylene	5	<0.50
toluene	5	<0.50
trichloroethylene	10	<0.50
1,2-dichloroethane	5	<0.50
1,1 dichloroethane	5	<0.50
1,1-dichloroethylene	5	<0.50
1,1,1-trichloroethane	5	<0.50

*Maximum allowed by requirements equivalent to a SPDES permit.

System Operations
The system began routine operations in June of 2004. The following information summarizes the systems operations for each month of 2004.

June –September 2004
The system was found off on July 12 and July 27, due power supply problems. Well EW I-1 was off from August 25–31 for well development to improve the well performance. EW I-1 was off from September 1–9 for well development. EW-2 was off from September 8–21 for well development. EW I-1 was off again from September 21–27 to complete the development process.

October 2004
The system was down October 12 for a routine carbon changeout and restarted October 13.

November 2004
The system was shut off from November 19 to November 22 for electrical work and was restarted November 23. Well EW I-1 operated at 115 gpm and well EW I-2 operated at 75 gpm for the remainder of the month.

December 2004
The system operated for the entire month with EW I-1 set at 115 gpm and EW I-2 set at 80 gpm.

3.2.16.5 System Operational Data

System Influent and Effluent
Based on the extraction well data, the overall TVOC influent water quality to the carbon vessels remained stable over the year. The influent TVOC concentration averaged 28 µg/L, with a high of 40 µg/L in June. **Tables F-39** and **F-40** in **Appendix F** present the influent and effluent data.

Cumulative Mass Removal
The mass of VOCs removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system. **Table F-41** lists monthly pumpage rates for 2004. These rates were used in determining mass removal of TVOCs.

Table F-41 gives total pounds of mass of VOCs removed by the treatment system. **Figure 3.2.16-1** plots mass removal versus time. Approximately 17 pounds (1.2 gallons) of VOCs were removed during 2004.

3.2.16.6 System Evaluation

The system became operational in June 2004. This system is designed to achieve the overall OU III ROD objectives of minimizing plume growth and meeting MCLs in the Upper Glacial aquifer in 30 years or less. According to the *OU III Explanation of Significant Differences* (BNL 2005b), MCLs within the Magothy aquifer must be met within 65 years or less. The system will address the highest VOC concentration portion of the plume (above 50 µg/L). A detailed description of the system pump test performance can be found in the *Startup Test Report for the OU III Industrial Park East Groundwater Treatment System* (BNL 2004j).

The Industrial Park East Pump and Treat System performance during 2004 can be evaluated based on the five major decisions identified for this system from the groundwater DQO process:

1. Was the BNL Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the treatment system during 2004.

2.Has the plume been controlled?

Yes. As per the Startup Report, the capture zone, depicted in **Figure 3.0-1**, for the treatment system is operating as planned.

3. Is the System operating as planned? Specifically, is the aquifer being restored at the planned rate for a particular treatment system?

Yes. The system is operating as planned. However, it is still early in the operational life of this system to fully answer this question.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements.

4a. Have asymptotic VOC concentrations been reached in core wells?

No. The system has only been in operation a short time.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?

No. The system has only been in operation a short time.

4c. How many individual plume core wells are above 50 µg/L?

Well 122-24 that is just upgradient of extraction well EWI-2, shows TVOCs concentrations up to 60 µg/L and 45 µg/L for the third and fourth quarters, respectively. Core well 000-514 shows TVOC concentrations up to 80 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?

The Industrial Park East System has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved in the Upper Glacial aquifer (expected by 2030) and the Magothy raquifer (expected by 2070)?

No. MCLs have not been achieved for individual VOCs in all plume core wells. MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.16.7 Recommendations

The following are recommendations for the Industrial Park East Pump and Treat System and groundwater monitoring program.

- Install an additional Magothy monitoring well adjacent to well 000-495, but deeper, to more accurately define the plume.
- Continue operations at 115 gpm for EWI-1 and 75 gpm for EWI-2.
- No changes are recommended at this time to the monitoring well network and sampling frequency.

3.2.17 LIPA/Airport Pump and Treat System

3.2.17.1 System Description

This project incorporates three separate areas. The LIPA portion encompasses four extraction wells. Three wells (EW-1L, -2L and -3L) are for the Upper Glacial portion of the OU III plume and are located along the LIPA right of way. Well EW-4L is in the Magothy aquifer and is located on Stratler Drive (see **Figure 3.2-1**). The water from these four wells is pumped to the treatment plant, about one mile south on Brookhaven Airport property, where it is combined with the water from the five Airport extraction wells (RTW-1A through -5A) and treated via granular activated carbon. The treated water is released back to the ground via a series of shallow reinjection wells located on Brookhaven Airport and Dowling College property.

The three components of the LIPA/Airport Pump and Treat System are as follows.

1. The Magothy extraction well on Stratler Drive addresses high-level VOCs identified in the Magothy aquifer immediately upgradient of this well on Carleton Drive. The capture goal for this well is 50 µg/L TVOC.
2. The three LIPA extraction wells were installed to address high concentrations of VOCs in the Upper Glacial aquifer that had migrated past the Industrial Park System before that system became operational in 1999. The capture goal for these extraction wells is 50 µg/L TVOC.
3. The five extraction wells in the Airport System were installed to address the leading edge of the plumes, which have migrated past the LIPA extraction wells and the North Street extraction wells. These Airport System wells were installed to prevent further migration of the plumes and have a lower capture goal: 10 µg/L TVOC.

A more detailed description of this system is contained in the *Operations and Maintenance Manual for the LIPA/ Airport Groundwater Treatment System* (BNL 2004g).

3.2.17.2 Groundwater Monitoring

Well Network

The monitoring network consists of 16 wells associated with the LIPA Upper Glacial wells and was designed to monitor the VOC plume off site, south of the OU III Industrial Park System. The wells are sampled quarterly for VOCs. The Airport System network has 23 monitoring wells, which monitor the portions of the plume south of the LIPA and the North Street systems. The Magothy extraction well on Stratler Drive has six monitoring wells associated with its operation. All of these wells are used to monitor and evaluate the effectiveness and progress of the cleanup associated with these three systems. **Figure 1-2** identifies the monitoring wells for these plumes.

Sampling Frequency and Analysis

The monitoring wells for these projects are currently on a quarterly schedule.

3.2.17.3 Monitoring Well Results

The primary VOCs associated with these portions of the plume are carbon tetrachloride, TCA, TCE, and 1,1-dichloroethylene. Groundwater monitoring for these systems was initiated in 2004. Fourth-quarter well data is posted on **Figures 3.2-1** and **3.2.17-1**. The complete results are in **Appendix C**. Results for key monitoring wells are as follows.

- Maximum TVOC concentrations during 2004 for the Magothy extraction well on Stratler Drive were detected in December, at 304 µg/L. This is a good indication that the high concentrations observed in monitoring well 000-130 several years ago are being captured by this well. This was the primary objective for installing extraction well EW-4L.

- One of the LIPA plume core monitoring wells, 000-448, had concentrations of 204 µg/L in March 2004. However, concentrations had dropped to 14 µg/L by December 2004. This well is adjacent to EW-1L, and beyond the capture zone of the LIPA extraction wells. Downgradient monitoring well 000-131 had a concentration of 213 µg/L in December 2004.
- All monitoring wells near the extraction wells for the Airport System are below MCLs at this time. However, upgradient monitoring well 800-94, approximately 1,500 feet north of wells RTW-1A and -2A, had a concentration of 62 µg/L in December 2004, indicating that higher concentrations should be expected.

3.2.17.4 System Operations

The extraction wells were sampled once per month in 2004. The influent, midpoint, and effluent of the carbon units were sampled once per week, along with weekly pH readings. All samples were analyzed for VOCs.

The following is a summary of the OU III Airport/LIPA operations for 2004. The treatment system was under final construction during the winter, and spring of 2004. Startup testing began in June 2004. Startup testing and troubleshooting of the system officially ended December 2004, when the first *Discharge Monitoring Report* (DMR) was submitted for the LIPA/Airport System.

January–September 2004

System startup and testing was conducted June–September. System operation was sporadic, as various system changes were made and punch list items were completed.

October–December

System startup and testing continued from October–November. In December the system operated reliably, with only one shutdown recorded from December 1–9, 2004, due to a carbon changeout.

Extraction Wells Operational Data

During 2004, approximately 147 million gallons were pumped and treated by the OU III Airport/LIPA system, with an average flow rate of 511 gpm since startup testing began in June. **Table F-45** shows the monthly pumping data for the system. VOC concentrations for the Airport and LIPA extractions wells are provided in **Table F-42**. VOC levels in all Airport extraction wells were below MCLs. **Table 3.2.17.1** shows maximum measured values and the values allowed under the SPDES Equivalency Permit. Concentrations in the three LIPA extraction wells were fairly consistent through the operational period. Concentrations in EW-4L, the Magothy extraction well, increased significantly during the period (see below).

Table 3.2.17.1
OU III LIPA/Airport Pump & Treat System
2004 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)*	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	6.45 SU
carbon tetrachloride	5	<0.50
chloroform	7	<0.50
1,1-dichloroethane	5	<0.50
1,1-dichloroethylene	5	<0.50
methylene chloride	5	<0.50
1,1,1-trichloroethane	5	<0.50
trichloroethylene	10	<0.50

*Max. effluent allowed. by requirements equivalent to a SPDES Permit.

3.2.17.5 System Operational Data

System Influent and Effluent

VOC concentrations in 2004 for the carbon influent and effluent are summarized in **Tables F-43** and **F-44** (in **Appendix F**).

The carbon vessels for the system effectively removed all contaminants from the influent groundwater. All effluent data were below the analytical method's detection limit and below the regulatory limit specified in the permit equivalency conditions.

Cumulative Mass Removal

The mass of TVOCs removed from the aquifer by the OU III Airport/LIPA treatment system was calculated using the average flow rates for each monthly monitoring period, in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds per month removed. The plot of cumulative mass of TVOCs removed vs. time (**Figure 3.2.17-2**) shows that 62 pounds of VOCs were removed during 2004.

Extraction Wells Data Evaluation

Table F-42 in **Appendix F** summarizes the data for the extraction wells. The Airport extraction wells are all below MCLs. The four LIPA wells all showed elevated levels of VOCs. EW-3L had the lowest TVOC concentrations (15-20 µg/L). Wells EW-1L and -2L both show TVOC concentrations above 50 µg/L. Magothy extraction well EW-4L started out with TVOC concentrations slightly over 100 µg/L in June and by December had concentrations slightly over 300 µg/L. The primary contaminant in EW-4L is carbon tetrachloride. These high concentrations were expected and are consistent with high concentrations historically detected in upgradient monitoring well 000-130.

3.2.17.6 System Evaluation

The Airport treatment system was designed to capture the leading edge of the OU III and OUI/IV VOC plumes. However, to date no concentrations of VOCs above MCLs have been detected in the five extraction wells. This was expected, based on the low concentrations of VOCs in the monitoring wells at this location. Some higher concentrations of VOCs have been detected upgradient of these wells. VOC concentrations in the LIPA wells are consistent with the groundwater modeling done for the design of this system.

The OU III Airport/LIPA system performance can be evaluated based on the five major decisions identified for this system resulting from the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells associated with the LIPA/Airport Treatment System during 2004.

2. Has the plume been controlled?

Yes. Based on the results of the *LIPA/Airport Pump Test Report* (Holzmacher 2004), the plumes are being controlled. The capture zones clearly show that the capture goal of 50 µg/L TVOC at the LIPA wells is being met. The leading edge of the plume has not reached the airport extraction wells.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

Yes, the system is operating as planned. However, these wells have not been operating long enough to evaluate the progress of aquifer restoration.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements (see below).

4a. Have asymptotic TVOC concentrations been reached in core wells?

There is not enough data to evaluate this at this time.

4b. Is the TVOC concentration in the LIPA core wells less than 50 µg/L (expected by 2025)?

No, there are two LIPA core wells (000-131 and 000-448) with TVOC concentrations greater than 50 µg/L .

4c. Is the TVOC concentration in the Airport core wells less than 10 μg/L ?
No, three Airport core wells (800-63, 800-94, and 800-99) have TVOC concentrations greater than 10 μg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?
The system has not been pulsed to date.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in plume core wells at LIPA. Although the core wells at the Airport are below MCLs, higher concentration portions of the plumes are expected to migrate to this area in the future. Based on model results, MCLs are expected to be achieved by 2030 for the Upper Glacial aquifer, and in the Magothy aquifer by 2070, as required by the OU III ROD and ESD.

3.2.17.7 Recommendations

The following are recommendations for the LIPA/Airport Groundwater Treatment System and groundwater monitoring program:

- Quarterly sampling of the monitoring wells associated with this project should continue in 2005 and will likely be reduced to semiannual for most wells in 2006.
- The extraction well sampling should continue on a monthly schedule.
- The leading edge of the plume has not reached the Airport extraction wells. Therefore, the Airport extraction wells should be pulse pumped beginning in October 2005. This will be accomplished by operating the wells one week each month and continuing to sample them monthly. This will verify that the higher concentrations have not reached the Airport system. If concentrations above the capture goal of 10 μg/L VOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.

3.3 OPERABLE UNIT IV

3.3.1 Post Closure Monitoring (Former OU IV AS/SVE System)

The OU IV Air Sparge system was shut down on August 08, 2001, and further monitoring was continued as per *OU IV Remediation Area 1 Proposed Supplemental Remedial Effort – Work Plan* (BNL May 2001c). The *Petition for Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System* (BNL 2002) was submitted to the regulatory agencies in June 2002. BNL received regulatory approval in July 2003, and decommissioned the system in December 2003.

A 5-year review report for OU IV was submitted to the regulators in June 2002. Following revisions made based on regulator comments, a final report was approved in September 2003. This report included changes to the continued groundwater monitoring program.

3.3.1.1 Groundwater Monitoring

Well Network

The *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e) stated that monitoring under this program should continue for three monitoring wells, 076-04, 076-06, and 076-185.

Monitoring wells 076-18, 076-19, and 076-23 will continue to be monitored under the BNL Facility Monitoring Program. The remaining monitoring wells were either included under the radionuclide monitoring under OU IV AOC 6 Program or abandoned as per the final report (BNL 2003e).

Sampling Frequency and Analysis

The wells were sampled quarterly for VOCs in 2004 (**Table 1-5**). In 2005, the following monitoring requirements from the *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e) will be implemented:

- Wells 076-04 and 076-06 will continue to be monitored quarterly for VOCs and SVOCs. If concentrations remain below MCLs for a 1-year period, the sampling frequency will be reduced to semiannual for a period of up to 5 years.
- Well 076-185 will continue to be monitored for VOCs on a semiannual basis.

3.3.1.2 Monitoring Well Results

Post-closure quarterly sampling of monitoring wells was conducted for 2004. The complete groundwater data are given in **Appendix C**. Here is a brief summary of the results.

- Well 076-04 – There was only one VOC detected which exceeded the MCLs. m/p Xylene was detected in October at a concentration of 5.2 μg/L, which is above the standard of 5 μg/L.
- Well 076-06 – There was one detection of a VOC exceeding MCLs. 1,3,5-trimethylbenzene was detected in October at a concentration of 5.7 μg/L, which is above the standard of 5 μg/L.
- Well 076-185 – There were no detections of VOCs exceeding the standards for the four quarters of sampling. However, in October, tetrachloroethylene was detected near the MCL, at 4.8 μg/L.

3.3.1.3 Post-Closure Monitoring Evaluation

The system can be evaluated based on the decision rule identified during the groundwater DQO process.

1. Was the BNL Contingency Plan triggered?

No. There were no unexpected VOC concentrations in groundwater during 2004.

3.3.1.4 Recommendations

The following are the recommendations for the OU IV Former AS/SVE Post Closure groundwater monitoring program:

- Fully implement the monitoring requirements defined in the *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e), as follows:
  - Wells 076-04 and 076-06 – Continue to monitor these wells quarterly for VOCs and SVOCs. If concentrations remain below MCLs for a 1-year period, reduce the sampling frequency to semiannual for up to 5 years.
  - Well 076-185 – Continue to monitor for VOCs on a semiannual basis.

3.3.2 Building 650 Strontium-90 Monitoring Program

The Building 650 Strontium-90 Monitoring Program monitors a Sr-90 plume emanating from a source area known as the former Building 650 Sump Outfall Area. This area was a depression at the terminus of a discharge pipe from the building. The pipe conveyed discharges from the decontamination of radioactively contaminated clothing and from the decontamination of equipment that was conducted on an outdoor pad at Building 650, beginning in 1959.

Remediation of the contaminated soils associated with the Building 650 sump outfall and the pipe leading to the outfall were excavated in 2002.

3.3.2.1 Groundwater Monitoring

Well Network
The network consists of 28 wells used to monitor the Sr-90 concentrations originating from the former Building 650 Sump Outfall Area. (**Figure 1-2**).

Sampling Frequency and Analysis
The wells were monitored semiannually, and the samples analyzed for gross alpha/beta, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**).

3.3.2.2 Monitoring Well Results

The complete results from radionuclide sampling can be found in **Appendix C**. The overall extent of the Sr-90 plume originating from the Building 650 sump outfall did not change significantly during 2004, although it continues to migrate to the southwest (**Figure 3.3.2-1**). The highest Sr-90 concentrations were detected in well 076-169, at 24 pCi/L, in March 2004. In general, the concentrations in wells associated with the Building 650 sump displayed a continued slow decline during 2004 (**Figure 3.3.2-2**). Based on sample results and water table flow direction, it appears that the center-line of the plume may be located just to the west of well 076-24.

Sr-90 concentrations in well 076-28 are shown in **Figure 3.3.2-2**. This well is located immediately north of Building 650, adjacent to a former decontamination pad. Contaminated soils were removed from the area of the former decontamination pad in 2002.

3.3.2.3 Groundwater Monitoring Program Evaluation

The system can be evaluated based on the three decision rules identified from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unexpected Sr-90 concentrations in groundwater during 2004.

2. Were performance objectives met?

No. The performance objective for this project is to achieve Sr-90 concentrations below the NYS DWS of 8 pCi/L. Currently, two wells exceed this limit. Therefore, the performance objectives have yet to be achieved. The removal of contaminated soils in 2002 appears to have alleviated some of the source of groundwater contamination, as evidenced by the declining Sr-90 concentrations in plume core wells.

3. If not, are observed conditions consistent with the attenuation model?

Yes. The observed data is consistent with the attenuation model in terms of the extent of Sr-90 contamination.

3.3.2.4 Recommendation

The recommendation for the Building 650 Strontium-90 Groundwater Monitoring Program is as follows:

- Continue to monitor to determine whether remediation of the Building 650 Decontamination Pad and Sump Outfall has removed the source of contamination and if the plume is attenuating and migrating as expected.

3.4 OPERABLE UNIT V

3.4.1 Sewage Treatment Plant Monitoring Program

Historically, Brookhaven's STP received discharges of contaminants from routine operations. Releases of contaminants to groundwater, in particular VOCs, metals, and radionuclides, occurred via the STP sand filter beds and discharges to the Peconic River. The OU V project monitors the identified groundwater contamination downgradient of the STP.

3.4.2 Groundwater Monitoring

Well Locations

A monitoring network of 34 wells was designed to follow groundwater contamination downgradient of the STP, at the boundary, and off site (**Figure 1-2**). Sentinel wells were installed downgradient of the leading edge of the off-site VOC plume. BNL's Groundwater Model was used to aid in placing these wells.

Sampling Frequency and Analysis

Wells are sampled semiannually, and samples are analyzed for VOCs, perchlorate, and tritium (**Table 1-5**).

3.4.3 Monitoring Well Results

The OU V wells were sampled during two rounds in 2004. **Appendix C** contains the complete data. There were no significant changes to the VOC plume in 2004 as compared to 2003 (**Figure 3.4-1**). During 2004, the highest TVOC concentration was 17 µg/L in well 000-122, located just north of the Long Island Expressway. In general, VOC concentrations in on-site plume core wells decreased slightly, while the TVOC concentrations in off-site plume core well 000-122 displayed a slight increase (**Figure 3.4-2)**. The only individual VOCs detected at levels exceeding NYS AWQS were TCA, TCE, and 1,2,3-trichloropropane. 1,2,3-trichloropropane and 1,2-dichloropropane have been detected in shallow off-site sentinel well 600-25 since 1998. During 2004, 1,2,3-trichloropropane was observed at an estimated detection of 0.41 µg/L, which exceeds the NYS AWQS of 0.05 µg/L. Based on the shallow depth of the well and its location approximately 4,000 feet southeast of the BNL site boundary, there appears to be an off-site source for this contamination. The contamination was not observed in either of the two deeper monitoring wells in this cluster.

The 34 OU V monitoring wells were sampled and analyzed for perchlorate during the August 2004 sampling round. This sampling was performed in response to a SCDHS request in June 2004. The request was prompted by the detection of perchlorate in SCDHS monitoring well EG-A located off site and east of BNL. The perchlorate was detected in the deep section of the Upper Glacial aquifer. Perchlorate was detected in four of the OU V wells (049-06, 050-02, 061-04, and 061-05), with concentrations ranging between 5.0 µg/L and 12.7 µg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 µg/L. Well 049-06 is near the eastern firebreak road, and is used to monitor the deep portion of the Upper Glacial aquifer. The remaining three wells are located on the BNL site, close to the eastern boundary, and are used to monitor the groundwater quality in the middle to deep sections of the Upper Glacial aquifer. BNL also sampled four shallow monitoring wells near the STP sand filter beds. The wells were sampled and analyzed in December 2004. No perchlorate was detected. BNL has added perchlorate analyses for eight OU V wells in 2005.

Tritium has historically been detected at low concentrations in monitoring wells 49-06, 50-02, and 61-05 (**Figure 3.4-3**). Historical trends for tritium in wells 50-02 and 61-05 are plotted in **Figure 3.4-4**. The maximum tritium concentration during 2004 was 2,160 pCi/L in well 049-06 ; this is nearly 10 times lower than the DWS of 20,000 pCi/L.

3.4.4 Groundwater Monitoring Program Evaluation

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unexpected contaminant concentrations in groundwater during 2004. Perchlorate was detected in several monitoring wells sampled at the request of SCDHS. Sampling of these wells for perchlorate will continue in 2005.

2. Were the performance objectives met?

No. The performance objective for this program is to attain DWS for VOCs in groundwater in the Upper Glacial aquifer within 30 years using monitored natural attenuation. These standards continue to be exceeded in two of the monitoring wells. **Figure 3.4-5** compares the plume distribution between 1997 and 2004. The leading edge of the plume is estimated to be between the Long Island Expressway and South Street.

3. Is the extent of the plume still defined by the existing monitoring well network?

Yes. The leading edge of the plume is southeast of well 000-122 (south of the Long Island Expressway). Currently, two well clusters serve as sentinel wells for this plume along North Street and Wading River Road.

3.4.5 Recommendations

It is recommended that eight OU V monitoring wells (000-122, 000-123, 049-05, 049-06, 050-01, 050-02, 061-04, and 061-05) continue to be analyzed for perchlorate in 2005.

3.5 OPERABLE UNIT VI EDB PUMP AND TREAT SYSTEM

The OU VI EDB Program monitors the extent of an ethylene dibromide plume in groundwater currently extending from the site boundary, off-site south of North Street. EDB was used during the 1970s as a fumigant for the BNL Biology Department's agricultural fields located in the southeastern portion of the site. In 1995 and 1996, low levels of EDB were detected in groundwater near the fields. Higher levels were found migrating toward the southern site boundary and off site to the south. In addition, the depth of the plume increased within the Upper Glacial aquifer to the south.

3.5.1 System Description

A groundwater remediation system to address the off-site EDB plume was constructed during 2004. The OU VI Treatment System consists of two extraction wells and two recharge wells. A complete description of the system is included in the *Operation and Maintenance Manual for the OU VI EDB Groundwater Treatment System* (BNL 2004e). Routine operations began in August 2004.

3.5.2 Groundwater Monitoring

Well Locations

A network of 33 wells monitor the EDB plume from the source area in the Biology Department's agricultural fields to locations on private property south of North Street (**Figure 3.5-1**). Five new monitoring wells were installed as part of the construction of the pump and treat system in 2004.

Sampling Frequency and Analysis

The wells are monitored quarterly, and analyzed for EDB by EPA Method 504.2. Samples are analyzed annually for VOCs and tritium (**Table 1-5**).

3.5.3 Monitoring Well Results

Appendix C contains the complete results of the quarterly sampling program. The distribution of the EDB plume is shown for the fourth quarter of 2004 (**Figure 3.5-1**). The leading edge of the plume is currently in the vicinity of well 000-507. This well was sampled for the first time in March 2005 and the data were included as part of the fourth-quarter plume map. EDB was detected at 0.028 μg/L in this sample, which is slightly above the 0.02 μg/L method detection limit. The plume appears to be just reaching extraction wells EW-1E and -2E, based on the detection in well 000-507. The plume is located in the deep Upper Glacial aquifer and is generally moving horizontally, as depicted on cross section L–L' (**Figure 3.5-2)**. The highest EDB concentration observed during 2004 was 4.1 μg/L, in well 000-284. This is less than the maximum EDB concentration reported in 2003 of 6.8 μg/L, in well 000-284. The federal DWS for EDB is 0.05 μg/L.

The southward migration of the plume can be observed by analyzing the trends in **Figure 3.5-3**. EDB shows decreasing trends for wells north of the plume's current core position. In contrast, EDB is increasing in the wells currently in the plume core area. Comparing the plume's distribution from 1997 to 2004 in **Figure 3.5-4** also illustrates the southward movement of the plume.

The wells are sampled annually for VOCs in addition to quarterly EDB analyses. There were no detections of VOCs besides EDB above MCLs in any of the wells (**Appendix C**).

The wells are sampled annually for tritium. There were no confirmed detections observed in 2004.

3.5.4 System Operational Data

The extraction wells are currently sampled every month. The influent and effluent of the carbon treatment system were sampled weekly. All samples were analyzed for VOCs and EDB. In addition, the effluent sample is analyzed for pH and tritium twice a month. **Table 3.5-1** provides the effluent limitations for meeting the requirements of the SPDES permit equivalency.

Table 3.5-1
OU VI EDB Pump & Treat System
2004 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)*	Max. Measured Value (µg/L)
pH (range)	5.0 – 8.5 SU	NS
ethylene dibromide	5.0	<0.50
chloroform	7.0	1.4
1,1-dichloroethene	5.0	<0.50
1,1,1-trichloroethane	5.0	<0.50

*Maximum allowed by requirements equivalent to a SPDES permit.
NS = not sampled in 2004

Extraction Wells
During 2004, 20 million gallons were pumped and treated by the OU VI EDB System, with an average flow rate of 154 gpm. Table 2-3 contains the monthly pumping data for the two extraction wells. VOC concentrations for EW-1E (000-503) and EW-2E (000-504) are provided in **Table F-47** in **Appendix F** (on the CD-ROM). EDB was not detected in either extraction well during 2004.

System Influent and Effluent
All parameters were below the regulatory limit specified in the SPDES equivalency permit.

Cumulative Mass Removal
As EDB was not detected in the influent, no cumulative mass calculations were performed. However, other low-level VOCs not attributable to BNL were detected; the results are potentially due to analytical lab contamination, and were all below MCLs.

3.5.5 System Evaluation Data

The OU VI EDB System was designed to remediate the leading edge of the EDB plume and capture the remainder of the plume as it travels south with the regional groundwater flow. Startup of the system was initiated in August 2004 and it is planned to run for approximately 10 years. Therefore, it is still early in the lifecycle of the system. The system is operating as designed; no operating difficulties were experienced beyond normal maintenance, and no permit equivalencies have been exceeded.

The OU VI EDB System performance can be evaluated based on the five major decisions identified in the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring wells associated with the OU VI EDB plume treatment system.

2. If not, has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass wells shows that there have been no detections of EDB in 2004; thus, we conclude that that plume has not grown and continues to be controlled.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?

The hydraulic capture performance of the system is operating as described in the Startup Report. EDB has yet to be detected in extraction wells EW-1E or EW-2E. The recent detection of EDB at levels just above detection limits in plume core well 000-507, located immediately north of the extraction wells, indicates that the leading edge of the plume is just now arriving at this location. As the system has been operating less than 6 months, it is still too early to determine if the aquifer is being restored at the planned rate.

4. Can the groundwater treatment system be shut down?

No, the system has only been operating for 5 months and has not met all shutdown requirements.

4a. Have asymptotic EDB concentrations been reached i nplume core wells?
No. Asymptotic conditions have not yet been achieved.

4b. Are there individual plume core wells above 0.05 µg/L EDB ?
There are currently six plume core wells with concentrations greater than 0.05 µg/L.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?
The OU VI EDB system has not been pulsed to date.

4d. Have the groundwater cleanup goals been met? Have MCLs been achieved by 2030?
No. MCLs have not been achieved for individual VOCs in plume core wells. MCLs are expected to be achieved by 2030, as required by the OU VI ROD.

3.5.6 Recommendation

The system will continue to operate in its present configuration while the plume location and influent EDB concentrations are monitored.

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3.6 SITE BACKGROUND MONITORING

Background water quality has been monitored since 1996. Historically, low levels of VOCs were routinely detected in several background wells that are screened in the deeper portions of the Upper Glacial aquifer.

3.6.1 Groundwater Monitoring

Well Network

The 2004 program included ten wells located in the northwestern portion of the BNL property and adjacent off-site areas (**Figure 1-2**). Background quality is defined as the quality of groundwater that is completely unaffected by BNL's operations.

Sampling Frequency and Analysis

The samples were collected and analyzed for VOCs (**Table 1-5**).

3.6.2 Monitoring Well Results

The complete groundwater data for 2004 is provided in **Appendix C**. There were detections of trace amounts of several VOCs in the site background wells. All VOC detections were below NYS AWQS. The highest concentration detected was chloroform, at 0.87 µg/L in well 017-01.

While radionuclides are no longer analyzed in background wells, historic results are presented for reference purposes. **Table 3.6-1** summarizes the range of radionuclide values detected in background wells from 1996 through 2001.

3.6.3 Monitoring Program Evaluation

The program can be evaluated using the decision rule developed as part of the groundwater DQO process.

1. Is groundwater quality at BNL being impacted by off-site, upgradient source(s) of contamination?

No. There were no VOCs detected in site background wells above NYS AWQS during 2004. Based on these results, there is no current impact to BNL groundwater quality from upgradient contaminant source(s).

3.6.4 Recommendations

No modifications are recommended for this monitoring program.

Table 3.6-1.
Radiological Background Monitoring, 1996 – 2001

Parameter	Activity Range (pCi/L)	Contract-Required Detection Limit
Cs-137	<MDA to 7.24	12
Gross alpha	<MDA to 2.66	1.5
Gross beta	<MDA to 6.41	4.0
Sr-90	<MDA to 3.84	0.8
tritium	<MDA	1,000

Notes:
Cs-137 = cesium-137
<MDA = Less than minimum detectable activity.

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3.7 CURRENT AND FORMER LANDFILL GROUNDWATER MONITORING

Groundwater monitoring data from both the Current and Former Landfills are discussed in detail in the *BNL 2004 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2005). This report can be found in **Appendix I**. The complete groundwater monitoring results for these programs are included in **Appendix C**.

3.7.1 Current Landfill Summary

Data show that, in general, contaminant concentrations have been decreasing following the capping of the landfill in 1995. Studies by Oweis and Biswas (1993) suggest that a period of 2 to 10 years may be required before groundwater quality improvements are observed downgradient of the landfills, depending on the underlying hydrogeology. At the end of 2004 the landfill had been capped for 10 years. Groundwater quality has been slowly improving. The trend in the data suggests that the cap is effective in mitigating contamination.

3.7.2 Current Landfill Recommendation

There were no recommendations to the sampling schedule.

3.7.3 Former Landfill Summary

Data show that contaminant concentrations have been decreasing following the capping of the landfill in 1996. Contaminant concentrations downgradient of this landfill were relatively low prior to capping, primarily due to it being approximately 50 years old. The trend in the data suggests that the cap is effective in mitigating remaining contamination. Based on the declining VOC and Sr-90 concentration trends in downgradient wells, it appears that the landfill cap is performing as planned.

The Sr-90 plume (as defined by concentrations exceeding 8 pCi/L) has migrated south of well 097-64 and continues to attenuate (see **Section 3.2.13**).

3.7.4 Former Landfill Recommendation

There were no recommendations to the sampling schedule presented.

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4.0 ENVIRONMENTAL SURVEILLANCE PROGRAM SUMMARY

During 2004, the Environmental Surveillance (ES) Program at BNL monitored the groundwater quality at 10 active research and support facilities. New York State operating permits require groundwater monitoring at two support facilities (the Major Petroleum Facility and the Waste Management Facility); the remaining eight research and support facilities are monitored in accordance with DOE Order 450.1, *Environmental Protection Program*. This Order requires BNL to establish environmental monitoring programs at facilities that can potentially impact environmental quality, and to demonstrate compliance with DOE requirements and the applicable federal, state, and local laws and regulations. BNL is implementing this part of the Environmental Management System to collect information on groundwater quality, and will use the data to determine whether current engineered and administrative controls effectively protect groundwater quality and whether additional corrective actions are needed.

During 2004, 125 groundwater surveillance wells were monitored during 318 individual sampling events. Information on groundwater quality at each of the monitored research and support facilities is described below. **Table 1-6** summarizes the ES Groundwater Monitoring Program by project. Complete analytical results from groundwater samples collected in 2004 can be found in **Appendix D** (on the CD-ROM).

4.1 Alternating Gradient Synchrotron (AGS) Complex

The structures that constitute the AGS Complex include Building 912, AGS Booster Beam Stop, 914 Transfer Tunnel, g-2 experimental area, E-20 Catcher, former U-Line Target, and the J-10 Beam Stop. Activated soil has been created near a number of these areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. A number of radionuclides can be produced by the interaction of secondary particles with the soil that surrounds these experimental areas. Once produced in the soils, some radionuclides can be leached from the soils by rainwater, and carried to the groundwater. The leaching processes are usually quite slow; therefore, only radionuclides with relatively long half-lives such as tritium (12.3 years) and sodium-22 (2.6 years) are likely to be detected in groundwater. Of the two radionuclides, tritium is more easily leached from the activated soils by rainwater and does not bind to soil particles. When tritium enters the water table, it migrates at the same rate as groundwater flow. Sodium-22 does not leach out of the soil as readily as tritium, and migrates at a slower rate in the groundwater. To prevent rainwater from leaching these radionuclides from the soil, impermeable caps have been constructed over many of the soil activation areas, as specified in the Standards Based Management System subject area entitled *Accelerator Safety*. BNL uses 56 groundwater monitoring wells to evaluate the impact of current and historical operations at the AGS beam stop and target areas. The locations of permanent monitoring wells are shown on **Figure 4-1**.

During 2004, all 56 AGS monitoring wells were used to evaluate groundwater quality near areas of potential soil activation within the AGS Complex. Following the 1999 installation of an improved monitoring well network at the AGS, BNL detected three tritium plumes that originated from activated soil shielding at the g-2/VQ-12 experimental area, the former U-Line beam stop, and the former E-20 Catcher. The subsequent installation of impermeable caps over these soil activation areas has resulted in a reduction of tritium levels to less than the 20,000 pCi/L drinking water standard in the Former U-Line and E-20 Catcher areas. As discussed below, tritium concentrations higher than 20,000 pCi/L continue to be detected downgradient of the g-2/VQ-12 soil activation area (see **Section 4.1.5**).

Historical surface spills and discharges of solvents to several cesspools and recharge basins near the AGS contaminated soil and groundwater with VOCs. VOC contamination is monitored under the Environmental Restoration Program's Operable Unit III Central groundwater monitoring program (see **Section 3.2.9**).

4.1.1 AGS Building 912

Building 912 consists of five interconnected structures that have been used to house as many as four experimental beam lines (A, B, C, and D Lines). A typical beam line consists of bending and focusing electromagnets, vacuum pipes, instrumentation, high-voltage electrostatic devices, beam targets, radiation shielding, cooling water systems, and experimental detectors. These beam lines stopped operations in 2002, and plans are being developed to reconfigure the experiment area for new experiments (e.g., National Science Foundation–sponsored Kopio and Meco experiments).

Beam loss and the production of secondary particles at proton target areas result in the activation of adjacent equipment, the floor, and probably the soil beneath the floor. The highest levels of soil activation beneath Building 912 are expected at the B-Line target cave. Stormwater infiltration around the building is controlled by paving and stormwater drainage systems that direct most of the water to recharge basins north of the AGS complex. Therefore, it is believed that the potentially activated soil underlying the beam targets and stops is adequately protected from surface water infiltration.

4.1.1.1 AGS Groundwater Monitoring

Well Network

Seventeen shallow Upper Glacial aquifer wells are upgradient and downgradient of Building 912 (**Figure 4-1**). Upgradient wells are positioned to monitor potential tritium contamination from sources such as the g-2 area and the former U-Line experimental area. The downgradient wells are positioned to monitor significant beam stop and target areas within Building 912.

Sampling Frequency and Analysis

During 2004, Building 912 wells that were used to help track the g-2/VQ-12 tritium plume were sampled quarterly, whereas the remaining wells were sampled semiannually. The groundwater samples were analyzed for tritium (**Table 1-6**).

4.1.1.2 AGS Monitoring Well Results

Other than tritium contamination that is traceable to either the g-2/VQ-12 magnet or the former U-Line beam target and beam stop source areas, groundwater surveillance data for 2004 indicate that appreciable levels of tritium are not being released from activated soil beneath the experimental floor of Building 912. The g-2 tritium plume has been tracked from the VQ-12 magnet source, beneath a portion of Building 912, to an area just south of the Waste Concentration Facility (**Figure 4-2**). Tritium from this plume was detected downgradient of Building 912 (in wells 065-121, -122, -123, -124, -322, -323, and -324), with a maximum concentration of 451,000 pCi/L in the January 2004 sample from well 065-122. Furthermore, low levels of tritium that are probably traceable to the former U-Line beam target and stop source areas were detected in wells 055-31 and 055-32 (up to 680 pCi/L). In areas not impacted by the g-2 tritium plume or former U-Line experimental areas, tritium was either not detectable or was only observed at trace levels. As described in Section 4.1.5, possible remedial actions for the g-2 tritium plume will be evaluated in a Focused Feasibility Study that is scheduled for completion in early 2006.

4.1.1.3 AGS Groundwater Monitoring Program Evaluation

As noted above, in areas not impacted by the g-2 tritium plume or former U-Line experimental areas, tritium was either nondetectable or only observed at trace levels. These results indicate that the building and associated stormwater management operations are effectively preventing rainwater from infiltrating potentially activated soil below the experimental hall.

4.1.2 AGS Booster Beam Stop

The AGS Booster is a circular accelerator with a circumference of nearly 660 feet. It is connected to the northwest portion of the main AGS ring and to the Linear Accelerator (Linac). The AGS Booster, which has been in operation since 1994, receives either a proton beam from the Linac or heavy ions from the Tandem Van de Graaff generator. The booster accelerates protons and heavy ions before injecting them into the main AGS ring. In order to dispose of the beam during studies, a beam scraper system, consisting of a beam kicker and an absorber block, was originally constructed at the 10 to 11 o'clock portion of the booster. In 1999 the beam stop was repositioned to the south side (6 o'clock section) of the booster ring to accommodate the construction of the NASA Space Radiation Laboratory (NSRL) tunnel in the original beam stop location.

The AGS Booster beam stop is an area where the interaction of secondary particles and soil surrounding the booster tunnel can result in the activation of soil surrounding the Booster tunnel. Although internal shielding around the beam stop was designed to keep secondary particle interactions with the soil to very low levels, a landfill-type geomembrane cap was constructed over the original beam stop region to prevent stormwater infiltration into potentially activated soil. When the beam stop was repositioned to the 6 o'clock region of Booster, a coated concrete cap was constructed over the new beam stop area to prevent stormwater infiltration.

4.1.2.1 AGS Groundwater Monitoring

Well Network

Two shallow Upper Glacial aquifer monitoring wells (064-51 and 064-52) are approximately 50 feet downgradient of the current beam stop (**Figure 4-1**). One of the upgradient wells for the Brookhaven Linac Isotope Producer facility (well 054-61) is also used to provide data on background tritium concentrations.

Sampling Frequency and Analysis

During 2004, the booster area wells were to be monitored semiannually, however, access to the wells was limited to one monitoring period, due to booster operations (**Table 1-6**). All of the groundwater samples were analyzed for tritium.

4.1.2.2 AGS Monitoring Well Results

Although low levels (up to 1,340 pCi/L) of tritium were detected downgradient of the AGS Booster stop during 2001 and 2002, tritium was not detected at concentrations above the MDL during 2003 and 2004 (**Figure 4-3**). The tritium that was detected in 2001 and 2002 was probably related to a short-term uncovering of activated soil shielding at the former AGS Booster beam stop location (northwestern section of the booster) during construction of the beam line tunnel that leads from the booster to the NSRL. This work, which began in September 1999 and was completed by October 1999, may have allowed rainwater to infiltrate the low-level activated soil shielding that surrounds the former beam stop location.

4.1.2.3 AGS Groundwater Monitoring Program Evaluation

The low-levels of tritium detected during 2001 and 2002 near the AGS Booster Beam Stop were likely related to a short-term uncovering of activated soil shielding near the former booster beam stop area during the construction of the tunnel leading from the booster to NSRL. This work, which began in September 1999 and was completed by October 1999, may have allowed rainwater to infiltrate the low-level activated soil shielding.[1] Tritium concentrations dropped to nondetectable levels by 2003, and remained that way during 2004.

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[1] Before construction of the NSRL tunnel commenced, soil samples were collected by drilling through the tunnel wall near the booster beam stop to verify that the tritium and sodium-22 levels were within acceptable limits for worker safety and environmental protection.

Figure 4-3.
Maximum Tritium Concentrations Downgradient of AGS Booster Beam Stop (Wells 064-51 and 064-52).

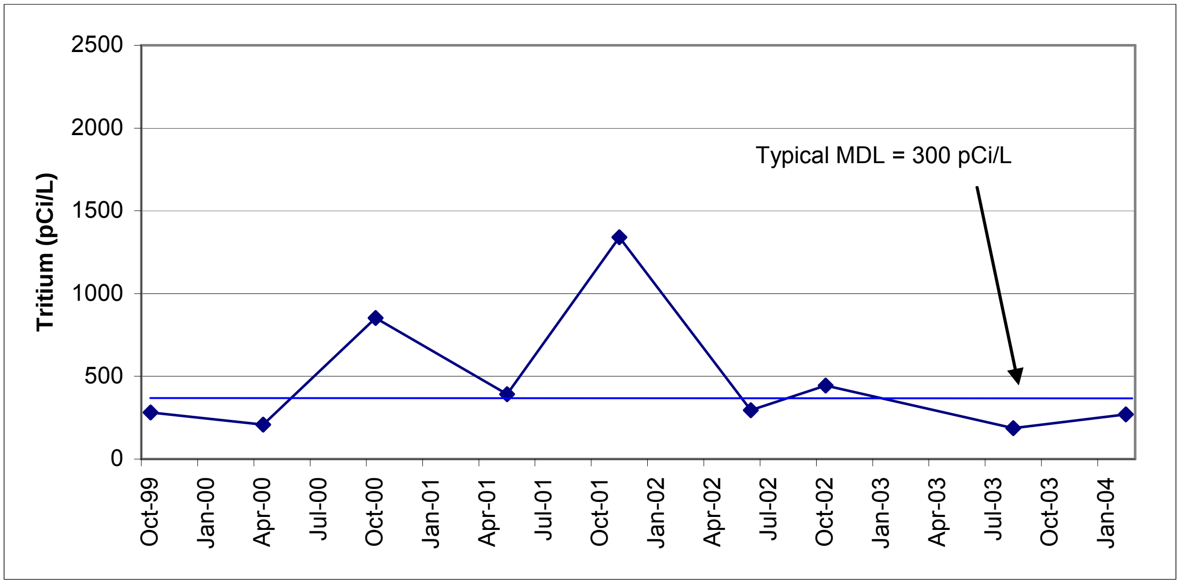
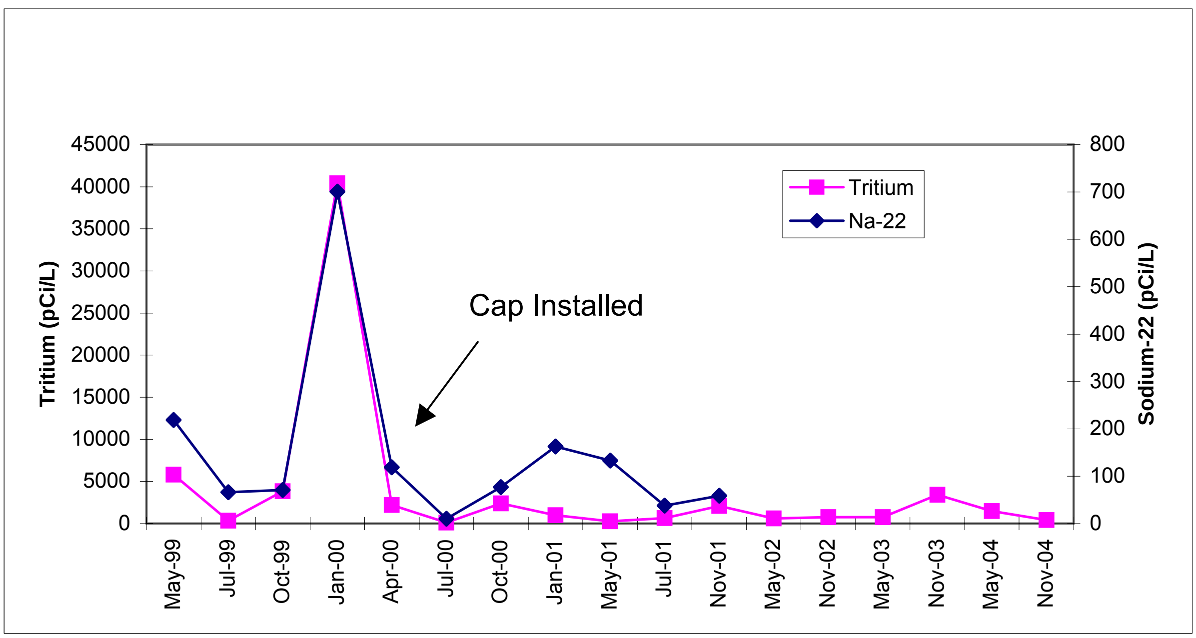


Figure 4-4.
Maximum Tritium and Sodium-22 Concentrations
in Temporary and Permanent Monitoring Wells Downgradient of the Former E-20 Catcher.



4.1.3 E-20 Catcher

The E-20 beam catcher was used from 1984 to 1999, and was located at the 5 o'clock position of the AGS ring (**Figure 4-1**). The E-20 Catcher was a minimum aperture area of the AGS ring, and was used to pick up or "scrape" protons that move out of acceptable pathways. The E-20 Catcher picked up about 80 to 90 percent of all losses resulting from beam injection, transition, ejection within the AGS Ring.

Like other beam loss areas within the AGS complex, the soil surrounding the E-20 Catcher became activated by the interaction with secondary particles. In late 1999, tritium and sodium-22 were detected in wells approximately 100 feet downgradient of the former E-20 Catcher. The highest levels of tritium and sodium-22 were 5,800 pCi/L and 219 pCi/L, respectively. To further evaluate the extent of contamination, temporary wells were installed in January 2000. Tritium and sodium-22 levels in the temporary wells were found to exceed the DWS, with concentrations of 40,400 pCi/L and 704 pCi/L, respectively. In April 2000, a temporary impermeable cap was installed over the E-20 Catcher soil activation area. A permanent cap was constructed by October 2000, and an additional downgradient well was installed for improved long-term monitoring.

4.1.3.1 E-20 Catcher Groundwater Monitoring

Well Network

To verify the effectiveness of the impermeable cap over the E-20 Catcher, the area is monitored by shallow Upper Glacial aquifer wells 064-55, -56, and -80. These wells are located approximately 100 feet downgradient of the source area (**Figure 4-1**).

Sampling Frequency and Analysis

During 2004, the E-20 Catcher wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-6**).

4.1.3.2 E-20 Catcher Monitoring Well Results

Following the installation of the cap in 2000, tritium and sodium-22 concentrations decreased to levels below applicable DWS (**Figure 4-4**). During 2004, the maximum observed tritium concentration was 1,490 pCi/L, detected in well 064-80.

4.1.3.3 E-20 Catcher Monitoring Program Evaluation

The reduction in tritium concentrations since the impermeable cap was constructed over the E-20 Catcher area in 2000 indicates that the cap has been effective in preventing additional rainwater infiltration into the activated soil that surrounds that portion of the AGS tunnel.

4.1.4 Building 914

Building 914 houses the transfer line between the AGS Ring and the Booster. Due to beam loss near the extraction (kicker) magnet, the extraction area of Building 914 is heavily shielded with iron. Because the extraction area is housed in a large building structure, most soil activation is expected to be below the floor of the building where it will be protected from water infiltration.

4.1.4.1 Building 914 Groundwater Monitoring

Well Network

Groundwater quality in the Building 914 transfer line area is monitored by five shallow Upper Glacial aquifer wells; two upgradient wells, and three downgradient wells (**Figure 4-1**).

Sampling Frequency and Analysis

During 2004, the Building 914 area wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-6**).

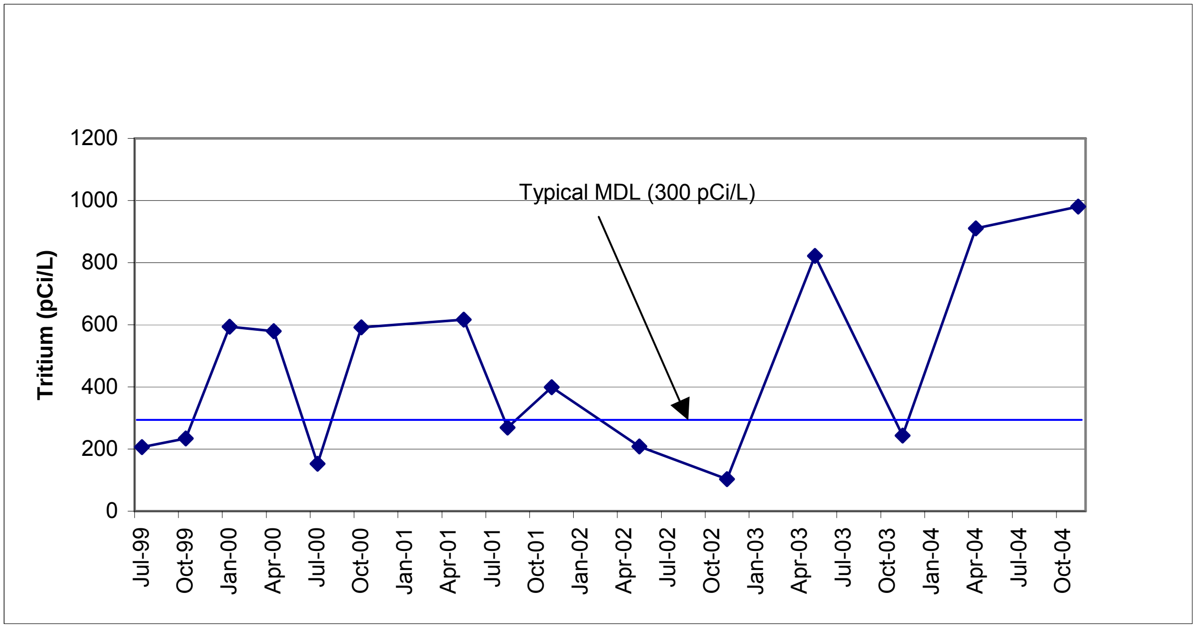
4.1.4.2 Building 914 Monitoring Well Results

Low levels of tritium have been detected in groundwater downgradient of the Building 914 transfer tunnel since January 2000 (**Figure 4-5**). During 2004, the maximum tritium concentration was 980 pCi/L, in a sample from downgradient well 054-53.

4.1.4.3 Building 914 Groundwater Monitoring Program Evaluation

Groundwater monitoring downgradient of Building 914 continues to indicate that the building structure and associated stormwater controls are effectively preventing significant rainwater infiltration into activated soil below the building. However, the detection of tritium during 2003 and 2004 at concentrations of 800 pCi/L to 1,000 pCi/L suggests that some rainwater may be infiltrating the activated soil. Continued monitoring is required.

Figure 4-5.
Maximum Tritium Concentrations Downgradient of 914 Transfer Tunnel (Wells 064-03, -53, and -54).



4.1.5 g-2 Beam Stop and VQ-12 Magnet Area

The g-2 experiment operated from April 1997 until April 2001. The g-2 beam stop is composed of iron, and is covered by soil. Like other beam loss areas within the AGS complex, the g-2 beam stop was an area where the soil surrounding the stop would have become activated by the interaction with secondary particles. To prevent rainwater from infiltrating the soil surrounding the beam stop, BNL installed a gunite (blown concrete) cap over the stop area before the start of beam line operations.

In November 1999, monitoring wells approximately 250 feet downgradient of the g-2 experimental area detected the presence of tritium and sodium-22 in the groundwater. A groundwater investigation conducted during November and December 1999 revealed a narrow plume of tritium with a maximum tritium concentration of 1,800,000 pCi/L. Sodium-22 was also detected, but at a concentration of only 60 pCi/L, or 15 percent of the 400 pCi/L DWS.

Following the discovery, an investigation into the source of the contamination revealed that the tritium originated from activated soil shielding adjacent to the g-2 experiment's VQ-12 Magnet. This section of the beam line was not a designed beam loss area, and the gunite cap installed over the nearby beam stop did not protect the VQ-12 area. In December 1999, an impermeable cap was installed over the VQ-12 soil activation area. This cap was joined to the existing beam stop cap. In September 2000, the activated soil shielding and associated tritium plume were designated as new sub-Area of Concern 16T. Following this designation, DOE agreed to conduct studies to determine the adequacy of the corrective actions taken to date and the need for further actions. A Focused Feasibility Study will be provided to the regulatory agencies in early 2006. Any decisions for corrective actions will be documented in a Record of Decision.

4.1.5.1 g-2 Beam Stop and VQ-12 Magnet Area Groundwater Monitoring

Well Network

Groundwater quality downgradient of the g-2 beam stop is monitored using three downgradient wells, and the tritium plume originating from the VQ-12 magnet area is monitored using 23 downgradient wells (**Figure 4-1**).

Sampling Frequency and Analysis

During 2004, the g-2 beam stop wells were monitored semiannually, and g-2 tritium plume wells were monitored quarterly. All samples were analyzed for tritium (**Table 1-6**).

4.1.5.2 g-2 Beam Stop and VQ-12 Magnet Area Monitoring Well Results

g-2 Tritium Plume

Samples collected during 2004 from wells approximately 150 feet downgradient of the VQ-12 area indicate that although tritium continues to be released to the groundwater, tritium concentrations are much lower than those observed in July 2002, when a tritium concentration of 3,440,000 pCi/L was observed in well 054-07. During 2003, tritium concentrations showed a steady decline from a maximum of 1,040,000 pCi/L in January to 113,000 pCi/L in October. During 2004, tritium concentrations continued to decline, dropping to a maximum of 93,200 pCi/L by October (**Figure 4-6**). In the area immediately downgradient of Building 912, a distance of approximately 600 feet from the VQ-12 source area, the maximum tritium concentration observed during 2004 was 451,000 pCi/L, in well 065-122 (**Figure 4-7**). In May 2004, seven temporary wells were installed in the AGS parking lot area to characterize the leading edge of the g-2 tritium plume. The maximum observed tritium concentration was 518,000 pCi/L, detected in temporary well GP-34. **Figure 4-2** shows the locations of the temporary wells and the position of the g-2 tritium plume during 2004. The segmented nature of the tritium plume resulted from up to four distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 before the impermeable cap was installed over the VQ-12 area, whereas subsequent releases appear to be related to the flushing of residual tritium from the vadose zone following periodic, significant rises in the local water table (**Figure 4-6**).

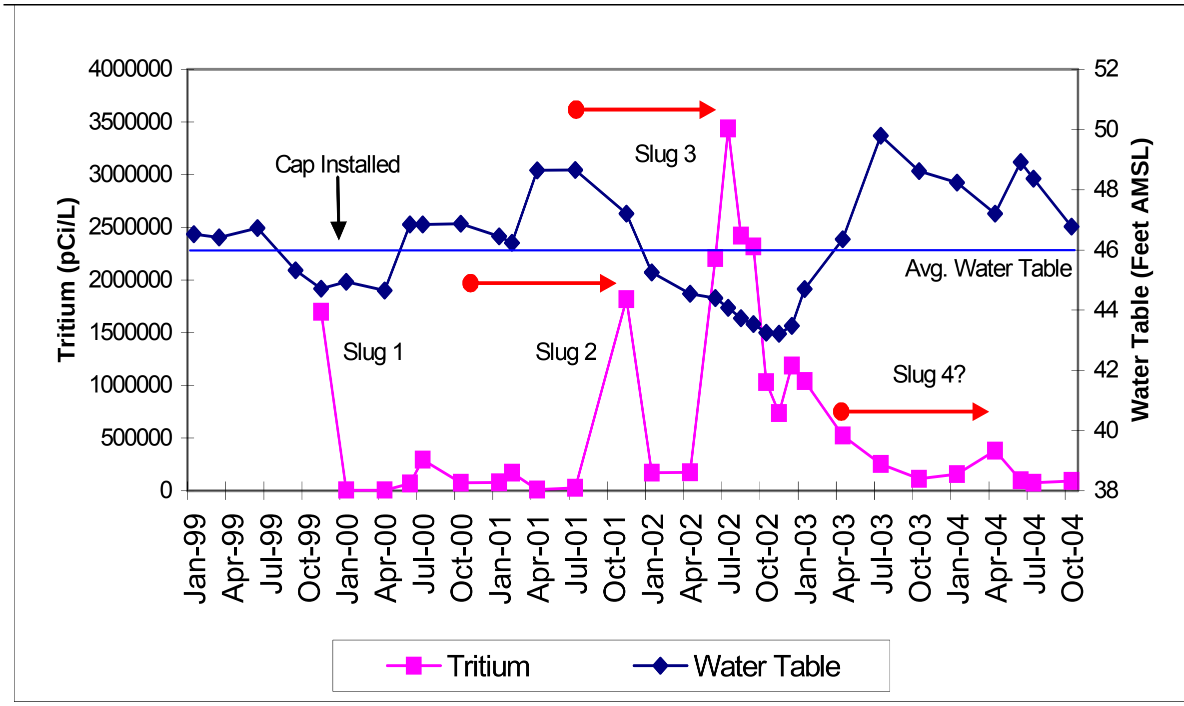
g-2 Beam Stop

During 2004, tritium was not detected in any samples from the three monitoring wells located downgradient of the g-2 beam stop.

4.1.5.3 g-2 Beam Stop and VQ-12 Magnet Area Groundwater Monitoring Program Evaluation

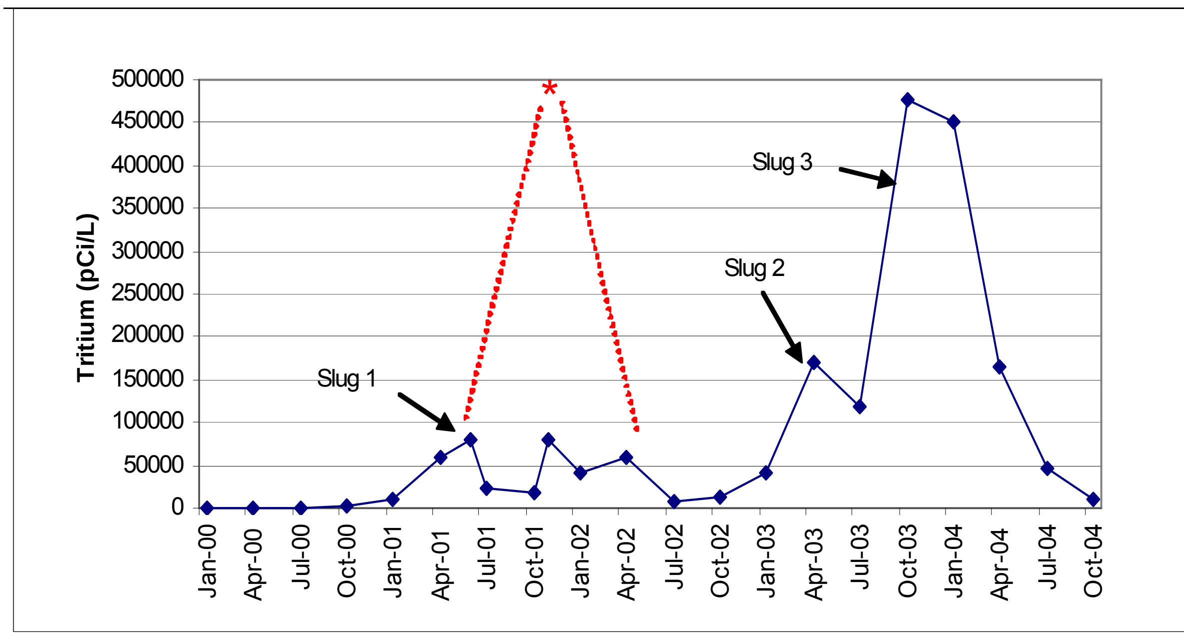
Monitoring of wells downgradient of the g-2 beam stop indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding. Inspections of the cap and review of its design have concluded that the cap over the VQ-12 area has not failed and is properly positioned. Although the cap prevents rainwater infiltration into the activated soil-shielding zone, a leading hypothesis at this time is that periodic natural fluctuations in the water table have released residual tritium from the deep vadose zone (i.e., unsaturated soil immediately above the water table). It is believed that this tritium was mobilized to the soil close to the water table before the cap was put in place in December 1999. Once the cap was in place, the lack of additional rainwater infiltration kept the tritium in the vadose zone from migrating into the groundwater until the significant rise in water table mobilized it. There appears to be good correlation between high tritium concentrations detected in monitoring wells immediately downgradient of VQ-12, and the groundwater table elevation about 1 year before the sampling (**Figure 4-6**). The groundwater travel time from beneath the source to the monitoring wells is about 1 year. Water levels in the central BNL area in mid 2000, mid 2001 and July 2003, were near the highest observed in 49 years of record by the USGS. Additional details on the vadose zone release hypothesis and possible remedial actions for the g-2 tritium plume will be provided in a Focused Feasibility Study scheduled for completion in early 2006.

Figure 4-6.
Maximum Tritium Concentrations in Permanent and Temporary Wells Downgradient of the g-2/VQ-12 Source Area (West Side of Building 912A).



Note 1: Slug 1 was released prior to capping the VQ-12 source area.
Note 2: Arrows indicate ~ 1 year of travel time from VQ-12 source area to first set of monitoring wells near Bldg. 912A (e.g., well 054-07).

Figure 4-7.
g-2 Tritium Plume Concentrations Downgradient of Building 912.



* Tritium concentrations up to 518,000 pCi/L were detected in temporary wells installed in the AGS parking lot in May 2004. This suggests that a small, narrow zone of high tritium concentrations representing Slug 1 was missed during the mid to late 2001 monitoring period. In 2002, four additional wells were installed east of Building 912 to provide improved monitoring of this narrow plume.

4.1.6 J-10 Beam Stop

In 1998, BNL established a new beam stop at the J-10 (12 o'clock) section of the AGS Ring, replacing E-20 as the preferred repository for any beam that might be lost in the AGS Ring (**Figure 4-1**). Activation products are likely to be produced in the soil surrounding the tunnel adjacent to the J-10 beam stop. The J-10 beam stop is subject to the same injection, transition, ejection and studies losses that occurred at the former E-20 Catcher, discussed earlier. The ability of rainwater to infiltrate potentially activated soil surrounding the J-10 stop is likely to be significantly reduced because the AGS tunnel has been covered by layers of styrofoam and soil-crete (a sand and concrete mixture). BNL also constructed a gunite cap over remaining exposed soil areas overlying the J-10 region before beam stop operations began.

4.1.6.1 J-10 Beam Stop Groundwater Monitoring

Well Network

The monitoring well network for the J-10 beam stop consists of one upgradient (054-62) and two downgradient wells (054-63 and 054-64) (**Figure 4-1**).

Sampling Frequency and Analysis

During 2004, the three J-10 beam stop wells were monitored semiannually and the samples were analyzed for tritium (**Table 1-6)**.

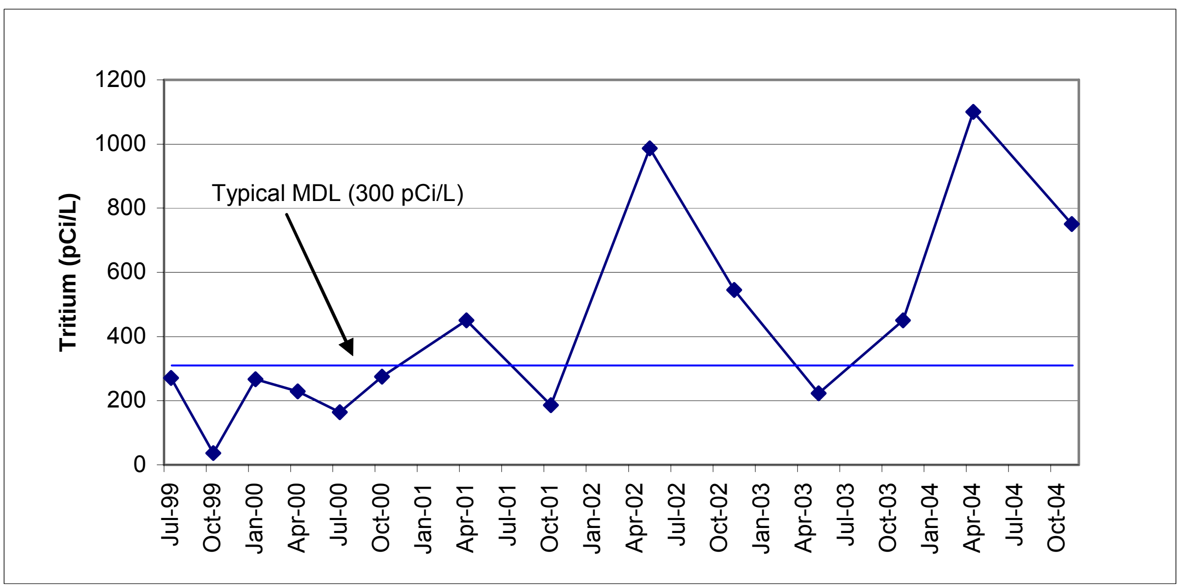
4.1.6.2 J-10 Beam Stop Monitoring Well Results

Since 2001, low levels of tritium have been routinely detected in groundwater downgradient of the J-10 beam stop (**Figure 4-8**). During 2004, the maximum tritium concentration was 1,100 pCi/L.

4.1.6.3 J-10 Beam Stop Monitoring Program Evaluation

Available groundwater monitoring data suggest that the engineered controls in place at J-10 are preventing significant rainwater infiltration into the activated soil shielding. However, the detection of tritium during 2002 and 2004 at concentrations of approximately 1,000 pCi/L suggests that some rainwater may be infiltrating the activated soil. Continued monitoring is required.

Figure 4-8.
Maximum Tritium Concentrations in Wells 054-63 and 054-64, Downgradient of the J-10 Beam Stop.



4.1.7 Former U-Line Beam Target and Stop Areas

The U-Line beam target area was in operation from 1974 through 1986. During its operation, a proton beam from the AGS would first strike a target and the resulting secondary particles would be selected by an arrangement of two magnetic "horns" and collimators immediately downstream of the target. Secondary particles desired for research would be focused by the horns, and other particles would either strike the collimators or be de-focused and enter the surrounding shielding. The entire assembly was in a ground-level tunnel covered with an earthen berm. Internal shielding was stacked around the horns. Although the U-Line beam target has not been in operation since 1986, the associated tunnel, shielding, and overlying soil remain in place. The former U-Line beam target, horns, and beam stop are areas where the interaction of secondary particles with soil surrounding the tunnel resulted in production of tritium and sodium-22.

In late 1999, BNL installed new monitoring wells downgradient of the target area to evaluate whether residual activated soil shielding was impacting groundwater quality. Subsequent monitoring found low levels of tritium and sodium-22, but at concentrations well below the applicable DWS. In early 2000, BNL installed four temporary wells downgradient of the former U-Line beam stop, which is approximately 200 feet north of the target area. Tritium was detected at concentrations up to 71,600 pCi/L. Sodium-22 was not detected in any of the samples. In May 2000, a temporary impermeable cap was installed over the U-Line beam stop soil activation area to prevent additional rainwater infiltration and the continued leaching of radionuclides out of the soil and into groundwater. By October 2000, a permanent cap was constructed over the U-Line beam stop area, and two additional permanent wells were installed to provide improved long-term monitoring of this source area.

4.1.7.1 Former U-Line Beam Groundwater Monitoring

Well Network

The former U-Line area is monitored by one upgradient and six downgradient wells. Three of the downgradient wells monitor the target area, and three wells monitor the beam stop area (**Figure 4-1**). Several Building 912 area wells (054-69, 055-14, 055-31, and 055-32) are also used to monitor low levels of tritium originating from the former U-Line area.

Sampling Frequency and Analysis

During 2004, the former U-Line area wells were monitored semiannually and the samples were analyzed for tritium (**Table 1-6**).

4.1.7.2 Former U-Line Beam Groundwater Monitoring Well Results

U-Line Target Area

Low levels of tritium have been routinely detected in wells downgradient of the former U-Line beam target since monitoring began in 2000 (**Figure 4-9**). The highest tritium concentration during 2004 was 2,400 pCi/L, in well 054-129 approximately 200 feet downgradient of the target area.

U-Line Beam Stop Area

Since 2001, tritium concentrations in downgradient wells have been well below the 20,000 pCi/L DWS (**Figure 4-10**). During 2004, the maximum observed tritium concentration in wells downgradient of the U-Line target area was 1,230 pCi/L, in well 054-168. Furthermore, low levels of tritium that are probably traceable to the former U-Line beam target and stop area were detected in Building 912 area wells 055-31 and 055-32 at concentrations up to 680 pCi/L.

4.1.7.3 Former U-Line Beam Groundwater Monitoring Program Evaluation

Although low levels of tritium continue to be detected downgradient of the former U-Line target, these concentrations are well below the 20,000 pCi/L DWS. Furthermore, the significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soil.

Figure 4-9:
Maximum Tritium Concentrations in Well 054-129, Downgradient of the Former U-Line Beam Target.

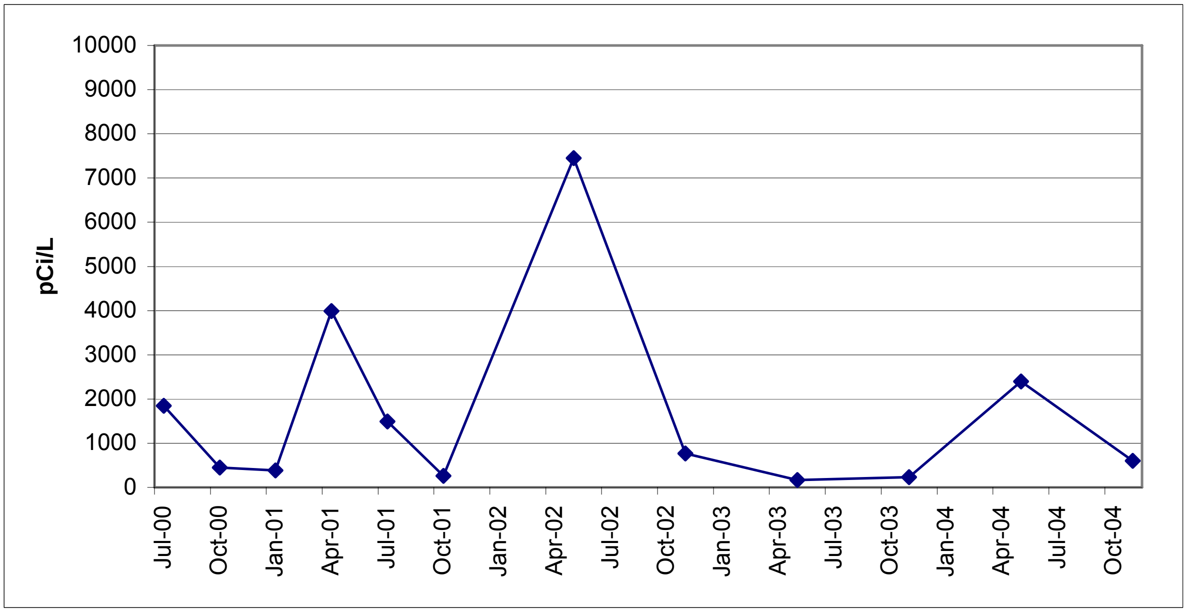
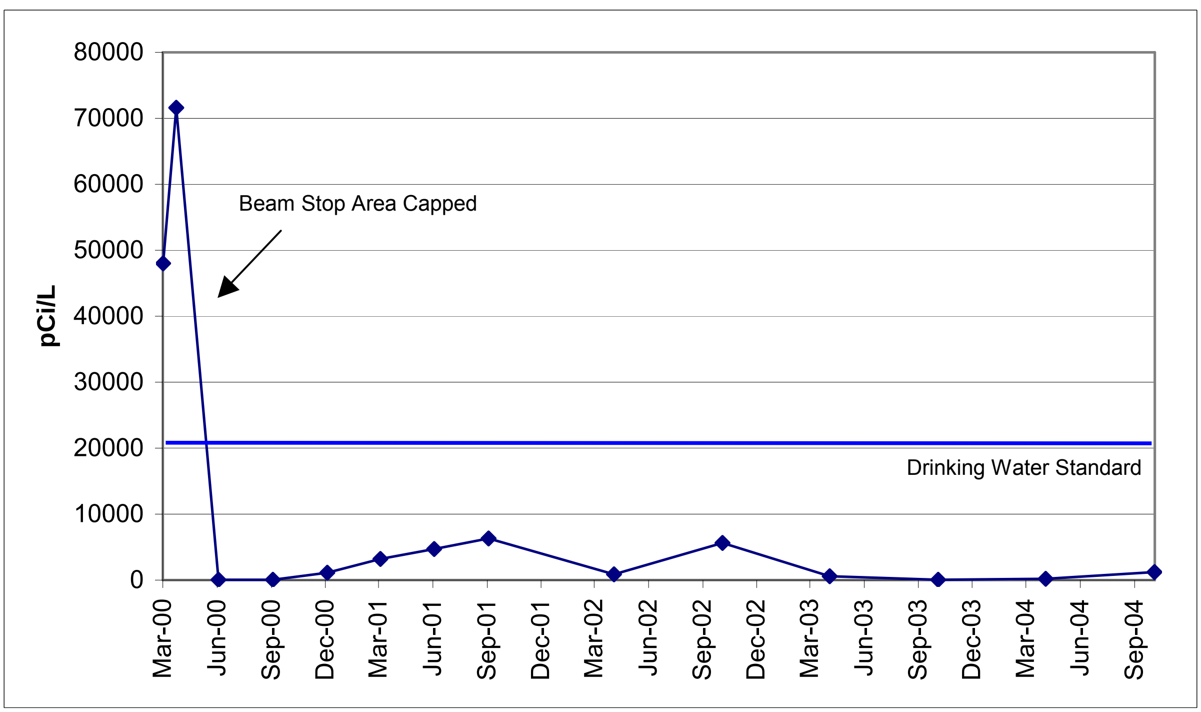


Figure 4-10.
Maximum Tritium Concentrations in Temporary & Permanent Wells, Downgradient of U-Line Beam Stop.



4.2 Brookhaven Linac Isotope Producer Area

When the Brookhaven Linac Isotope Producer (BLIP) is operating, the Linac delivers a beam of protons that impinge on a series of targets in the BLIP target vessel, positioned at the bottom of a 30-ft underground tank. The targets rest inside a water-filled 18-in. diameter shaft that runs the length of the tank, and are cooled by a 300-gal closed loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and soil immediately outside the tank is activated by the production of secondary particles at the target.

As part of a 1985 redesign of the vessel, leak detection devices were installed and the open space between the water-filled shaft and the vessel's outer wall became a secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements, and is registered with SCDHS. The BLIP facility also has a 500-gal underground storage tank (UST) for liquid radioactive waste (change-out water from the BLIP primary system). The waste tank and its associated piping system conform to Article 12 requirements and are registered with SCDHS.

In 1998, BNL conducted an extensive evaluation of groundwater quality near the BLIP facility. Tritium concentrations of 52,000 pCi/L and sodium-22 up to 151 pCi/L were detected in a temporary well installed approximately 50 feet downgradient of the BLIP target vessel. Due to the activation of the soil shielding surrounding the BLIP target vessel and the detection of tritium and sodium-22 in groundwater, the BLIP facility was designated as Area of Concern (AOC) 16K under the Environmental Restoration Program.

Starting in 1998, BNL improved the stormwater management program at BLIP in an effort to prevent rainwater infiltration of the activated soil below the building. The BLIP building's roof drains were redirected away from the building, existing paved areas on the south side of the building were resealed, and a gunite cap was installed on the remaining three sides of the building. In May and June 2000, BNL undertook additional protective measures by injecting a colloidal silica grout (known as a Viscous Liquid Barrier) into the activated soil. The grout reduces the permeability of the soil, thus further reducing the potential of rainwater leaching radionuclides if stormwater controls fail.

As an added measure of protection, the Medical Department and Collider–Accelerator Department constructed a new protective cap over the Linac to BLIP spur in late 2004, and a cap over the Linac to Booster transition is scheduled for construction in 2005. Direct soil measurements and beam loss calculations suggest that the tritium and sodium-22 concentrations in soils surrounding these beam lines could result in stormwater leachate concentrations that exceed the "5 percent" criteria described in the *Accelerator Safety* SBMS (Site-Based Management System) subject area.[2] When completed, this integrated cap system will join the BLIP and Booster caps.

4.2.1 BLIP Groundwater Monitoring

Well Network

The monitoring well network for the BLIP facility consists of two upgradient and five downgradient wells. These wells provide a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality (**Figure 4-11**).

Sampling Frequency and Analysis

During 2004, most of the BLIP area wells were monitored quarterly. Because the tritium concentration in well 064-48 (immediately downgradient of BLIP) increased to 24,900 pCi/L in January 2004, well 064-48 and nearby well 064-67 were monitored one additional time for

[2] The BNL *Accelerator Safety* SBMS subject area requires stormwater controls where rainwater infiltration into activated soil shielding could result in leachate concentrations that exceed 5 percent of the drinking water standard (i.e., >1,000 pCi/L for tritium and 20 pCi/L for sodium-22).

confirmatory sampling. All samples were analyzed for tritium, and select samples from several wells were analyzed for sodium-22 (**Table 1-**6).

4.2.2 BLIP Monitoring Well Results

Monitoring data collected from January 1999 to July 2000 indicated that the corrective actions taken during 1998 were highly effective in preventing the release of tritium and sodium-22 from the activated soil surrounding the BLIP target vessel. Prior to May 2000, tritium and sodium-22 concentrations in wells located directly downgradient of BLIP were <3,000 pCi/L and <5 pCi/L, respectively. However, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples collected after the silica grout injection process that took place in late May and early June 2000 (**Figure 4-12**). This suggests that tritium and sodium-22 in the soil pore water near the target vessel were displaced by the grout. Samples collected in July 2000 indicated tritium and sodium-22 concentrations of 5,700 pCi/L and 57 pCi/L, respectively. By October 2000, tritium concentrations increased to a maximum of 56,500 pCi/L in samples from monitoring well 064-67, located approximately 40 feet downgradient of the BLIP vessel. By December 2000, tritium concentrations in wells immediately downgradient of BLIP dropped to below the 20,000 pCi/L, and remained below this level throughout all of 2001 and 2002 (**Figure 4-12**). As the slug of tritium that was released during the grout project continued to migrate downgradient, tritium concentrations in well 064-50 increased, reaching a maximum of 60,800 pCi/L in July 2001. Tritium concentrations in well 064-50 have remained below 10,000 pCi/L since May 2002 (**Figure 4-13**). In January 2003, tritium concentrations once again exceeded the 20,000 pCi/L standard in wells immediately downgradient of BLIP, with a concentration of 27,700 pCi/L detected in well 064-67. Tritium concentrations increased throughout most of 2003, reaching a maximum of 42,900 pCi/L in October (**Figure 4-12**). Tritium concentrations declined to less than 20,000 pCi/L by November 2003. During 2004, tritium concentrations rose to 24,500 pCi/L in January, and then dropped below 20,000 pCi/L for the remainder of the year.

Figure 4-12.
Maximum Tritium Concentrations in Wells ~ 40 feet Downgradient of BLIP Target Vessel.

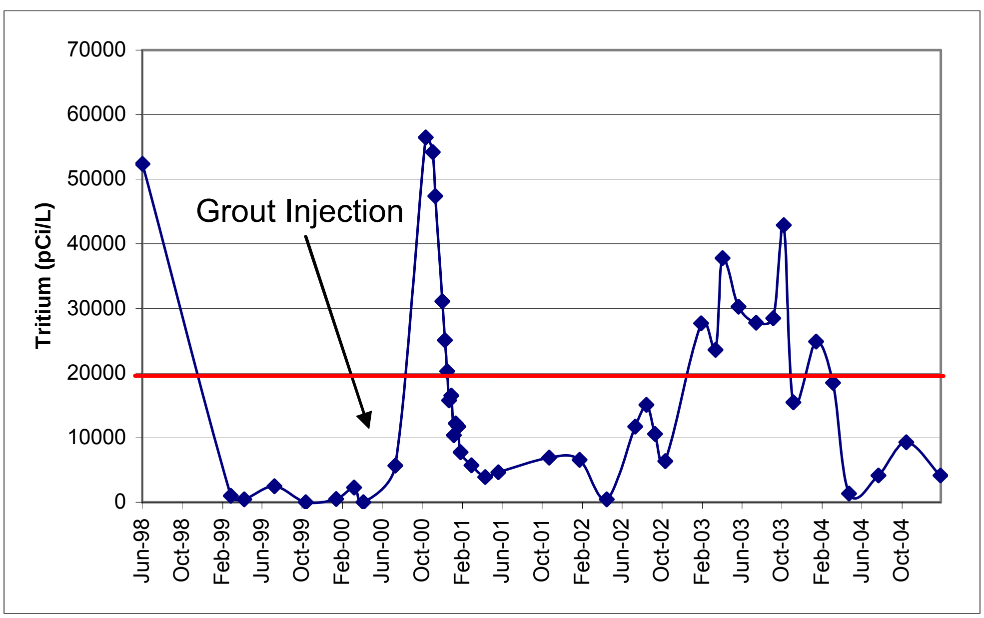
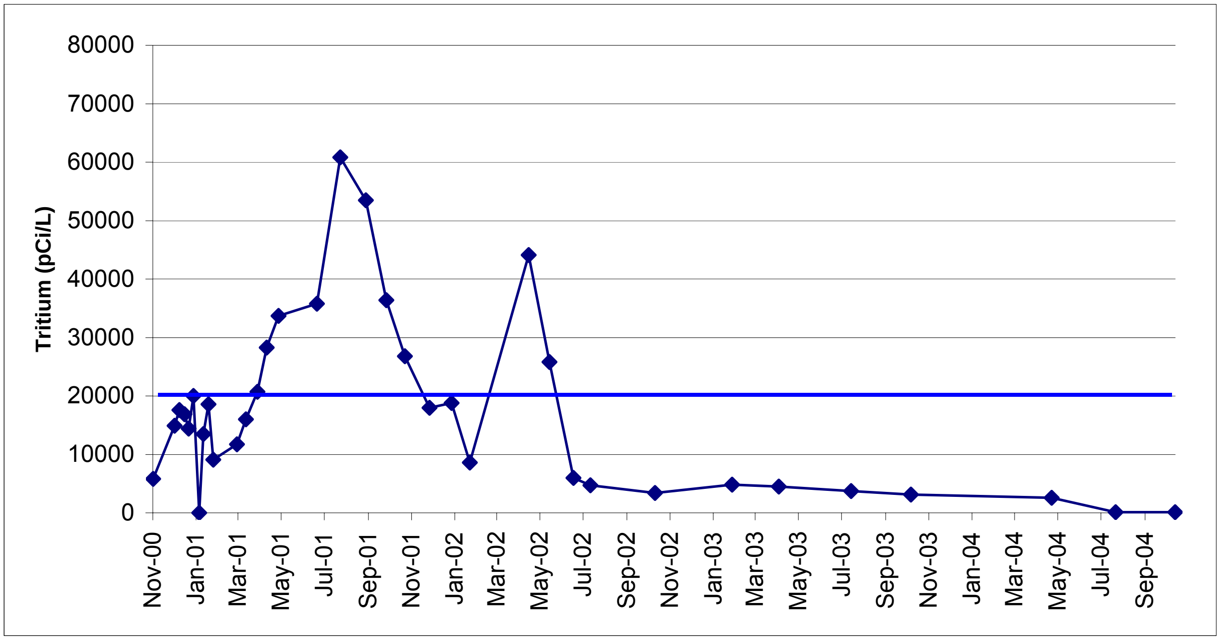


Figure 4-13.
Maximum Tritium Concentrations Approximately 150 feet Downgradient of the BLIP Target Vessel.



4.2.3 BLIP Groundwater Monitoring Program Evaluation

The gunite cap, paved areas, and roof drains at BLIP are in good condition and are effectively controlling stormwater infiltration. Although direct inspection of the silica grout is not possible, it is expected to be in good condition and would be effective in preventing significant leaching of tritium from the activation zone should the primary stormwater controls fail. A comparison of tritium concentrations to changes in water table position suggests that the 2003 increase in tritium concentrations is probably associated with the 6.5-foot increase in water table elevation that occurred between November 2002 and July 2003 (**Figure 4-14**). As the water table rose, older tritium that had leached from the soil before capping in 1987 or that was released during the grout injection project may have been flushed from the soil close to the water table. The amount of tritium remaining in the vadose zone close to the water table is expected to decline over time, due to this flushing mechanism and by natural radioactive decay. During 2004, the elevation of the water table in the BLIP area generally declined, and tritium concentrations in groundwater remained below the 20,000 pCi/L drinking water standard.

4.3 Relativistic Heavy Ion Collider (RHIC)

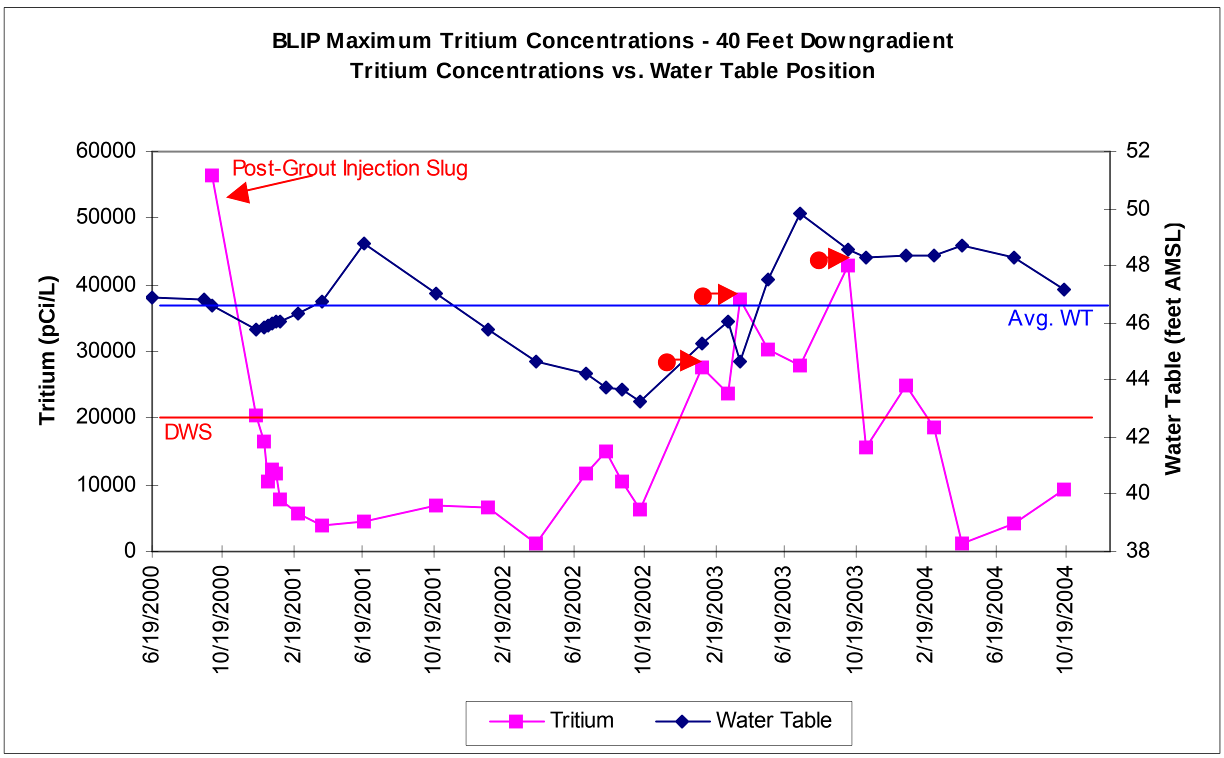
Beam line interaction with the Relativistic Heavy Ion Collider (RHIC) collimators and beam stops produces secondary particles that interact with soil surrounding the 8 o'clock and 10 o'clock portions of the RHIC tunnel, and the W-Line stop (**Figure 4-15**). These interactions result in the production of tritium and sodium-22, which could be leached out of the soil by rainwater. Before RHIC operations began, BNL installed impermeable caps over these beam loss areas to reduce the potential impact to groundwater quality.

4.3.1 RHIC Groundwater Monitoring

Well Network

Thirteen shallow wells are used to verify that the engineered (i.e., impermeable caps) and operational controls implemented at the RHIC beam stops and collimators are effective in protecting groundwater quality. Six of the monitoring wells are located in the 10 o'clock beam stop area, six wells in the collimator area, and one well downgradient of the W-Line beam stop (**Figure 4-15**). As an extension to the groundwater monitoring program, surface water samples are also collected from the Peconic River both upstream (location HY) and downstream (location HV) of the beam stop area to verify that potentially contaminated groundwater is not being discharged into the Peconic River stream bed during high water table conditions.

Figure 4-14.
Tritium Concentrations vs. Water Table Position, 40 Feet Downgradient of the BLIP Target Vessel.



Note 1: Arrows indicate approximate groundwater travel time from directly below the BLIP target to the first set of monitoring wells (e.g., well 064-67). Travel time is approximately 89 days based upon a distance of 40 feet and groundwater velocity of 0.45 ft/day (see modeling studies of T. Sullivan and D. Bennett).

Sampling Frequency and Analysis

During 2004, groundwater samples were collected from the 13 RHIC monitoring wells on a semiannual schedule, and the samples were analyzed for tritium (**Table 1-6**). Routine analysis for sodium-22 was dropped from the groundwater surveillance program in 2002 because tritium is the best indicator of possible cap failure (i.e., tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater). Surface water samples were collected quarterly and analyzed for tritium and gamma-emitting radionuclides (such as sodium-22).

4.3.2 RHIC Monitoring Well Results

As in past years, no tritium was detected in any of the groundwater samples. Although a trace level (300 pCi/L) of tritium was apparently detected in the May 2004 surface water sample from downstream location HV, there is a degree of uncertainty with the measurement because the result was very close to the analytical detection limit. Tritium was not detected in two subsequent samples from the downstream location, and sodium-22 was not detected in any of the surface water samples.

4.3.3 RHIC Groundwater Monitoring Program Evaluation

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps installed over the RHIC beam stop and collimator areas are effective in preventing rainwater infiltration into the potentially activated soil shielding.

4.4 Brookhaven Medical Research Reactor (BMRR)

The Brookhaven Medical Research Reactor (BMRR) was a 3-megawatt light water reactor that was used for biomedical research. Research operations at the BMRR stopped in December 2000. All spent fuel was removed in 2003 and plans are underway to drain the primary cooling water system. BNL is preparing plans to permanently decommission the facility.

The BMRR's primary cooling water system consists of a recirculation piping system that contains 2,550 gallons of water. The cooling water contains approximately five curies of tritium. Unlike the High Flux Beam Reactor, the BMRR does not have a spent fuel storage canal or pressurized imbedded piping systems that contain radioactive liquids. Historically, fuel elements that required storage were either stored within the reactor vessel, or were transferred to the HFBR spent fuel canal. The BMRR's primary cooling water system piping is fully exposed within the containment structure, and is accessible for routine visual inspections. When the BMRR was operational, excess heat was transferred by means of heat exchangers with once-through (secondary) cooling water, which was obtained from nearby process supply wells or the BNL Chilled Water System. This secondary water was discharged to recharge basin HP located 800 feet south of the Medical Department complex, and was monitored as part of the SPDES program. All cooling water discharges from the BMRR stopped in December 2000.

In 1997, tritium was detected in wells installed directly downgradient (within 30 feet) of the BMRR. The maximum tritium concentration observed during 1997 was 11,800 pCi/L, almost one-half of the DWS of 20,000 pCi/L. The highest observed tritium concentration since the start of groundwater monitoring was 17,100 pCi/L in October 1999. The tritium currently detected in groundwater is believed to have originated from the historical discharge of small amounts of BMRR primary cooling water to a basement floor drain and sump system that may have leaked. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (nonradioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any accidental future releases to the underlying soil.

4.4.1 BMRR Groundwater Monitoring

Well Network

The monitoring well network for the BMRR facility consists of one upgradient and three downgradient wells (**Figure 4-16**). Samples collected from the four groundwater monitoring wells are used to verify that the engineered and administrative controls described above are effective in preventing additional impacts to groundwater quality.

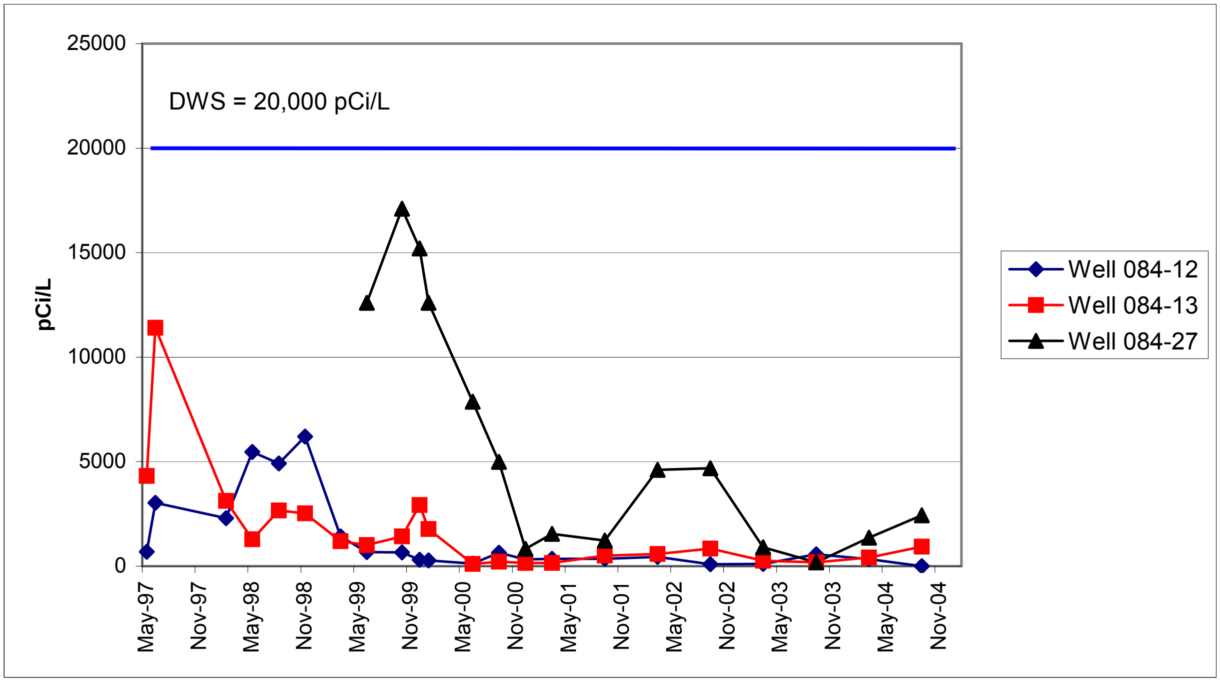
Sampling Frequency and Analysis

During 2004, the BMRR wells were monitored semiannually and the samples were analyzed for tritium (**Table 1-6**).

4.4.2 BMRR Monitoring Well Results

Monitoring results for sampling conducted during 2004 indicate that tritium concentrations continued to be well below the 20,000 pCi/L DWS. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 2,430 pCi/L detected in well 084-27 (**Figure 4-17**). Note that groundwater monitoring conducted from 1997 though 2001 did not detect any other reactor-related radionuclides. Therefore monitoring for 2002–2004 focused on tracking tritium concentrations in the groundwater.

Figure 4-17.
Tritium Concentrations Downgradient of the BMRR from 1997–2004.



4.4.3 BMRR Groundwater Monitoring Program Evaluation

Tritium concentrations in groundwater have never exceeded the 20,000 pCi/L drinking water standard, and have remained <5,000 pCi/L since 2001. Discontinuing the use of the BMRR floor drains has apparently helped to reduce the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater.

4.5 Sewage Treatment Plant

The STP processes sanitary wastewater from BNL's research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit (NY-0005835). On average, 1.25 million gallons per day (MGD) are processed during the summer and 0.72 MGD are processed daily during the rest of the year. Before discharge into the Peconic River, the sanitary waste stream is fully treated by 1) primary clarification to remove settleable solids and floatable materials, 2) aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia, 3) secondary clarification, 4) sand filtration for final effluent polishing, and 5) ultraviolet disinfection for bacterial control. Oxygen levels are regulated during the treatment process to remove nitrogen biologically, using nitrate-bound oxygen for respiration.

Wastewater from the STP clarifier is released to the sand filter beds, where water percolates through 3 feet of sand before being recovered by an underlying clay tile drain system, which transports the water to the discharge point at the Peconic River (SPDES Outfall 001). Approximately 15 percent of the water released to the filter beds is either lost to evaporation or to direct groundwater recharge. At the present time, six sand filter beds are used in rotation.

Two emergency hold-up ponds are located east of the sand filter bed area. The hold-up ponds are used to store sanitary waste in the event of an upset condition or if the influent contains contaminants in concentrations exceeding BNL administrative limits and/or SPDES permit effluent release criteria. The hold-up ponds have a combined holding capacity of nearly 8 million gallons of water, and provide the Laboratory with the ability to divert all sanitary system effluent for approximately one week. The hold-up ponds are equipped with fabric-reinforced plastic liners that are heat-welded along all seams. As part of the Phase III Sewage Treatment Plant Upgrades project in 2001, the liners were enhanced by the addition of new primary liners and a leak detection system. The older liners now serve as secondary containment.

4.5.1 STP Groundwater

Well Network

The STP's groundwater monitoring program is designed to provide a secondary means of verifying that STP operations are not impacting environmental quality. Six wells are used to monitor groundwater quality in the filter bed area and three wells are monitored in the holding pond area (**Figure 4-18**).

Sampling Frequency and Analysis

During 2004, the six STP filter bed area wells were monitored semiannually and the three holding pond area wells were sampled annually. The samples were analyzed for VOCs, anions, metals, tritium, gross alpha, gross beta, and gamma emitting radionuclides (**Table 1-6**).

4.5.2 STP Monitoring Well Results

Radiological Analyses

Radioactivity levels in samples collected from the STP wells during 2004 were generally typical of ambient (background) levels. Tritium was not detected in any of the STP groundwater monitoring wells.

Nonradiological Analyses

During 2004, all water quality and most metals concentrations were below the applicable NYS AWQS or drinking water standards. Sodium, iron, and aluminum were occasionally detected at concentrations above water quality standards in several of the filter bed area wells. Sodium was detected in wells 039-86 and 039-87, at a maximum concentration of 373 mg/L (NYS AWQS is 20 mg/L). Iron was detected in two wells, 038-03 and 038-08, with a maximum concentration of 1.18 mg/L (NYS AWQS is 0.3 mg/L) and aluminum was detected in well 039-08 at a concentration of 0.4

mg/L (secondary drinking water standard is 0.2 mg/L). Nitrates were detected in most STP area wells, with a maximum concentration of 5.8 mg/L detected in filter bed area monitoring well 039-08. The NYS AWQS for nitrate is 10 mg/L. No VOCs attributable to BNL operations were detected in any of the monitoring wells.

In response to the detection of perchlorate in an SCDHS off-site monitoring well and several of the OU V monitoring wells (for details see **Section 3.4**), BNL also analyzed groundwater samples from four of the STP filter bed monitoring wells to determine whether the filter bed area was the source for the perchlorate. Perchlorate was not detected in any of the filter bed area well samples.

4.5.3 STP Groundwater Monitoring Program Evaluation

Monitoring results for 2004 indicate that STP operations are not having a significant impact on groundwater quality, and that the BNL administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system continue to be highly effective.

4.6 Motor Pool/Site Maintenance Area

The Motor Pool (Building 423) and Site Maintenance facility (Building 326) are attached structures located along West Princeton Avenue (**Figure 4-19**). The Motor Pool area consists of a five-bay automotive repair shop, which includes office and storage spaces. The Site Maintenance facility provides office space, supply storage, locker room, and lunchroom facilities for custodial, grounds, and heavy equipment personnel. Both facilities have been used continuously since 1947.

Potential environmental concerns at the Motor Pool include 1) the historical use of USTs to store gasoline, diesel fuel, and waste oil, 2) hydraulic fluids used for lift stations, and 3) the use of solvents for parts cleaning. In August 1989, the gasoline and waste oil USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes two 8,000-gallon USTs used to store unleaded gasoline, one 260-gallon aboveground storage tank used for waste oil, and one 3,000-gal UST for No. 2 fuel oil. The Motor Pool facility has five vehicle lift stations. The hydraulic fluid reservoirs for the lifts are located above ground.

Since 1996, several small-scale hydraulic oil and diesel oil spills have been remediated at the Motor Pool. The only known environmental concern associated with the Site Maintenance facility (Building 326) was the December 1996 discovery of a historic oil spill directly south of the building. In an effort to investigate the potential impact that this spill had on groundwater quality, four wells were installed downgradient of the spill site. Although the solvent TCA was detected in the groundwater at concentrations above NYS AWQS, petroleum hydrocarbons were not detected.

4.6.1 Motor Pool/Site Maintenance Area Groundwater Monitoring

Well Network

The Motor Pool facility's groundwater monitoring program for the UST area is designed to confirm that the engineered and institutional controls are effective in preventing contamination of the aquifer. Two shallow Upper Glacial aquifer wells (102-05 and -06) are used to monitor for potential contaminant releases from the UST area (**Figure 4-19**).

Groundwater quality downgradient of Building 423 and Building 326 is monitored using four wells (102-10, -11, -12, and -13). The program is designed to periodically assess existing solvent contamination that resulted from historical vehicle maintenance operations, and to confirm that the current engineered and institutional controls are effective in preventing additional contamination of the aquifer.

Sampling Frequency and Analysis

During 2004, the UST area wells were monitored semiannually, and the samples were analyzed for VOCs and annually for SVOCs. The wells were also checked for the presence of floating petroleum hydrocarbons on a semiannual basis (**Table 1-6**). The Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs.

4.6.2 Motor Pool/Site Monitoring Well Results

Underground Storage Tank Area

During 2004, MTBE was the only chemical related to gasoline products detected in groundwater downgradient of the gasoline UST area (**Figure 4-20**). Although MTBE concentrations had reached a maximum of nearly 34 µg/L (the NYS AWQS is 10 µg/L) during 2003, MTBE concentrations decreased to <2 µg/L by October 2004. As in past years, low levels of the solvent TCA were also detected, but at concentrations that continued to be below the NYS AWQS of 5 µg/L. Wells 102-05 and -06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating product was observed. No SVOCs were detected in the samples collected in September.

Building 423/326 Area

During 2004, TCA was detected in all four wells, at concentrations up to 38 µg/L (**Figure 4-21**). Up to 13 µg/L DCA was detected in wells 102-11, -12 and -13. The gasoline additive MTBE was detected in all four wells, at concentrations up to 18 µg/L. It is believed that the TCA, DCA, and MTBE originate from historical vehicle maintenance operations.

4.6.3 Motor Pool/Site Monitoring Program Evaluation

Analysis of groundwater samples collected at the Motor Pool facility during 2004 indicates that releases from historical operations continue to impact groundwater quality. There were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). The MTBE and TCA that is periodically detected in the groundwater near the UST area is likely to have originated from historical spills near Buildings 423/326.

Figure 4-20.
VOC Concentration Trends Downgradient of the Gasoline UST Area.

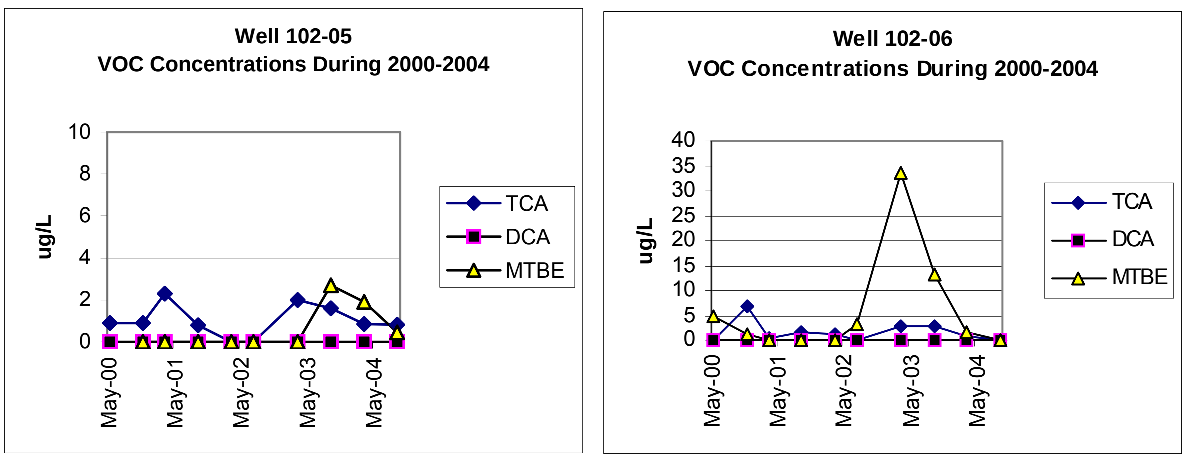


Figure 4-21.
VOC Concentration Trends in Wells Downgradient of Building 323/326.

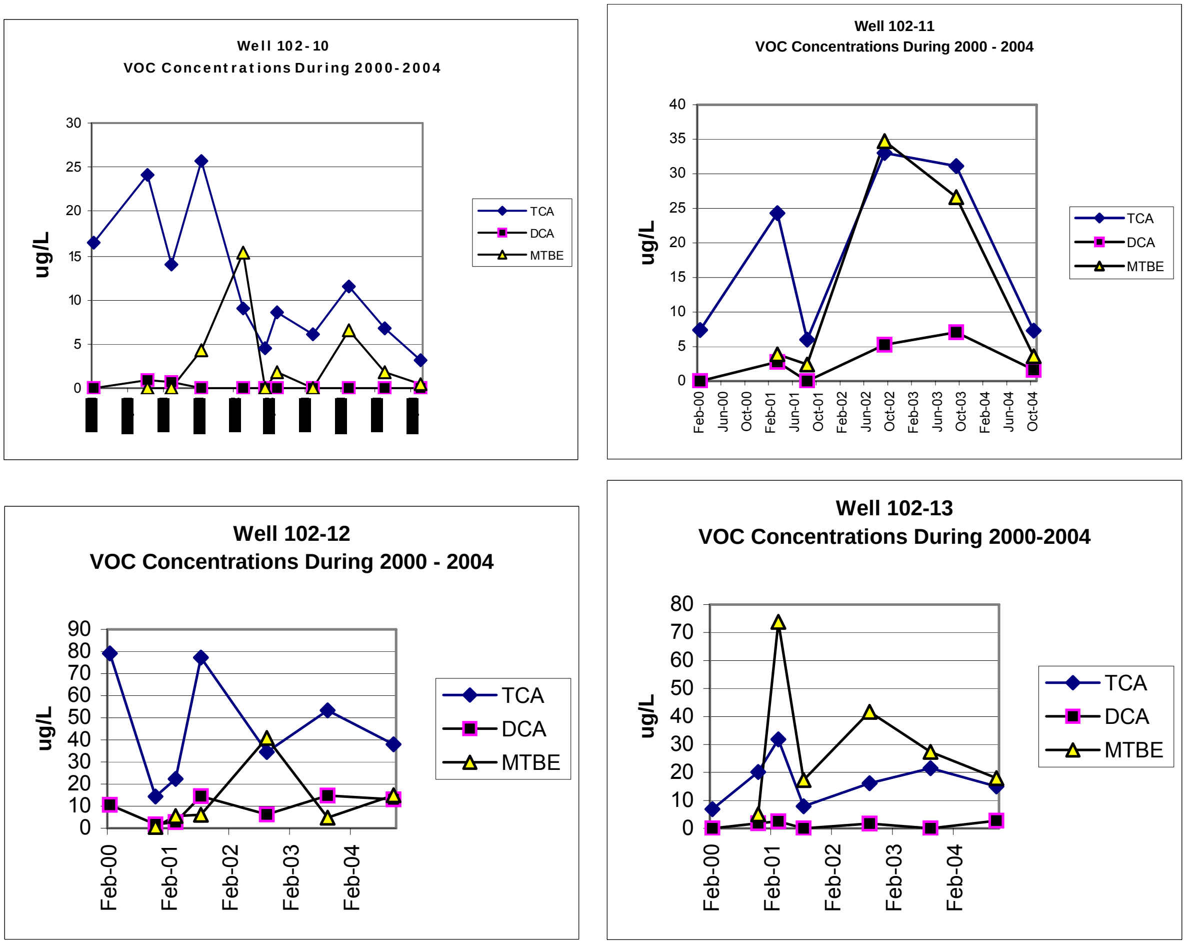
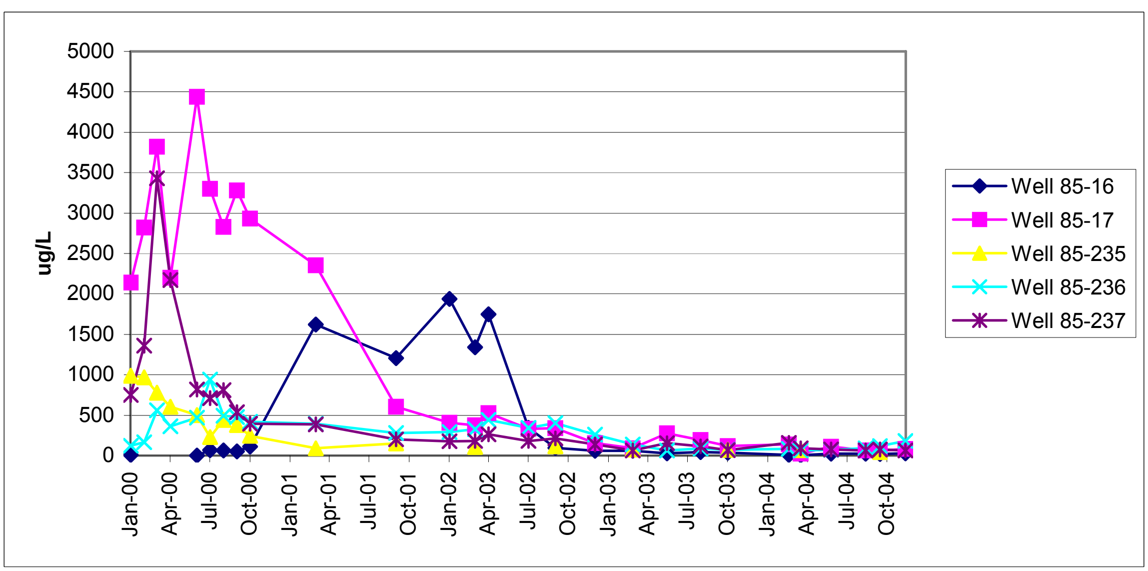


Figure 4-23.
Carbon Tetrachloride Concentration Trends in Service Station Monitoring Wells.



4.7 On-Site Service Station

Building 630 is a commercial automobile service station, privately operated under a contract with BNL. The station was built in 1966, and is used for automobile repair and gasoline sales.

Potential environmental concerns at the service station include the historical use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. When the service station was built in 1966, the UST inventory consisted of one 6,000-gal and two 8,000-gal tanks for storing gasoline, and one 500-gal tank for used motor oil. An inventory discrepancy discovered in 1967 suggested that up to 8,000 gallons of gasoline might have leaked from one of the USTs. There are no records of remedial actions other than the replacement of the tank, and the loss of 8,000 gallons of gasoline has never been confirmed. In August 1989, the USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. During the removal of the old USTs, there were no obvious signs of soil contamination.

The current tank inventory includes three 8,000-gal USTs for storing unleaded gasoline, and one 500-gal UST used for waste oil. The facility has three hydraulic vehicle lift stations.

Groundwater quality in the service station area has been impacted by historical small-scale spills of oils, gasoline, and solvents, and by carbon tetrachloride contamination associated with a nearby UST that was used as part of an experiment conducted in the 1950s. In April 1998, BNL removed a UST from an area approximately 200 feet northwest (upgradient) of the service station. Although there are indications that the tank was releasing small quantities of carbon tetrachloride before its removal, a significant increase in carbon tetrachloride concentrations in groundwater indicated that additional amounts of this chemical were inadvertently released during the excavation and removal process. BNL started to remediate the carbon tetrachloride plume in October 1999 (see **Section 3.2.1**).

4.7.1 Service Station Groundwater Monitoring

Well Network

The service station's groundwater monitoring program is designed to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer. Five wells are used to monitor for potential contaminant releases (**Figure 4-22**).

Sampling Frequency and Analysis

During 2004, the service station facility wells were monitored quarterly, primarily by the Environmental Restoration program as part of the Carbon Tetrachloride Plume monitoring project. The samples were analyzed for VOCs (**Table 1-6**). Three of the wells were also checked semiannually for the presence of floating petroleum hydrocarbons.

4.7.2 Service Station Monitoring Well Results

During 2004, carbon tetrachloride (and its breakdown product, chloroform) continued to be observed in the service station monitoring wells (**Figure 4-23**). The maximum carbon tetrachloride concentration was 180 μg/L, observed in the November 2004 sample from well 085-236. This level is considerably less than those observed during 2000, when carbon tetrachloride concentrations in wells near the service station approached 4,500 μg/L. The reduction in carbon tetrachloride concentrations reflects the effectiveness of the groundwater restoration system (see **Section 3.2.1**), which achieved its cleanup objectives and was shut down in August 2004.

In addition to the carbon tetrachloride contamination originating from the former UST area, groundwater quality has been affected by a variety of VOCs that appear to be related to historical service station operations. During 2004, petroleum-related compounds continued to be detected in the groundwater (**Figures 4-24, 4-25, and 4-26**). The highest VOC concentrations were detected in well 085-236 in November 2004, with m/p xylene at 67 μg/L, o-xylene at 79 μg/L, 1,2,4-trimethylbenzene at 16 μg/L, 1,3,5-trimethylbenzene at 24 μg/L, and the solvent tetrachloroethylene at a concentration of 20 μg/L.

Low levels of the gasoline additive MTBE continued to be detected in all service station area wells, but at concentrations significantly lower than in 2003, when MTBE levels reached a maximum concentration of 144 μg/L. During 2004, the highest MTBE level was detected in well 085-237, at a concentration of 14 μg/L (Figure 4-26). The NYS AWQS for MTBE is 10 μg/L.

Three of the service station wells were tested for SVOCs and for floating product. As in previous years, no SVOCs or floating product were detected.

4.7.3 Service Station Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the service station facility during 2004 indicates that releases from historical operations continue to impact groundwater quality. There were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). It is believed that the petroleum hydrocarbon-related compounds and solvents detected in groundwater originate from historical vehicle maintenance operations before improved chemical storage and handling controls were implemented in 1989.

Figure 4-24.
Downgradient Well 085-17: Trend of Service Station-Related VOCs. Note that carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.

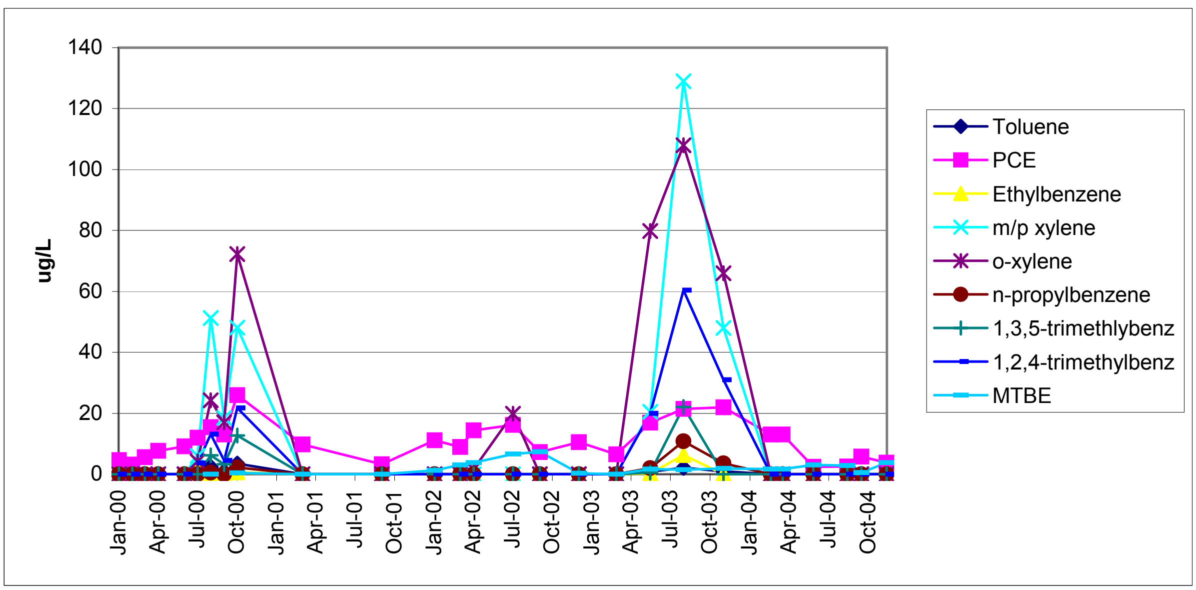


Figure 4-25.
Downgradient Well 085-236: Trend of Service Station-Related VOCs. Note that carbon tetrachloride from the upgradient carbon tetrachloride UST source area is not included.

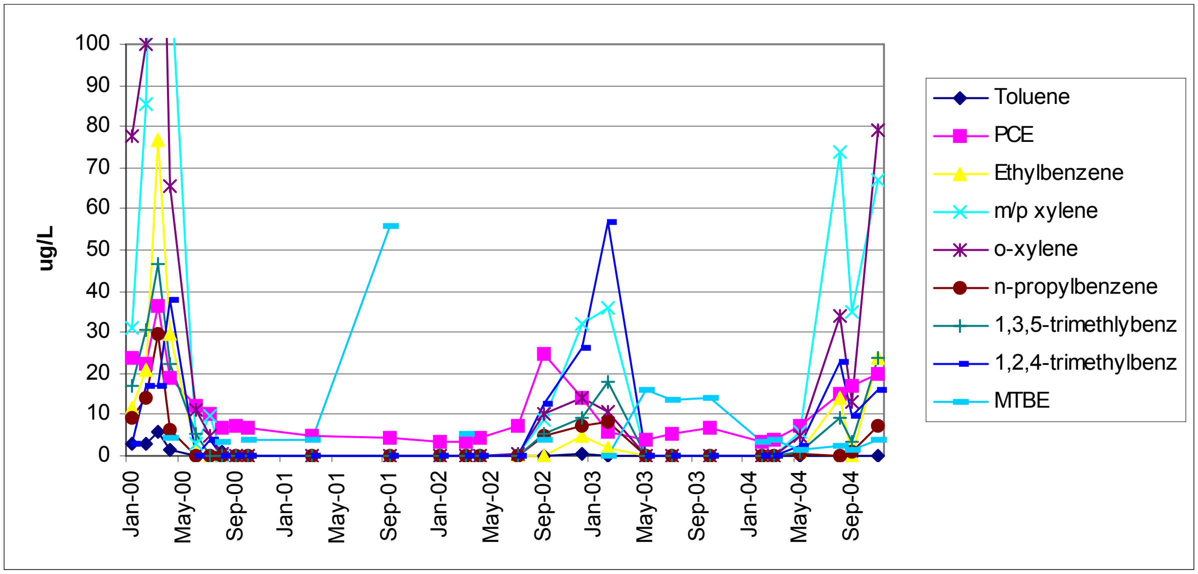
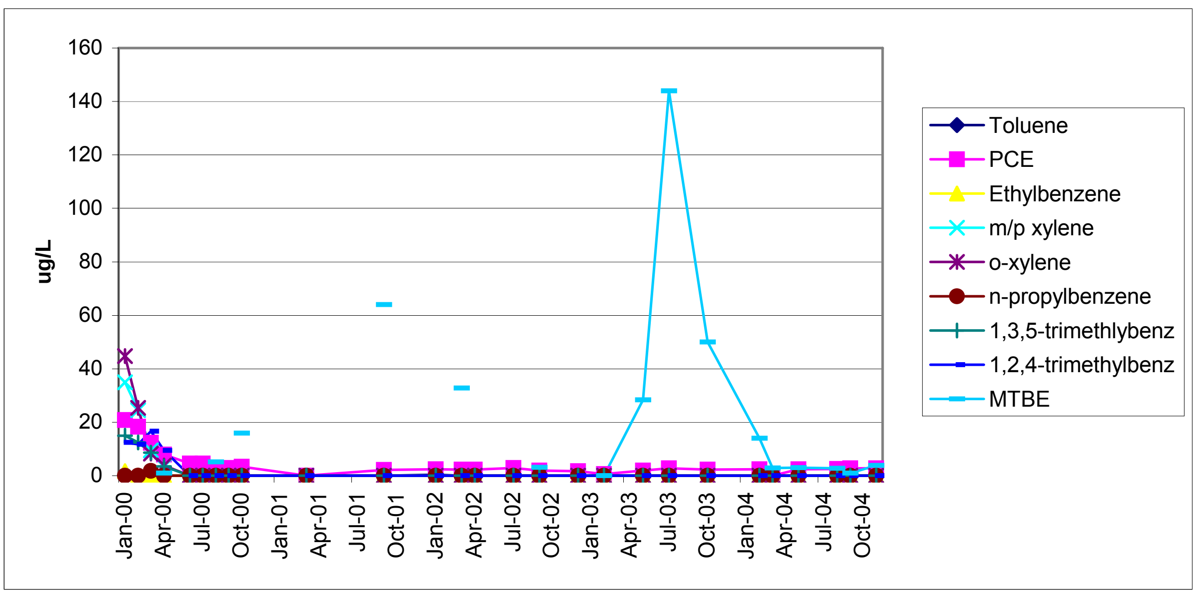


Figure 4-26. **Downgradient Well 085-237: Trend of Service Station-Related VOCs.** Note that carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.



4.8 Major Petroleum Facility Area

The Major Petroleum Facility (MPF) is the holding area for fuel oil used at the Central Steam Facility (CSF). The fuel oil is held in a network of seven aboveground storage tanks, which have a combined capacity of up to 2.3 million gallons of No. 6 fuel oil and 60,000 gallons of No. 2 fuel oil. The tanks are connected to the CSF by aboveground pipelines that have secondary containment and leak detection devices. All of the fuel storage tanks are positioned in bermed containment areas that have a capacity to hold >110 percent of the volume of the largest tank located there. The bermed areas have bentonite clay liners consisting of either Environmat™ (bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soil to form an impervious soil/clay layer. As of December 1996, all fuel-unloading operations were consolidated to one centralized building that has secondary containment features. The MPF is operated under NYSDEC Permit #1-1700 and, as required by law, a Spill Prevention and Countermeasures (SPCC) Plan and a Facility Response Plan have been developed for the facility. Groundwater quality near the MPF has been impacted by several oil and solvent spills: 1) the 1977 fuel oil/solvent spill to the east of the MPF that was remediated under the Environmental Restoration Program (see **Section 3.3.1**); and 2) by solvent spills near the CSF.

4.8.1 MPF Groundwater Monitoring

Well Network

Eight shallow Upper Glacial aquifer wells are used to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer (**Figure 4-27**).

Sampling Frequency and Analysis

Groundwater contaminants from the fuel oil products stored at the MPF can travel both as free product and in dissolved form with advective groundwater flow. Historically, the Special License Conditions for the MPF required semiannual sampling for SVOCs and monthly monitoring for floating petroleum. Samples were also periodically tested for VOCs as part of the Environmental Surveillance Program. In early 2002, NYSDEC expanded the required list of routine analyses to include VOCs, including testing for MTBE (**Table 1-6**). MTBE was a common gasoline additive until January 2004, and it was occasionally introduced to fuel oil as a contaminant during the storage and transportation process.

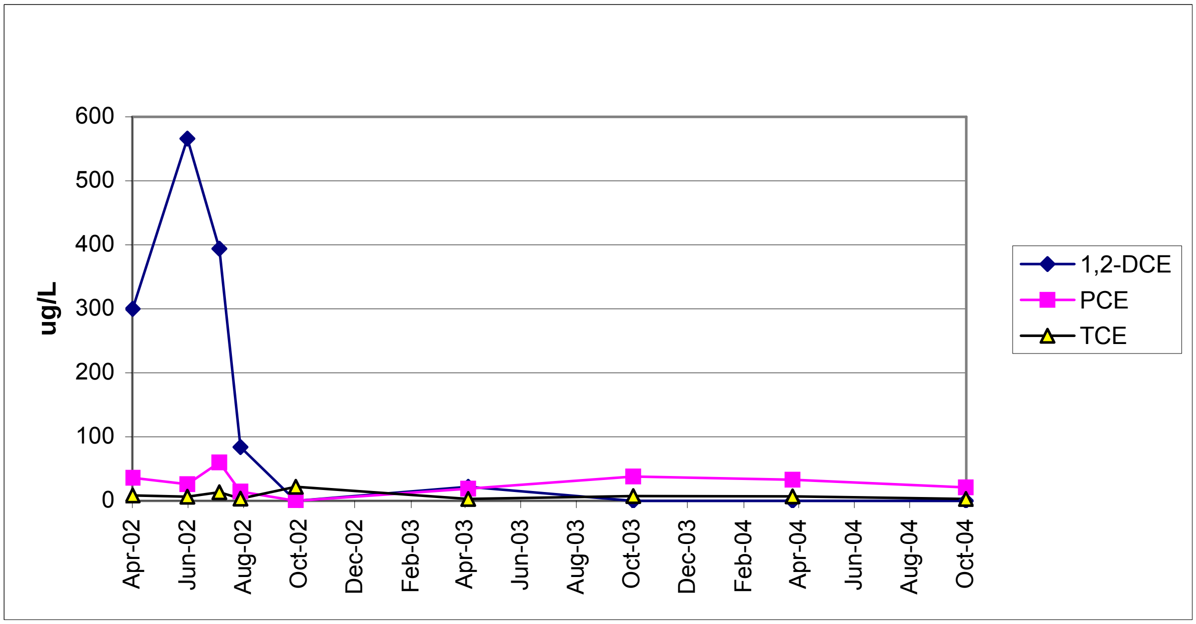
4.8.2 MPF Monitoring Well Results

BNL sampled the MPF wells in April and October 2004. The samples were tested for SVOCs and VOCs. As in the past, no SVOCs were detected, and no floating product was observed. However, as in past years, several VOCs (solvents) continued to be detected at concentrations exceeding the NYS AWQS of 5 μg/L. In well 076-380, PCE was detected at concentrations up to 33 μg/L, and TCE was observed up to 6.9 μg/L (**Figure 4-28**). In OU IV monitoring well 076-185, the PCE was detected at 4.8 μg/L, and PCE breakdown product trans-1,2-dichloroethene was detected at a concentration of 10 μg/L. These solvents are believed to have originated from documented historical spills near the CSF building; their presence in groundwater is not the result of recent CSF or MPF operations.

4.8.3 MPF Monitoring Program Evaluation

Groundwater monitoring at the MPF continues to show that fuel storage and distribution operations are not impacting groundwater quality. The low levels of PCE and TCE are likely to have originated from historical solvent spills near Building 610. The historical nature of this contamination is supported by: 1) degreasing agents such as PCE have not been used at the CSF in many years, 2) PCE has been detected in well 076-19 since the early 1990s, and 3) trans-1,2-dichloroethene is a breakdown product of PCE. A number of historical spill sites near the CSF were identified in the late 1990s, and the contaminated soil was excavated in accordance with regulatory requirements.

Figure 4-28.
VOC Concentrations Downgradient of the Major Petroleum Facility, in Well 076-380.



4.9 Waste Management Facility

The WMF is designed to safely handle, repackage, and temporarily store BNL-derived wastes prior to shipment to off-site disposal or treatment facilities. The WMF is a state-of-the-art facility, with administrative and engineered controls that meet all applicable federal, state, and local environmental protection requirements. The WMF consists of four buildings: the Operations Building, Reclamation Building (for radioactive waste), RCRA Waste Building, and the Mixed Waste Building.

Groundwater monitoring is a requirement of the RCRA Part B permit issued for WMF operations. The groundwater monitoring program for the WMF is designed to supplement the engineered and institutional controls by providing additional means of detecting potential contaminant releases from the facility. The WMF is located adjacent to BNL Potable Supply Wells 11 and 12, which are south of East Fifth Avenue and just north of the WMF site. Because of the proximity of the WMF to these wells, it is imperative that the engineered and institutional controls implemented at the WMF are effective in ensuring that waste handling operations do not degrade the quality of the soil and groundwater in this area.

4.9.1 WMF Groundwater Monitoring

Well Network

Eight wells are used to monitor groundwater quality near the WMF (**Figure 4-29**). Four wells are used to assess background water quality, and four wells are positioned downgradient of the three waste handling and storage buildings.

Sampling Frequency and Analysis

During 2004, the WMF wells were monitored two times. Groundwater samples were analyzed twice for VOCs, tritium, gamma spectroscopy, gross alpha, and gross beta, and one time for metals and anions (**Table 1-6**).

4.9.2 WMF Monitoring Well Results

Radiological Analyses

Gross alpha and beta concentrations in samples from both upgradient and downgradient monitoring wells are consistent with background concentrations, and no BNL-related gamma-emitting radionuclides were identified. During 2003, tritium levels in Reclamation Building area monitoring well 056-23 increased from 407 pCi/L in February to 1,120 pCi/L in August (**Figure 4-30**). Low levels of tritium were also occasionally detected in upgradient well 066-07 (**Figure 4-31**). Although the tritium concentrations were well below the 20,000 pCi/L DWS, BNL implemented its Groundwater Protection Contingency Plan in an attempt to identify the source of the tritium and verify that the tritium was not impacting nearby potable water supply wells 11 and 12. As part of this response, the monitoring frequency was increased for well 056-23, nearby monitoring wells 056-22 and 066-84, and supply wells 11 and 12. BNL also formed a technical team to help identify a possible source of the tritium. Tritium concentrations in well 056-23 reached a maximum level of 2,430 pCi/L in November 2003, then decreased to 350 pCi/L by February 2004. Tritium was not detected in any of the WMF monitoring well samples collected in August 2004. Only trace levels of tritium were detected in one sample from nearby monitoring well 056-22 (528 pCi/L) and one sample from supply well 12 (340 pCi/L). No tritium was detected in samples from supply well 11.

Figure 4-30.
Tritium Concentration Trends in Well 056-23 Downgradient of Waste Management Facility.

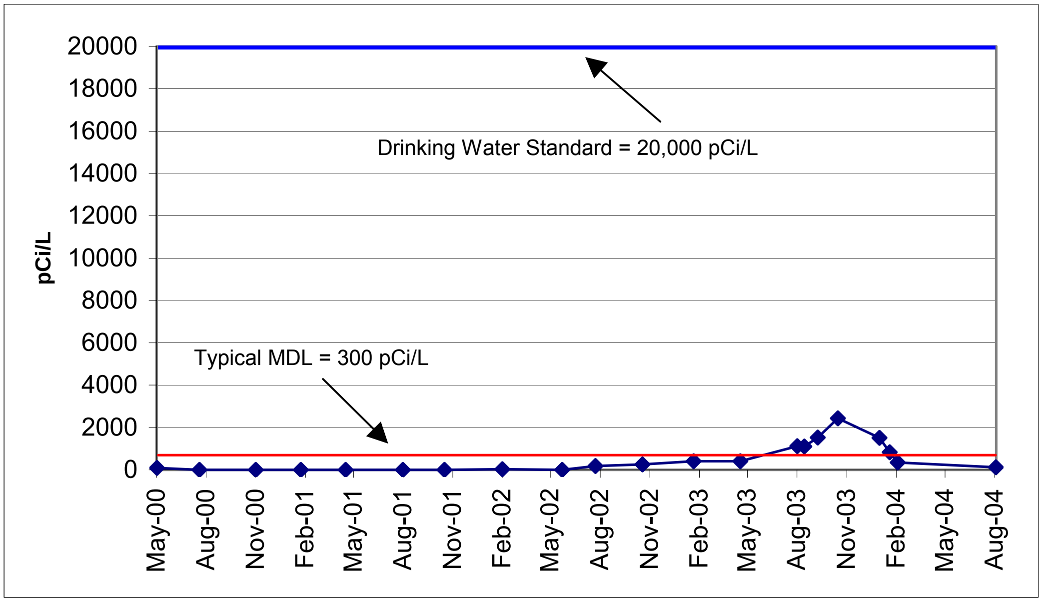
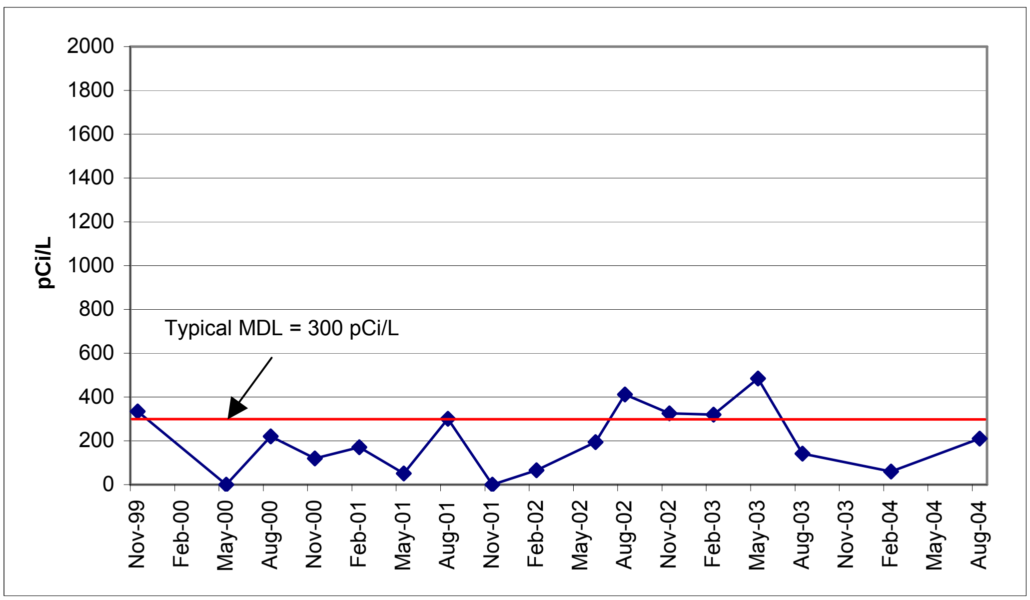


Figure 4-31.
Tritium Concentration Trends in Well 066-07, Upgradient of Waste Management Facility.



Nonradiological Analyses

All anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable New York State water quality or drinking water quality standards. As in past years, sodium was detected in shallow upgradient well 055-03 at concentrations above the NYS AWQS of 20 mg/L, with a maximum concentration of 144 mg/L in the August 2004 sample. Well 055-03 is near a road, and the elevated sodium concentrations are likely due to road salting operations. Aluminum was detected in downgradient well 056-21 at a concentration of 0.26 mg/L, just slightly above the 0.2 mg/L federal secondary drinking water standard. The aluminum is probably related to naturally occurring minerals within the Upper Glacial aquifer deposits. During 2004, no VOCs were detected at concentrations above NYS AWQS. Low levels (up to 3.2 μg/L) of chloroform were occasionally detected in all four upgradient wells and in three of four downgradient wells. As in previous years, trace levels (up to 1.1 μg/L) of TCA were also detected in upgradient well 066-07. The NYS AWQS for TCA is 5 μg/L.

4.9.3 WMF Groundwater Monitoring Program Evaluation

Groundwater monitoring results for 2004 were consistent with previous years' monitoring, and continued to show that WMF operations were not affecting groundwater quality. There were no outdoor or indoor spills at the facility that could have impacted soil or groundwater quality. Except for sodium and aluminum detected in several wells, all chemical and radionuclide concentrations were below NYS AWQS or DWS. During 2004, only trace levels of tritium were detected. Although a definitive source for the tritium has not been identified, a thorough review of waste management operations suggests that the tritium was not released from the WMF. Rather, the periodic detection of tritium in upgradient well 066-07 suggests that the tritium was released from another upgradient facility or system.

4.10 Building 801

In early December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the floodwater indicated that the water contained Cs-137, Sr-90, and tritium at concentrations of 784 pCi/L, 594 pCi/L, and 25,000 pCi/L, respectively. It is believed that the floodwater became contaminated when it came into contact with the basement floor, which contains significant residual contamination from historical radiological spills. When the floodwater was pumped from the basement on March 8, 2002, approximately 4,950 gallons of contaminated water were removed. Taking into account possible losses due to evaporation, estimates were that between 1,350 and 2,750 gallons of contaminated floodwater might have seeped into the soil below Building 801. To evaluate the potential impact to groundwater quality of such a release, BNL installed a new water table well immediately downgradient of the building and monitored several nearby wells.

4.10.1 Building 801 Groundwater Monitoring

Well Network

From May through October 2002, three existing downgradient wells were sampled. Well 065-169 is approximately 10 feet south of Building 801, whereas wells 065-37 and 065-170 are approximately 80 feet downgradient of the building (**Figure 4-32**). These wells were installed in 1999 to monitor historical releases from the Waste Concentration Facility and the former Pile Fan Sump area. Well 065-37 is screened close to the water table, whereas wells 065-169 and -170 are screened approximately 10 feet below the water table. Because well 065-37 is not ideally screened at the water table to properly monitor a nearby contaminant source area, a new shallower well, 065-325, was installed in early October 2002.

Sampling Frequency and Analysis

During 2004, Building 801 monitoring well 065-325 was sampled three times under the Environmental Surveillance Program (**Table 1-6**). The samples were analyzed for gross alpha, gross beta, Sr-90, Cs-137, and tritium. Monitoring wells 065-37, -169, and -170 were sampled semiannually under the Environmental Restoration Program, and the samples were analyzed for Sr-90 and Cs-137.

4.10.2 Building 801 Monitoring Well Results

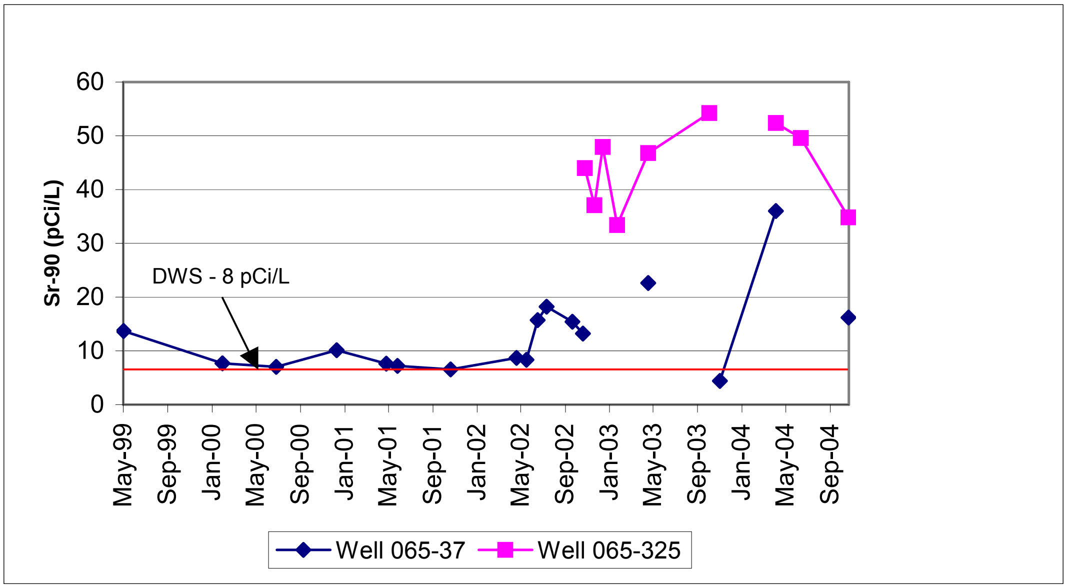
The April, June, and October 2004 samples from well 065-325 had Sr-90 concentrations of 52.4 pCi/L, 49.6 pCi/L, and 34.8 pCi/L, respectively (**Figure 4-33**). Cs-137 was not detected in any of the samples; however, trace levels of tritium were detected in the April and October samples at concentrations of 580 pCi/L and 410 pCi/L, respectively. Sr-90 concentrations in slightly deeper well 065-37 ranged from 36 pCi/L in April to 16.2 pCi/L in October 2004. Only low levels of Sr-90 were detected in deeper wells 065-169 and -170, with maximum concentrations of 2.1 and 2.9 pCi/L, respectively

4.10.3 Building 801 Monitoring Program Evaluation

Sr-90 concentrations in samples collected during 2004 from shallow groundwater wells located downgradient of Building 801 are consistent with pre-December 2001 values. Additionally, Cs-137 has not been detected in any of the groundwater samples. It is estimated that it could take approximately 3 to 8 years for Sr-90, and approximately 100 years for Cs-137, from the December 2001 Building 801 floodwater release to migrate to the closest downgradient well (065-325). Furthermore, detecting any new groundwater impacts from this release will be difficult to identify, as the local groundwater is already contaminated with radioactivity from legacy releases (see discussions related to nearby Pile Fan Sump in **Section 3.2.12**).

Because of the slow migration rates for Sr-90 and Cs-137, the monitoring frequency for well 065-325 continues to be semiannual, and the monitoring will coincide with planned semiannual sampling of wells 065-37, 065-169, and 065-170 by the Environmental Restoration Program.

Figure 4-33.
Sr-90 Concentration Trends in Downgradient Wells 065-37 and 065-325 at Building 801.



5.0 SUMMARY OF RECOMMENDATIONS

This section, a summary of all of the recommendations from Sections 3 and 4, is provided as a quick reference. The recommendations are sequenced as they appear in Sections 3 and 4.

5.1 OU I South Boundary Pump and Treatment System

The following actions are recommended for the OU I South Boundary Pump and Treatment System and groundwater monitoring program:

- The routine operation and maintenance monitoring frequency implemented in the fourth quarter of 2004 should be continued. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency.
- Implement reductions and pulsing of the pumping rates for the treatment system wells to optimize system performance. Beginning in October 2005, the system should be pulsed on and off on a monthly basis. The flow rates will be reduced from the current rates of 450 gpm and 250 gpm to about 375 gpm and 200 gpm.
- Install a permanent monitoring well downgradient of the 2004 vertical profile location to continue to track the remaining plume concentrations as they migrate to the extraction wells.
- Maintain the current monitoring well sampling frequency.

5.2 Carbon Tetrachloride Pump and Treat System

The following actions are recommended for the OU III Carbon Tetrachloride Pump and Treat System and groundwater monitoring program:

- Continue sampling of the extraction wells on a monthly basis.
- The monitoring well network is adequate and no modifications are necessary at this time.
- If significant concentrations of carbon tetrachloride are detected, the system will be turned on.

5.3 Building 96 Air Stripping System

The following actions are recommended for the OU III Building 96 groundwater remediation system and monitoring program:

- Based on the information gathered during the previous year, the Building 96 RTW-1 recovery well can now be shut down and placed in standby mode on June 1, 2005.
- An integral part of the shutdown of the Building 96 recovery well RTW-1 is the continued monitoring of the VOC concentrations in the groundwater beneath the Building 96 former scrap yard. The monitoring program currently in place for the previously shut down recovery wells RTW-2, -3, and -4 will be expanded to include RTW-1 and the 12 new monitoring wells installed in the silty zone injection grid. The 16 wells that are being monitored as part of the permanganate injection program, including RTW-1, will be sampled monthly, while all other Building 96 wells will be monitored quarterly, including RTW-2, -3, and -4. Monthly monitoring will change to quarterly when concentration trends have stabilized. Prior to implementation, any schedule change will be discussed in the *BNL Annual Groundwater Status Report*.
- If, after shutdown of the system, up to 2 years of groundwater monitoring data indicate that TVOC contaminant concentrations in all monitoring wells are consistently below the cleanup

goal of 380 µg/L for each chemical, then a formal petition for closure of the remediation system, system decommissioning, and termination of post-closure monitoring may be submitted to the regulatory agencies for review and approval.

- In addition to monitoring, the Building 96 silt zone area will have repeat injections of permanganate on an as-needed basis in locations where concentrations are not declining. This activity will be repeated until it is clear, due to VOC concentrations less than 380 µg/L, that the OU III ROD cleanup objectives will be met. The results of the injection(s) and any further recommendations will be reported in the *BNL Annual Groundwater Status Report*.

5.4 Middle Road Pump and Treat System

The following actions are recommended for the OU III Middle Road Pump and Treat System and groundwater monitoring program:

- The operation and maintenance monitoring frequency was implemented during 2003 and 2004 and should be maintained for 2005 for the monitoring well network.
- Extraction wells RW-4 and RW-5 will continue in standby mode during 2005. The wells will be restarted should extraction well or monitoring well data indicate that VOC concentrations are showing significant rebound.
- Install one or two temporary wells near the HFBR tritium extraction wells to monitor the high-concentration portion of the plume. Based on the results from the temporary wells, a monitoring well may be installed.

5.5 South Boundary Pump and Treat System

The following actions are recommended for the South Boundary Pump and Treat System and groundwater monitoring program:

- A routine operations and maintenance monitoring frequency was implemented in the fourth quarter of 2003. This frequency should be maintained during the O&M phase.
- Continue to monitor the OU III South Boundary Magothy wells (121-40, 121-44, 122-41, and 122-05) at a quarterly (startup mode) frequency in 2005.
- Extraction well EW-12, which was installed in 1999 to address a slug of contamination that was to the east of the original capture zone of the South Boundary system, achieved VOC concentrations below NYS AWQS in 2003. This well was placed in standby mode in 2003. This well will continue in standby mode during 2005. The well will be restarted should monitoring well data indicate that VOC concentrations are showing significant rebound.
- Install a temporary well in the Magothy aquifer downgradient of the Middle Road treatment system to enhance the monitoring well network. This will help determine the extent of VOCs in the Magothy aquifer between the Middle Road and South Boundary plume monitoring networks, as well as provide additional hydrogeologic data.

5.6 Western South Boundary Pump and Treat System

The following actions are recommended for the Western South Boundary Pump and Treat System and groundwater monitoring program:

- Due to the steadily decreasing low influent concentrations and because six out of seven plume core wells have reached the cleanup objective of 20 µg/L TVOCs, it is recommended that pulse pumping the extraction wells begin. The wells will be shut down as of October 2005 and kept off for 2 months, then turned back on for 1 month. This process will continue for approximately 1 year to evaluate any changes to the VOC concentrations in the influent and the monitoring wells. The extraction wells will continue to be sampled monthly during pulse pumping.

- Complete the connection of communications to central on-site location.
- Monitoring well sampling will be changed to shutdown frequency to collect data for submittal of a petition for shutdown in the future.

5.7 Industrial Park In-Well Air Stripping System

The following actions are recommended for the Industrial Park In-Well Air Stripping System and groundwater monitoring program:

- The current routine O&M monitoring frequency should be maintained during 2005.
- The system should continue operations at 60 gpm per well except for well UVB-1, which is to be shut down and put in a standby mode in October 2005. This well had concentrations below MCLs throughout 2004. Monthly sampling will continue and if higher concentrations are observed, well UVB-1 will be restarted.

5.8 Off-Site Monitoring

No changes to the monitoring program are warranted at this time.

5.9 North Street Pump and Treat System

The following action is recommended for the North Street Pump and Treat system:

- Continue to monitor the wells and system on the current schedule.
- Continue routine operations as per the O&M Manual.

5.10 Central Monitoring

No changes to the monitoring program are warranted at this time.

5.11 Magothy Monitoring

No changes to the monitoring program are warranted at this time.

5.12 HFBR Tritium Monitoring

The following actions are recommended for the HFBR groundwater monitoring program.

- Several temporary wells will be installed in 2005 to track the high-concentration portion of the plume south of Rowland Street along Grove Street as outlined in the *HFBR Tritium Low Flow Pumping Evaluation Report* (BNL 2001b).
- The frequency in perimeter monitoring well 096-84 and outer perimeter monitoring wells 105-22, 105-23, and 105-42, located on Princeton Avenue, will remain quarterly. There will be no change to the monitoring parameters or frequency for the remainder of the network of wells. Extraction wells EW-9, -10, and -11 will also be sampled quarterly.

5.13 BGRR/Waste Concentration Facility Strontium-90 Monitoring

The following actions are recommended for the BGRR groundwater monitoring program:

- Maintain the southerly groundwater flow direction by managing the pumping of BNL supply wells.
- Abandon the monitoring of wells 085-299, 085-300, and 085-311 due to the construction of the new Nanocenter. These wells will be replaced once the construction has been completed.

5.14 Chemical/Animal Holes Strontium-90 Pilot Study Treatment System

The following actions are recommended for the Chemical/Animal Holes Strontium-90 Pilot Study Treatment System and groundwater monitoring program:

- Continue evaluating the use of Clinoptilolite, a natural occurring zeolite.
- Continue operating the treatment system at 6 gpm.
- Sample all wells in the monitoring well network semiannually for Sr-90.
- Install several geoprobes in the plume segment downgradient of the extraction well and particularly in monitoring well 106-49, to better define downgradient concentrations and evaluate the data.
- Install several geoprobes downgradient from monitoring well 106-64 to better define the downgradient concentrations of the Sr-90 plume from the Former Landfill.
- Move future discussion of the Sr-90 concentrations downgradient of monitoring well 106-64 to the Former Landfill section of the Annual Report, since that is the source of this plume.

5.15 South Boundary Radionuclide Monitoring Program

No changes are recommended for the OU III South Boundary Radionuclide Monitoring Program.

5.16 North Street East Pump and Treat System

The system will continue to operate in its present configuration. No changes to the monitoring well network or the sampling schedule are recommended.

5.17 Industrial Park East Pump and Treat System

The following are recommendations for the Industrial Park East Pump and Treat System and groundwater monitoring program.

- Install an additional Magothy monitoring well adjacent to well 000-495, but deeper, to more accurately define the plume.
- Continue operations at the design rates.
- Maintain monitoring well sampling frequency at the current rate.

5.18 LIPA/Airport Pump and Treat System

The following are recommendations for the LIPA/Airport Groundwater Treatment System and groundwater monitoring program:

- Quarterly sampling of the monitoring wells associated with this project should continue in 2005 and will likely be reduced to semiannual for most wells in 2006.
- The extraction well sampling should continue on a monthly schedule.

- The leading edge of the plume has not reached the Airport extraction wells. Therefore, the Airport extraction wells should be pulse pumped beginning in October 2005. This will be accomplished by operating the wells one week each month and continuing to sample them monthly. This will verify that the higher concentrations have not reached the Airport system. If concentrations above the capture goal of 10 µg/L VOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into operation.

5.19 Air Sparge/Soil Vapor Extraction (AS/SVE) Remediation System

The following actions are recommended for the OU IV AS/SVE groundwater monitoring program:

- Fully implement the monitoring requirements defined in the *Final CERCLA Five Year Review Report for OU IV* (BNL 2003e), as follows:
  - Wells 076-04 and 076-06 – Continue to monitor these wells quarterly for VOCs and SVOCs. If concentrations remain below MCLs for a 1-year period, reduce the sampling frequency to semiannual for up to 5 years.
  - Well 076-185 – Continue to monitor for VOCs on a semiannual basis.

5.20 Building 650 (Sump Outfall) Strontium-90 Monitoring

Continue to monitor to determine whether remediation of the Building 650 Decontamination Pad and Sump Outfall has removed the source of contamination and if the plume is attenuating and migrating as expected.

5.21 Operable Unit V

Eight OU V monitoring wells (000-122, 000-123, 049-05, 049-06, 050-01, 050-02, 061-04, and 061-05) should continue to be analyzed for perchlorate in 2005.

5.22 Operable Unit VI Pump and Treat System

The system will continue to operate in its present configuration while the plume location and influent EDB concentrations are monitored.

5.23 Site Background Monitoring

No modifications are recommended to the Site Background monitoring program.

5.24 Current Landfill Groundwater Monitoring

There were no recommendations to the sampling schedule.

5.25 Former Landfill Groundwater Monitoring

There were no recommendations to modify the sampling schedule presented.

5.26 Alternating Gradient Synchrotron (AGS) Complex

The following actions are recommended for 2005:

- Continue quarterly monitoring the g-2 tritium plume with existing wells. Install temporary wells to monitor the leading edge of the plume. Collect data needed for Focused Feasibility Study to be submitted to the regulatory agencies in 2006.
- Monitoring data indicate that engineered controls in the former E-20 Catcher, former U-line Target and Stop areas, Building 912, J-10 Stop, the 914 Transfer Area, and the Booster Stop are effectively protecting groundwater quality. During 2005, groundwater samples will continue to be collected on a semiannual basis. Due to a planned reduction in accelerator

facility operations in the AGS Ring and Booster areas in 2006, BNL is considering reducing the groundwater monitoring frequency in these areas to annually.

5.27 Relativistic Heavy Ion Collider Facility

To date, tritium has not been detected in RHIC area monitoring wells, indicating that engineered controls in the RHIC beam loss areas are effectively protecting groundwater quality. During 2005, groundwater samples will continue to be collected semiannually. BNL is considering reducing the monitoring frequency to annually, starting in 2006.

5.28 Brookhaven Linac Isotope Producer Facility

During 2005, groundwater samples will continue to be collected quarterly from the three wells located immediately downgradient of BLIP. The remaining wells will be sampled semiannually. If tritium concentrations are continually less than the 20,000 pCi/L drinking water standard by the end of 2005, consideration will be given to reducing the sampling frequency for all the BLIP monitoring wells, starting in 2006. The final remedy for BLIP groundwater will be documented in a ROD.

5.29 Brookhaven Medical Research Reactor Facility

Tritium levels in groundwater downgradient of the BMRR have never exceeded the 20,000 pCi/L drinking water standard, with tritium concentrations being consistently <5,000 pCi/L for the past 5 years. Starting in 2005, the monitoring frequency will be reduced from semiannual to annually.

5.30 Waste Management Facility

Groundwater monitoring at the WMF will continue to be conducted on a semiannual basis, in accordance with the RCRA Part B Permit modifications approved by NYSDEC in 2003. Samples will be analyzed for gross alpha, gross beta, gamma, and VOCs semiannually, whereas samples will be analyzed annually for metals and anions.

5.31 Major Petroleum Facility

Groundwater monitoring at the MPF will continue in accordance with NYSDEC operating permit. The wells will be tested monthly for floating product and semiannually for VOCs and SVOCs.

5.32 Sewage Treatment Plant

No changes to the STP groundwater monitoring program are recommended. Maintain the monitoring program on its current semiannual schedule for wells in the STP filter bed area, and annually for the wells near the emergency holding ponds. BNL is considering reducing the sampling frequency for all STP wells to annually, starting in 2006.

5.33 Motor Pool

For the Motor Pool, the following actions are recommended for 2005:

- Maintain the groundwater monitoring program for the gasoline UST area on its current semiannual schedule, and test for floating product and VOCs.
- Maintain the groundwater monitoring program for the Building 423/326 area on its current annual schedule, and test for VOCs.
- Discontinue sampling for SVOCs.

5.34 Service Station

For the Service Station, the following actions are recommended for 2005:

- The ER Program will sample four of the five service station wells quarterly for VOCs, as part of the carbon tetrachloride plume monitoring project. The ES Program will sample one well (085-235) semiannually for VOCs, and all five wells semiannually for floating product.
- Discontinue sampling for SVOCs.

5.35 Biology Department Greenhouse Area

Because none of the contaminants of concern were detected during the first 3 years of sampling at the Biology Department Greenhouse Area, active monitoring of the greenhouse wells was suspended in 2003. Assuming that the current controls on chemical use at the greenhouse area are maintained, suspension of the routine groundwater surveillance program for the greenhouse area is recommended. The wells will be maintained for the collection of routine water level measurements used to assess sitewide groundwater flow patterns, and for potential future water quality sampling.

5.36 Shotgun Range

Because lead was not detected in groundwater during the first 3 years of sampling, active monitoring of the Shotgun Range wells was suspended in 2003. Continued suspension of routine groundwater surveillance for the range is recommended. The wells will be maintained for the collection of routine water level measurements, which are used to assess site wide groundwater flow patterns, and for potential future water quality sampling.

5.37 Live-Fire Range

Because lead was not detected in groundwater during the first 3 years of sampling, active monitoring of the Live-Fire Range wells was suspended in 2003. Continued suspension of the routine groundwater surveillance program for the range is recommended. The wells will be maintained for the collection of routine water level measurements, which are used to assess site wide groundwater flow patterns, and for potential future water quality sampling.

5.38 Building 801

Because of the slow migration rates for Sr-90 and Cs-137, the monitoring frequency for well 065-325 will continue to be semiannual, and the monitoring will coincide with planned semiannual sampling of nearby wells 065-37, 065-169, and 065-170 by the EM Sitewide Groundwater Monitoring Program.

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