2003 BNL GROUNDWATER STATUS REPORT

June 1, 2004

Environmental and Waste Management Services Division
Environmental Restoration

Brookhaven National Laboratory
Operated by
Brookhaven Science Associates
Upton, NY 11973

Under Contract with the United States Department of Energy
Contract No. DE-AC02-98CH10886

BROOKHAVEN NATIONAL LABORATORY

EXPLORING EARTH'S MYSTERIES
…PROTECTING ITS FUTURE

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From the initial collection of samples, to the final reproduction, the 2003 BNL Groundwater Status Report required the expertise and cooperation of many people and organizations to complete. The contributions of the following individuals are gratefully acknowledged:

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2003 BNL Groundwater Status Report

TABLE OF CONTENTS

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

(TABLE OF CONTENTS CONTINUED)

LIST OF FIGURES

(LIST OF FIGURES CONTINUED)

(LIST OF FIGURES CONTINUED)

(LIST OF FIGURES CONTINUED)

LIST OF TABLES

LIST OF APPENDICES

(LIST OF APPENDICES CONTINUED)

(LIST OF APPENDICES CONTINUED)

(LIST OF APPENDICES CONTINUED)

LIST OF ACRONYMS

2003 BNL Groundwater Status Report

µg/L	Micrograms per Liter	COC	Chain of Custody
AGS	Alternating Gradient Synchrotron	CRDL	Contract Required Detection Limit
AOC	Area of Concern	CSF	Central Steam Facility
AS/SVE	Air Sparge/Soil Vapor Extraction	CY	Calendar Year
ASL	Analytical Services Laboratory	DCA	1,1-dichloroethane
ASTM	American Society for Testing and Materials	DCE	1,1-dichloroethene
AWQS	Ambient Water Quality Standards	DCG	Derived Concentration Guide
BERA	Brookhaven Employees Recreation Association	DMR	Discharge Monitoring Report
BGD	Below Ground Ducts	DOE	U.S. Department of Energy
BGRR	Brookhaven Graphite Research Reactor	DQO	Data Quality Objective
BLIP	Brookhaven LINAC Isotope Producer	DTW	Depth to Water
BLS	Below Land Surface	DWS	Drinking Water Standard
BMRR	Brookhaven Medical Research Reactor	EDB	Ethylene Dibromide
BNL	Brookhaven National Laboratory	EDD	Electronic Data Deliverable
CERCLA	Comprehensive Environmental Response Compensation and Liability Act	EE/CA	Engineering Evaluation/Cost Analysis
CFR	Code of Federal Regulations	EIMS	Environmental Information Management System

LIST OF ACRONYMS

2003 BNL Groundwater Status Report

EM	Environmental Management	HWMF	Hazardous Waste Management Facility
EMS	Environmental Management System	IAG	Inter Agency Agreement
EPA	United States Environmental Protection Agency	ID	Identification
ER	Environmental Restoration	K gal	Thousand gallons
ERP	Emissions rate potential	lb/gal	Pounds per gallon
ES	Environmental Surveillance	lbs	Pounds
EWMSD	Environmental and Waste Management Services Division	LIE	Long Island Expressway
FFA	Federal Facility Agreement	LINAC	Linear Accelerator
FRP	Facility Response Plan	LIPA	Long Island Power Authority
FS	Feasibility Study	MCL	Maximum Contaminant Level
ft msl	feet above mean sea level	MDL	Minimum Detection Limit
GAC	Granular Activated Carbon	mg/L	Milligrams per Liter
gal/hr	Gallons per hour	MGD	Millions of Gallons per Day
GeV	Giga Electron Volt	MNA	Monitored Natural Attenuation
GPM	Gallons per minute	MPF	Major Petroleum Facility
HFBR	High Flux Beam Reactor	MS/MSD	Matrix Spike/Matrix Spike Duplicate

LIST OF ACRONYMS

2003 BNL Groundwater Status Report

msl	Mean Sea Level	SOP	Standard Operating Procedure
MTBE	Methyl tertiary Butyl Ether	SPCC	Spill Prevention Control and Countermeasures
NCP	National Oil and Hazardous Substances Pollution Contingency Plan	QA/QC	Quality Assurance and Quality Control
NPL	National Priorities List	RA V	Removal Action V
NSRL	NASA Space Radiation Laboratory	RCRA	Resource Conservation and Recovery Act
NYCRR	New York Code of Rules and Regulations	RHIC	Relativistic Heavy Ion Collider
NYS	New York State	RI	Remedial Investigation
NYSDEC	New York State Department of Environmental Conservation	RI/FS	Remedial Investigation/Feasibility Study
NYSDOH	New York State Department of Health	ROD	Record of Decision
O&M	Operation and Maintenance	RPD	Relative Percent Difference
OU	Operable Unit	SCDHS	Suffolk County Department of Health Services
PCBs	Polychlorinated Biphenyls	SCGs	Standards, Criteria and Guidances
PCE	Tetrachloroethylene	SCWA	Suffolk County Water Authority
pCi/L	pico Curies per Liter	SDG	Sample Delivery Group
PE	Plant Engineering	SDWA	Safe Drinking Water Act
PLC	programmable logic controller	SPDES	State Pollutant Discharge Elimination System

LIST OF ACRONYMS

2003 BNL Groundwater Status Report

Sr-90	Strontium-90
STP	Sewage Treatment Plant
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
TCA	1,1,1- Trichloroethane
TCE	Trichloroethene
TVOC	Total Volatile Organic Compounds
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VLB	Viscous Liquid Barrier
VOC	Volatile Organic Compound
WCF	Waste Concentration Facility
WMF	Waste Management Facility

2003 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 2003 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 seventh 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 Affairs office, as well as BNL's annual 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 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, and
- 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.

Section 1 summarizes the drivers of the data collection work in 2003, the site's groundwater classification, and the objectives of the groundwater monitoring efforts. Section 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 2003. Section 3 summarizes the groundwater cleanup data, progress towards achieving the site's cleanup goal and recommended modifications to the remediation systems or monitoring programs. Section 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 Section 5.

Hydrogeologic Data

The following were important hydrogeologic findings in 2003;

- Groundwater flow directions were relatively stable during 2003 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.

- Total annual precipitation in 2003 was recorded as 63.11 inches, well above the average for the period of record of 48.5 inches per year. This included a maximum monthly precipitation of 12.28 inches during June. 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 2003 was estimated as approximately 32 inches.

- The Magothy Aquifer Characterization was completed in early 2003. Information obtained from deep off-site borings during well installation in 2003 did not significantly alter the interpretation of the extent of the Magothy Brown Clay and Gardiners Clay units in these off-site areas. These are important confining units that govern the flow of groundwater from the Upper Glacial aquifer to the Magothy aquifer.

Progress in Groundwater Restoration Actions (CERCLA)

629 wells were sampled as part of the Environmental Restoration (ER) Groundwater Monitoring Program in 2003 comprising a total of 2,510 sampling events. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site. Seven VOC groundwater remediation systems were in operation by the end of 2003, with the addition of the Chemical/Animal Holes Strontium-90 Pilot Study Treatment System. Seven groundwater treatment systems will be constructed in 2004 (LIPA, Airport, Industrial Park East, North Street, North Street East, EDB, and BGRR Strontium-90). The OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) system was decommissioned in 2003 following regulatory approval. The HFBR Pump & Recharge System remained in standby mode in 2003. The total groundwater cleanup treatment capacity was increased from 2,875 gpm to 2,925 gpm in 2003. Ultimately, the total groundwater cleanup capacity will be on the order of 4,800 gpm.

Pulse pumping of Carbon Tetrachloride extraction wells was performed. The Magothy aquifer groundwater characterization project was completed, and a final report was published in May 2003. Additional groundwater characterization work was performed in the Building 96 system source area and immediately to the west of the system. The data obtained from these investigations refined our understanding of the BNL contaminant plumes. The progress of the groundwater restoration program is summarized in **Table E-2** Other progress highlights include:

- OU III Middle Road extraction wells EW-4 and EW-5 were placed on standby in September 2003 due to low VOC concentrations. Sampling of these wells continues to show low VOC concentrations.
- Pulse pumping of the four OU III Building 96 recirculation wells was performed in 2003. VOC concentrations in the RTW-2, 3, and 4 have been significantly lowered, and are currently at or near detectable levels. TVOC concentrations in RTW-1 remain greater than 100 μg/L.

- The OU III Carbon Tetrachloride Treatment System achieved its goals by the end of 2003. A petition to shutdown the system will be submitted to the regulators for review in 2004.
- The high concentration segment of the HFBR tritium plume continued to be monitored. Geoprobe samples were collected in the vicinity of Rowland Street. A geoprobe was also installed along Cornell Avenue and it was determined that there had been a slight westward shift of the tritium plume in this area. The highest tritium concentration detected in 2003 was 217,000 pCi/L in a temporary well just east of Rowland Street.
- A pre-design groundwater characterization effort consisting of geoprobe samples collected from multiple depths at 60 locations was performed in late 2003 into early 2004 for the BGRR, WCF, PFS, and BGD areas. The data obtained helped refine plume and source area extents, as well as extraction well locations.
- The OU III Chemical Holes Strontium-90 Treatment System began operation in February 2003 at a 50 gpm pumping rate, and is now operating at 6 gpm.
- Core team meetings were conducted with the regulatory agencies during 2003 and into 2004 to address groundwater remediation of VOC contamination in the Magothy aquifer, and the BGRR/WCF Strontium-90 plume. An Explanation of Significant Differences (ESD) to the OU III ROD will be prepared in 2004 to address these issues.

Table E-1 summarizes the status and progress of groundwater cleanup at BNL. In 2003, 510 pounds (lbs) of volatile organic compounds (VOCs) were removed from the aquifer by the treatment systems. To date, approximately 4,156 (or about 14%) of the estimated 25,000 to 30,000 lbs of VOCs in the aquifer have been removed. The startup of the OU III Chemical Holes Strontium-90 System in 2003 has resulted in 0.88 mCi of strontium-90 being removed from the aquifer.

Table E-1. BNL Groundwater Remediation System Treatment Summary for 1997 through 2003.

Remediation System (Start date)	1997-2002 Water Treated (Gallons)	1997-2002 VOCs Removed (Pounds)	2003 Water Treated (Gallons)	2003 VOCs Removed (Pounds) [c]
OU III South Boundary (June 1997)	1,901,436,850	1920	353,423,000	184
OU III Industrial Park (Sept. 1999)	602,915,330	631	187,013,000	127
OU III W. South Boundary (Sept. 2002)	74,287,000	11.66	138,761,000	10
OU III Carbon Tetrachloride (Oct. 1999)	122,798,300	327	27,348,000	14
OU I South Boundary (Dec. 1996)	2,118,390,000	278	306,390,000	19
OU III HFBR Tritium Plume (May 1997) [a]	241,528,000	180	0	0
OU IV AS/SVE (Nov. 1997)[b]	--	35	--	0
OU III Building 96 (Feb. 2001)	69,238,416	46	29,027,000	9
OU III Middle Road (Oct. 2001)	336,353,550	217	278,000,000	147
OU III Chemical Holes Sr-90	--	--	3,834,826	0.88 [d]
Total	5,466,947,446	3,646	1,323,796,826	510

Notes:
[a] System was shut down and placed in standby mode on September 29, 2000.
[b] Air Sparging/Soil Vapor Extraction system performance measured by pounds of VOC removed per cubic feet of air treated.
[c] Values rounded to the nearest whole number.

[d] Strontium-90 removal in mCi.

Groundwater remediation is expected to be a long-term process. Some noticeable improvements in groundwater quality are evident in the OU I South Boundary, OU III Carbon Tetrachloride, Building 96 and South Boundary areas. Groundwater remediation activities are expected to continue until approximately 2030 to meet the ultimate cleanup objective (i.e., to reduce contaminant levels in the Upper Glacial aquifer to below drinking water standards).

Figures E-1 and E-2 summarize the extent of the primary VOC and radionuclide plumes at BNL as of December 2003, respectively.

Environmental Surveillance (Facility) Monitoring Results

During 2003, the Environmental Surveillance program monitored groundwater quality at ten active research and support facilities. Groundwater samples were collected from 125 wells during approximately 300 individual sampling events. Although no new impacts to groundwater quality were discovered during 2003, groundwater quality continues to be impacted at four facilities: continued high levels of tritium at the g-2/VQ12 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 Service Station.

High levels of tritium continue to be detected in wells located approximately 150 feet downgradient of the VQ12 area, but at lower concentrations than those observed in 2002 when tritium concentrations up to 3,440,000 pCi/L was 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. The continued appearance of high levels of tritium is likely related to the flushing of residual tritium from the vadose zone following a significant rise in the local water table.

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 the year, reaching a maximum of 42,900 pCi/L in October. Tritium concentrations declined to less than 20,000 pCi/L by November 2003.

At the Motor Pool/Facility Maintenance area, the solvents 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane (DCA) continue to be detected at concentrations greater than the New York State Ambient Water Quality Standards (NYS AWQS) of 5 µg/L, with concentrations that are slightly higher than those observed during 2002. TCA was detected at concentrations up to 53.4 µg/L, and DCA was detected at concentrations up to 14.8 µg/L. The gasoline additive methyl tertiary butyl ether (MTBE) was also detected, with a maximum observed concentration of 33.8 µg/L. The NYS AWQSfor MTBE is 10µg/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. Petroleum related compounds included m/p xylene at 129 µg/L, o-xylene at 108 µg/L, 1,2,4-trimethylbenzene at 60 µg/L, and 1,3,5-trimethylbenzene at 22 µg/L. The solvent tetrachloroethylene was detected in several wells at a maximum concentration of 22µg/L. Additionally, the gasoline additive MTBE was detected in two wells at a maximum concentration of 144 µg/L. No floating petroleum was detected in the monitoring wells.

Monitoring of the leak detection systems at both vehicle maintenance facilities indicate 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 solvents and MTBE detected in groundwater at these facilities originate from historical vehicle maintenance activities, and are not related to current operations.

Emerging Issues

OU I South Boundary System

A persistent VOC hot spot remains in the aquifer south of the former HWMF. An evaluation will be undertaken in FY 04 to look at the life-cycle economics with respect to installing a third extraction well in this area. Active treatment of the hot spot would potentially reduce the duration of active remediation.

OU III Building 96 System

Groundwater characterization has determined that there is a continuing source for this VOC plume. Residual contamination is located in a shallow silty zone. The original system was not designed to address this source area. A recommendation to treat VOCs in the silty zone in situ with potassium permanganate will be submitted to the regulators in 2004.

Brookhaven LINAC Isotope Producer (BLIP)

Although tritium concentrations in groundwater declined to less than the 20,000 pCi/L drinking water standard during 2002, monitoring conducted during the first half of 2003 once again showed elevated tritium levels (up to 37,800 pCi/L in April 2003). Inspections of the cap and review of its design indicate that the stormwater controls (e.g., the combined gunite cap, the BLIP building, and paved areas) have not failed and should be effective in protecting the BLIP target vessel activation zone. However, a comparison of tritium concentrations to changes in water table position suggests that the 2003 increase in tritium concentrations may be correlated to a 6.5 foot increase in water table elevation that occurred between November 2002 and July 2003. As the water table rose, older tritium that was leached from the activated soils prior to capping in 1987 and from the grout injection project may have been flushed from the soils close to the water table. It is expected that the amount of tritium remaining in the vadose zone close to the water table will decline over time due to this flushing mechanism and by natural radioactive decay.

AGS g-2 Tritium Plume

High levels of tritium continued to be detected in groundwater directly downgradient of the VQ12 source area (3, 440,000 pCi/L in July 2002 and 1,040,000 pCi/L in January 2003). Inspections of the cap and review of its design indicate that the cap over the VQ12 area has not failed and is properly positioned. It is likely that the continued release is probably related to the flushing of residual tritium from the vadose zone following natural fluctuations in water table position.

During 2004, BNL will collect additional groundwater samples using permanent and temporary wells to validate the water table fluctuation hypothesis, to track the leading edge of the plume and to more confidently predict the rate of attenuation of the pulses of tritium already in the groundwater. Current plans call for the preparation of a Focused Feasibility Study by 2006.

1,4-Dioxane and Perchlorates

1,4-Dioxane and Perchlorates have recently emerged as potential threats to groundwater quality in a number of areas throughout the country.

1,4-Dioxane is used as a chemical stabilizer for a number of solvents such as tetrachloroethylene, 1,1-Dichloroethylene, and 1,1,1-Trichloroethane. This compound is not strippable or is poorly strippable using conventional air stripping or carbon filtration treatment, respectively. 1,4-Dioxane is not included in current, widespread methods used to test drinking water and groundwater treatment systems (e.g., EPA Methods 524 and 624). BNL has not tested the local groundwater for this compound, which would require the use of EPA Method 8260. Testing at a number of sites across the country has detected high levels of this compound. Although a drinking water standard for 1,4-Dioxane has not been promulgated, the USEPA and some state agencies are assessing potential impacts that this compound may have on public drinking water supplies.

Perchlorates have been detected in a number of areas on Long Island. Perchlorates are used as an oxidizer and are the primary ingredient in solid propellant for rockets, missiles, fireworks, and munitions. Its presence in groundwater in some areas may be related to the use of fertilizers obtained from Chile. Its environmental occurrence coupled with its known mobility and persistence has elevated regulatory concern regarding the compound. Reduced thyroid function has been associated with developmental effects in animal testing. In 2003, perchlorates were detected at a concentration of approximately 30 μg/L in a deep Upper Glacial aquifer test well installed by SCDHS immediately east (downgradient) of BNL. The NYS DOH guidance value for perchlorate is 18 μg/L. In response to the SCDHS data, BNL sampled the Sewage Treatment Plant effluent and several monitoring wells located downgradient of the Safeguard and Security Division's Live-Fire Range. No perchlorates were detected in the STP effluent sample, and the groundwater samples from the Live-Fire Range indicated only a possible trace level of perchlorates (<0.5 μg/L). These results suggest that these areas are not an active source for perchlorate. BNL will likely conduct additional monitoring during 2004, including the possible sampling of the OU V monitoring well network to evaluate the extent of perchlorate in the aquifer downgradient of the STP.

Proposed Changes to the Groundwater Protection Program

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

- Reductions in groundwater monitoring for both the OU I Current and Former Landfill Programs as specified in the 2003 Environmental Monitoring Report, Current and Former Landfills.
- Perform evaluation of the OU I South Boundary System to evaluate life-cycle economics with respect to installing an additional extraction well to reduce the operation time of the system.
- Petition to shutdown the OU III Carbon Tetrachloride System and place in standby mode.
- Treat the persistent high VOCs in the Building 96 area silty zone area in situ with potassium permanganate. Install up to five geoprobes in 2004 to verify the extent of the eastern and western prongs of the plume.
- Proposed monitoring frequency increase for the OU III HFBR Tritium program outer perimeter wells south of the plume. Focus 2004 plume characterization on leading edge of tritium plume and enhance the monitoring network if necessary.
- Evaluate the use of Clinoptillolite resin in place of the current UOP A51 zeolite resin for the OU III Chemical Holes Strontium-90 System.
- Install several additional geoprobes (and possibly a well) to monitor the leading edge of the OU IV AOC6 Building 650 Strontium-90 plume.

Table E-2
Groundwater Restoration Progress

Operable 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)	297 lbs of VOCs treated to date	7 of 14	The decline in VOCs leveled off. The mean total VOC concentration in the monitoring wells decreased from approximately 55 µg/L in 1999 to 22 µg/L in 2003. The hot spot near the former HWMF showed a total VOC decrease in 2003 from 125 µg/L to 64µg/L.
	Current Landfill	VOCs tritium	Long-term Stewardship	Landfill capping	Cap is maintained and stable	8 of 30	VOCs and tritium stable or slightly decreasing.
	Former Landfill	VOCs Strontium-90 (Sr-90) tritium	Long-term Stewardship	Landfill capping	Cap is maintained and stable.	7 of 30	Continued decline in Sr-90. VOCs have been below New York State Ambient Water Quality Standards (NYS AWQS) since 1998.
	Former HWMF	Sr-90	Long-term Stewardship	Monitoring	NA	NA	Sr-90 detected at 21.6 at well 088-26 June 2003, decreased to 12.6 September 2003. No detections of Sr-90 in sentinel wells.
OU III	Chemical/Animal Holes	Sr-90	Operational	P&T with ion exchange	Pilot Study remediation system began operations in February 2003	1 of 8	Pilot Study completed, operational since February 2003.
	Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Operational	P&T, carbon adsorption	341 lbs of VOCs treated to date	4 of 4	Petition for shutdown submitted in April 2004.
	Building 96 source control	VOCs	Operational	Recirculation wells with air stripping	55 lbs of VOCs treated to date	3 of 2 (planned)	System operated in pulsed mode in 2003. Partial shutdown petition is planned for 2004. Significant reduction in VOCs has been observed in system influent and monitoring wells for the southern portion of the plume. Silt zone remediation planned for 2004.

Table E-2
Groundwater Restoration Progress

Operable Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
	South Boundary	VOCs	Operational	P&T with air-stripping	2,104 lbs of VOCs treated to date	6 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, which spiked up during 2003. EW-12 placed in stand-by mode in October 2003 due to low VOC concentrations.
	Middle Road	VOCs	Operational	P&T with air-stripping	364 lbs of VOCs treated to date	2 of 25	Eastern extraction wells showing low VOC concentrations. RW-4 and RW-5 placed in stand-by due to low VOCs in October 2003.
	Western South Boundary	VOCs	Operational	P&T with air-stripping	21.5 lbs of VOCs treated to date	2 of 11	System in operation. Maximum total VOCs in monitoring well during 2003 was 49 µg/L.
	Industrial Park	VOCs	Operational	In-well stripping	758 lbs. of VOCs treated to date.	4 of 12	Generally decreasing VOC levels with the exception of fluctuating VOC concentrations in the eastern portion of system.
	Industrial Park East	VOCs	Construction	P&T with carbon treatment	NA	0 of 5	Concentrations in VOC plume in this area showed a decreasing trend in 2003. Construction to be completed spring 2004.
	North Street	VOCs	Construction	P&T with carbon treatment	NA	0 of 4	VOC plume continued to migrate south with higher concentration portion of plume reaching Vita Dr. in 2003. Additional monitoring wells installed during 2003. Construction to be completed spring 2004.
	North Street East	VOCs	Construction	P&T with carbon treatment	NA	0 of 10	VOC plume continued to migrate south. Additional monitoring wells installed during 2003. Construction to be completed spring 2004.

Table E-2
Groundwater Restoration Progress

Operable Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
	Long Island Power Authority (LIPA) Right of Way	VOCs	Construction	P&T wells with carbon treatment	NA	0 of 10	Additional monitoring wells installed during 2003. Construction expected to be completed summer 2004.
	Airport	VOCs	Construction	Recirculation wells with carbon treatment	NA	0 of 10	Additional Monitoring wells installed during 2003. Construction expected to be completed summer 2004.
	Magothy	VOCs	Construction	NA	NA	NA	Additional monitoring wells were installed in late 2003 and early 2004. Two Magothy extraction wells installed (April 2004) system operation scheduled to begin summer 2004.
	HFBR tritium	Tritium	The pump & recharge system remained in standby	Monitoring	0.2 Curies removed for off-site disposal. 180 pounds of VOCs were also removed from the aquifer and treated by this system.	NA	The high concentration area continues to migrate south and is now located south of Rowland St.. The peak concentration observed in 2003 was 217,000 pCi/L in temporary well 85-341 located along Rowland Street.
	BGRR/Waste Concentration Facility (WCF)	Sr-90	Construction scheduled for summer/fall 2004	P&T with Ion Exchange	NA	0 of 30	Characterization performed in 2003, system designed, construction expected to be completed in fall 2004.
OU IV							
	AS/SVE system	VOCs	Decommissioned	Air sparging/ soil vapor extraction	35 lbs. of VOCs were treated to date.	4 of 4	VOC concentrations in monitoring wells remain low. System decommissioned in December 2003.

Table E-2
Groundwater Restoration Progress

Operable Unit	Project	Target	Mode	Treatment Type	Treatment Progress	Years of Operation	Groundwater Quality Highlights
	AOC 6/650 sump outfall	Sr-90	Long Term Response Action	Monitored Natural Attenuation	Plume slowly migrating to south within monitoring-well network.	NA	The Sr-90 plume continues to migrate slowly to the southwest from the Bldg. 650 sump outfall. The highest Sr-90 detection was 42 pCi/L in well 76-13, (February 2003). Sr-90 concentrations in well 76-28 remained at or below detectable levels. Contaminated soils were excavated in these areas in 2002.
OU V	STP	VOCs tritium	Long Term Response Action	MNA	NA	NA	Low-level VOC plume concentrations remained stable during 2003. Tritium was detected in four wells above the detection limits but well below NYS AWQS and continued to slowly decline.
OU VI	Ethylene Dibromide (EDB)	EDB	Construction	P&T with carbon treatment	NA	0 of 10	Treatment system construction scheduled completion in summer 2004. The highest EDB concentration observed in 2003 was 6.8 µg/L.

1.0 INTRODUCTION AND OBJECTIVES

The mission of Brookhaven National Laboratory's (BNL'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 has 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 (CY) 2003 Groundwater Status Report is a comprehensive summary of groundwater data collected in 2003 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the sixth 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, the Community Affairs office, as well as the annual Site Environmental Report.

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 and,
- Proposed changes to the groundwater protection program.

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

Section 1 discusses the drivers of the data collection work in 2003, the site's groundwater classification, and the objectives of groundwater monitoring. Section 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 2003. The groundwater cleanup data and progress towards achieving the site's cleanup goal are described in Section 3. Section 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. Section 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 supports the discussions in Section 2. **Appendices C** and **D** contain the analytical results for each sample obtained under the Environmental Restoration (ER) and Environmental Surveillance (ES) Groundwater Monitoring Programs, respectively. Due to the volume of these data, all of the report appendices are included on a CD ROM; which 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. A hardcopy of the results can be printed from the CD ROM. The groundwater results are arranged by specific monitoring project and analytical group; Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), metals, chemistry, pesticides/ polychlorinated biphenyls (PCBs), and radionuclides. The data are organized further by well identification (ID) and the date of sample collection. Chemical/radio nuclide 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 [Groundwater Quality and Classification]) are identified by bold text. By including the complete results, the reader can analyze the data in detail. **Appendix E** contains information on sample collection, analysis and Quality Assurance/Quality Control (QA/QC). **Appendix F** consists of data supporting the remediation system discussions in Section 3 and **Appendix G** is a compilation of data usability report forms.

1.1 Groundwater Monitoring Program

Groundwater monitoring at BNL is performed for two reasons:

1. Meet regulatory requirements.
2. Monitoring is an integral part of ISO 14001 Environmental Management Systems (EMS).

1.1.1 Regulatory Drivers

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA): On December 21, 1989, the BNL site was included as a Superfund Site on the National Priorities List (NPL). The U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and New York State Department of Environmental Conservation (NYSDEC) integrated the DOE's response obligations under CERCLA, the Resource Conservation and Recovery Act (RCRA), and New York State (NYS) hazardous waste regulations into a comprehensive Federal Facilities Agreement (FFA). This IAG was finalized and signed by these parties in May 1992 (EPA 1992). The IAG 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 (O&M) 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 (SPCC) Plan.

The BNL's Waste Management Facility (WMF) is a NYSDEC permitted hazardous waste storage facility (NYSDEC Permit No. 1-422-00032/00102-0). Groundwater monitoring is required under a permit for the WMF. This program is specifically designed as a secondary means of verifying the effectiveness of the facility's administrative and engineered controls.

DOE Orders: DOE Order 5400.1, Chapter IV - *Environmental Monitoring Requirements* states that "Groundwater that is or could be affected by DOE activities shall be monitored to determine the effects of operations on groundwater quality and quantity and to demonstrate compliance with DOE requirements and applicable federal, state and local laws and regulations" (DOE 1988).

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). The 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, the Laboratory followed Federal Drinking Water Standards, NYS Drinking Water Standards (NYS DWS), and NYS Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater as the goals for protecting and remediating groundwater.

For drinking water supplies, the applicable federal maximum contaminant levels (MCLs) are set forth in 40 CFR (Code of Federal Regulations) 141 (primary MCLs) and 40 CFR 143 (secondary MCLs). In NYS, the SDWA requirements on the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code [10 NYCRR Part 5], that is enforced by the Suffolk County Department of Health Services (SCDHS) as an agent for the NYS Department of Health (NYSDOH). These regulations apply to any water supply that has at least five service connections, or 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's and DOE's 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, Strontium-90 (Sr-90), and gross beta), NYS AWQS (for gross alpha, radium-226, and radium-228), and 40 CFR 141/DOE DCGs (for determining the 4 mrem/yr dose for other beta-/gamma-emitting radio nuclides).

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

1.1.3 Monitoring Objectives

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

<u>Groundwater Resource Management:</u>

- Refine the conceptual hydrogeologic model of the site and maintain a current assessment of the dynamic patterns of groundwater flow and water table fluctuations to support initiatives in protecting, managing, and remediating groundwater;

- 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 those on groundwater quality from affected areas. This network of wells also can warn us of any contaminants originating from potential sources that may be located upgradient of the BNL site; and,
- Ensure that potable water supplies meet all regulatory requirements.

Groundwater Surveillance:

- Verify that operational- and engineered-controls effectively prevent groundwater contamination.
- Trigger early action and communication should the unexpected happen (e.g. control failure).
- Determine the efficacy of the operational and engineered control measures designed to protect the groundwater;
- Demonstrate compliance with applicable requirements for protecting and remediating groundwater.

Groundwater Restoration

- Track a dynamic groundwater cleanup problem when designing, constructing, and operating treatment systems;
- Measure the performance of the groundwater remediation efforts in achieving cleanup goals;
- Protect public health and the environment during the cleanup period;
- Define the extent and degree of groundwater contamination; and,
- 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). The Environmental Monitoring Plan includes: a description of the source area: description of groundwater quality; criteria for selecting locations for groundwater monitoring; and, and frequency of sampling and analysis. **Figure 1-1** highlights BNL, Operable Unit (OU) locations designated as part of the CERCLA program, and key site features. Details on the screen depths, sampling parameters, frequency and analysis by well are listed in **Tables 1-5** through **1-8**. Figure **1-2** shows the locations of wells monitored as part of The Laboratory's groundwater protection program.

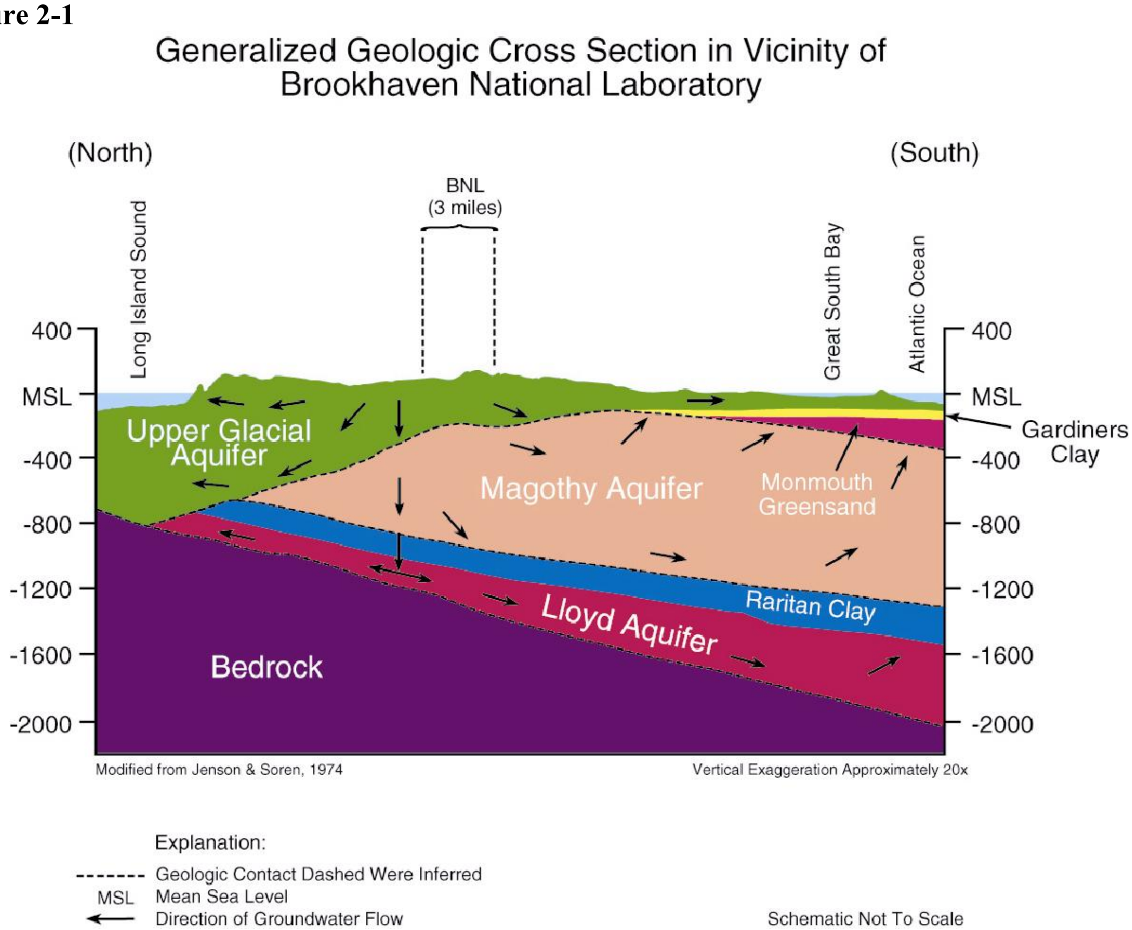
Starting in 2001, BNL has been using a structured Data Quality Objective (DQO) process to review and refine the groundwater monitoring and remediation projects. The results of these DQO reviews are documented annually in the updates to the Environmental Monitoring Plan.

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 2003 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 United States Geologic Survey (USGS) report by Scorca *et al*. (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 underneath BNL consists of approximately 1,300 feet of unconsolidated deposits overlying bedrock (**Figure 2-1**). Among these unconsolidated deposits, the Groundwater Monitoring Program currently focuses on groundwater quality within the Upper Pleistocene deposits, and the upper portions of the Matawan Group-Magothy Formation.

Figure 2-1



The Pleistocene deposits, are about 100 to 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 Sewage Treatment Plant [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. **Figure 2-2** shows the locations of pumping wells and recharge basins. Under natural conditions, recharge to the regional aquifer system is derived solely from precipitation. **Figure 2-3** illustrates the trends in annual precipitation at BNL. A regional groundwater divide exists immediately to the 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 to the north of this divide flows north, ultimately discharging to the Long Island Sound (**Figure 2-1**). Shallow groundwater in the BNL area generally flows to the south and east, and during high water table conditions it 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, and the Lloyd. 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 our 2003 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 is obtained from the USGS.

During 2003, water level data were collected during four synoptic events from March 24 to 27, June 16 to 18, September 22 to 24, and December 16 to 19, measuring 769 to 968 wells each period. Approximately 200 fewer wells were measured in December as the result of an 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 (EM) Standard Operating Procedure (SOP) EM-SOP-300.

Appendix A (located on the enclosed CD-ROM) has the depth-to-water (DTW) measurements and the calculated groundwater elevations for these quarterly synoptic measurements.

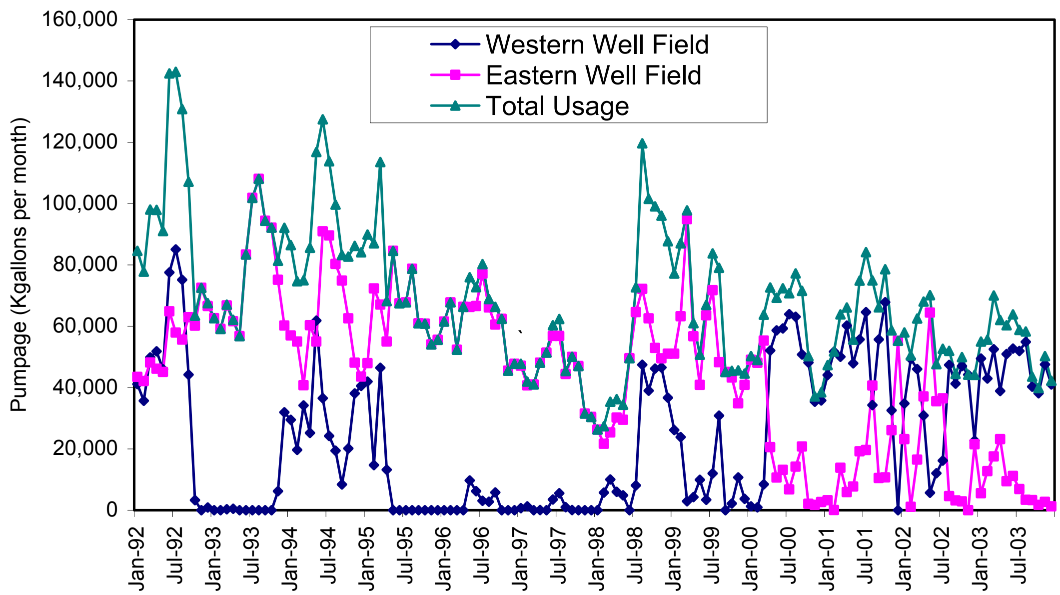
Long-term and short-term hydrographs for select wells are provided in Section 2.2 (Groundwater Flow).

2.1.2 Pumpage of Onsite Water Supply and Remediation Wells

BNL operates six water supply wells to provide potable and process cooling water, and 35 treatment wells to hydraulically contain and remediate contaminated groundwater. **Figures 2-4** and **2-5** show the locations of the water supply and remediation wells, and the effects that the groundwater withdrawals have on the aquifer system are discussed in Section 2.2 (Groundwater Flow).

Table 2-1 provides the monthly and total water usage for 2003 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 2-6** summarizes monthly pumpage for the eastern and western well fields.

Figure 2-6. Summary of BNL Supply Well Pumpage 1992 through 2003



The western well field was the primary source of water for 2003. Overall, BNL's pumping of potable water generally decreased since 1999. This reduction generally is due to water conservation measures throughout the Laboratory.

Table 2-3 summarizes the 2003 monthly water pumpage for the groundwater remediation systems.

2.1.3 Offsite Water Supply Wells

Several Suffolk County Water Authority 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 **Figures 2-2** and **2-7**) for locations of the SCWA well fields). Other SCWA well fields (e.g., Lambert Avenue and Main Street-Mastic Well Fields) are sited south of Sunrise Highway.

The William Floyd Well Field is located to the west/southwest of BNL (**Figure 2-2**), 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 located south/southeast of BNL, and consists of two water supply wells that withdraw groundwater from the mid section of the Upper Glacial aquifer. Information for 1989 through 2002 is provided below as **Figure 2-8 (note: data was not obtained for 2003)**. In 2002, the William Floyd (Parr Village) and Country Club Drive Well Fields produced 246 and 448 millions of gallons per year, respectively. Lambert Avenue (south of BNL near Sunrise Highway) produced 354 million gallons in 2002 and has averaged approximately 509 million gallons of water produced per year. While there are seasonal variations, the pumpage rate at William Floyd and Lambert Avenue has been reasonably steady for the last 10 years. However, pumpage at Country Club Drive is increasing.

Figure 2-8
SCWA Pumping Near BNL

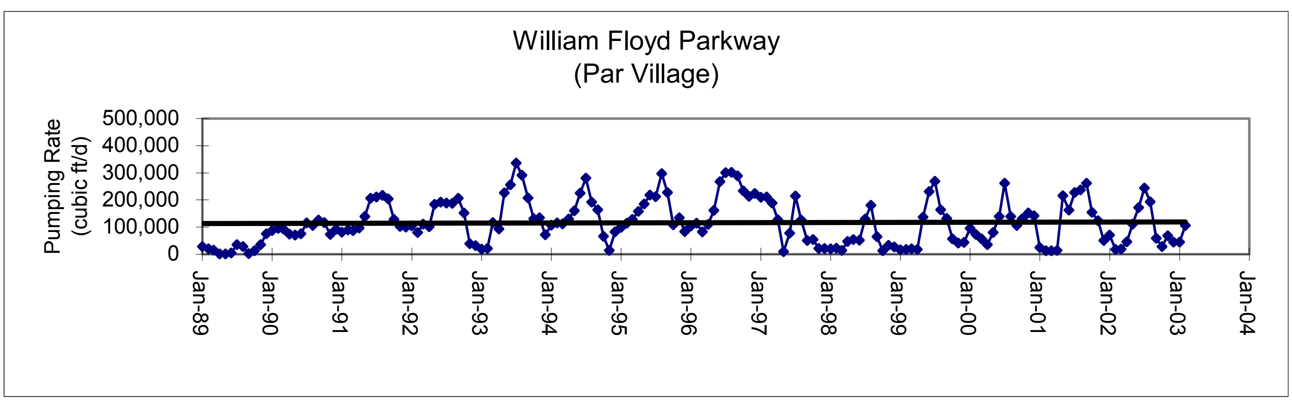
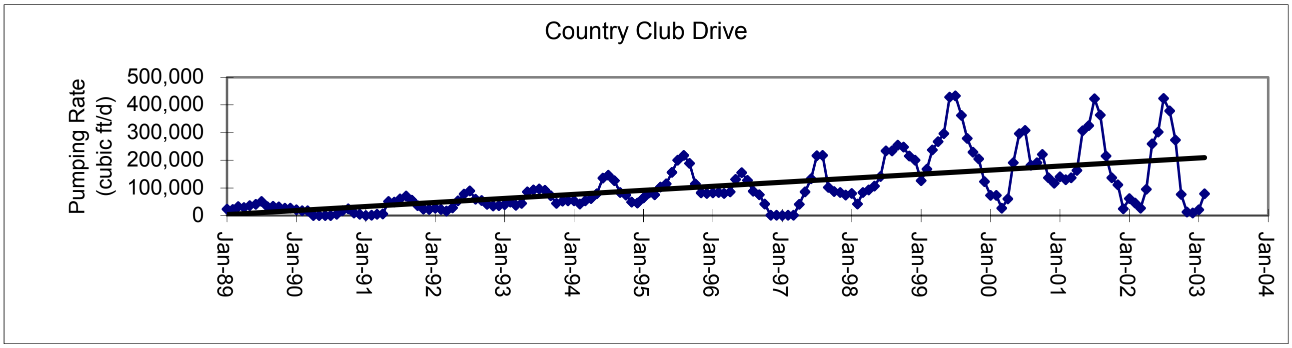
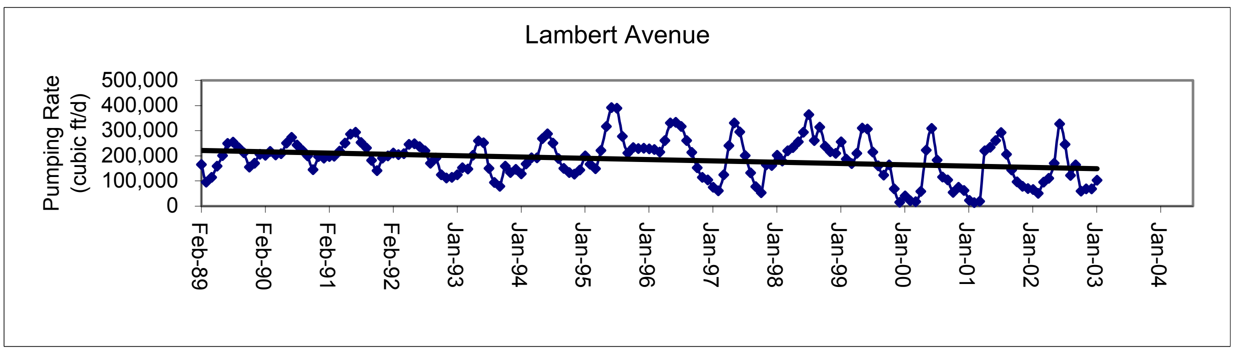


Figure 2-8 (continued)
SCWA Pumping Near BNL





2.1.4 Summary of Onsite 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 eleven on-site recharge basins during 2003. Their locations are shown on **Figure 2-2**. Section 2.2 (Groundwater Flow) provides a discussion on the effects associated with recharge. Eight of the basins (HN, HO, HP, HS, HT 1, HT 2, HX and HZ) receive water that was withdrawn by BNL's supply wells and not consumed or lost via evaporation, and storm water runoff. Flow into these basins is monitored monthly. 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 the annual Site Environmental Reports.

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 located adjacent to 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 2003 (27,462 and 52,994 K 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 storm-water 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 and is near several contaminant plumes. At the sand filter beds, approximately 10 percent of the treated effluent (or 14 million gallons annually) seeps directly to the underlying water table via leaks in the underlying tile-drain collection system. The remaining treated effluent (approximately 140 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. Over the last few years, this total STP effluent has decreased by about 50% due to routing of cooling water to recharge basins and improved water management practices.

Precipitation provides the majority of 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 soils and recharges the ground water system (Aronson and Seaburn, 1974; Franke and McClymonds, 1972). In 2003, it is estimated that the recharge at BNL was approximately 32 inches. **Table 2-5** summarizes monthly and annual precipitation results from 1949 to 2003 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 2003 was 63.11 inches, above the yearly average of 48.76, and significantly more than the total annual precipitation in 2002, which was 52.07 inches. Monthly precipitation for 2003 ranged from 2.38 inches (July) to 12.28 inches (June).

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 2-4 shows groundwater elevation contour maps representing the configuration of the water table for March, June, September, and December 2003. The contours were generated from the water level data collected during each synoptic round from shallow glacial wells, assisted by a computer-aided contouring package (SURFER and 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 [Hydrogeologic Data]).

Groundwater flow in the shallow Upper Glacial aquifer in 2003 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 (**Figure 2-2**). This pattern is consistent with comparable historical data published by the SCDHS and USGS.

The highest water table elevations on-site occurred in the northwestern section, (nearest the groundwater divide), varying from a high of approximately 52 feet above mean sea level (msl) in June and September, to a low of approximately 49 feet above msl in March. The lowest elevations were along the southern boundary, with a high of approximately 36 feet above msl in June, September, and December and a low of approximately 33 feet above msl in March. In 2003, the water table elevations were roughly three to five feet higher than in 2002, this was due to the abnormally high amount of precipitation during 2003. The lack of typical seasonal variation in precipitation and groundwater elevations during 2002 combined with the abnormally high precipitation in 2003 resulted in a slightly reduced seasonal variation of groundwater elevations of only one to three feet in terms of highs and lows for 2003. Localized hydrogeologic disturbances are evident on the quarterly contour maps. They result primarily from active on-site 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 in the vicinity of the groundwater treatment wells along the southern boundary.

Influences from water recharge activities can be observed as localized mounding of the water table, particularly around the recharge basin HO and the RA V basin (in the central site), the HP/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 (Hydrogeologic Data). 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 Carman's River is a significant discharge boundary.

2.2.2 Deep Glacial Contour Maps

Figure 2-5 shows the potentiometric surface contour maps of the deep zone of the Upper Glacial aquifer for March, June, September, and December 2003. 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 2003 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 to the south/southwest of BNL, the deep glacial contour maps also show flow towards 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, 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 2-7**).

The patterns for groundwater flow in the Upper Magothy for 2003 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 1950-2003) and short term (1997 through 2003) well hydrographs were constructed from water level data obtained for select USGS and BNL wells respectively. These hydrographs track fluctuations in water level over time. Precipitation data also were also 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 the USGS and BNL (2001 data was not available for well S-74289 due to problems with access). 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 2003 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 2003 which had higher than normal precipitation especially in the summer leading to relatively high water table elevations in June and September with a slight decrease to the expected seasonally low elevations during December). This seasonal fluctuation, while slightly out of phase with historical trends, generally correlates to the short-term trends in precipitation given in **Appendix B**.

2.3 New Geologic Data

The focus of the Environmental Restoration Program related to groundwater activities in 2003 was the construction of groundwater remediation systems as opposed to aquifer characterization. Incidental new data was collected during the installation of recovery and injection wells, however these data did not alter the BNL site conceptual model.

3.0 Environmental Restoration Groundwater Monitoring and Remediation

Groundwater remediation systems have operated at Brookhaven 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 (ROD), is to prevent and minimize plume growth and achieve MCLs in the Upper Glacial aquifer in 30 years or less.

There are presently eight groundwater remediation systems in operation, and seven additional systems will be in operation by the end of 2004. One system is in stand-by mode (HFBR Pump and Recharge), and one has met its cleanup goals and has been abandoned (OU IV Area of Concern (AOC) 5 Air Sparge/Soil Vapor Extraction (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 were capped (Current and Former), which minimizes them as sources of groundwater contamination.

In general, Brookhaven uses two types of groundwater remediation systems to treat VOC contamination, pump and treat with air stripping or carbon treatment, or recirculation with in-well 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. Pump and treat is a standard environmental cleanup technology, and particularly lends itself to on-site applications at BNL where the property needed for construction of a recharge basin is available.

Recirculation wells with in-well air stripping are an innovative groundwater remediation technology, and have been a preferred technology in off-site areas where there is limited space for recharge basins and the noise generated by air stripper towers is undesirable to local residents. This technology is based on a remediation well with two hydraulically isolated screen zones set some distance apart. Contaminated water is pumped up from the deeper zone in the contaminant plume, and treated below the ground surface with a shallow tray air stripper. The treated water then is returned to the aquifer via a shallow recharge screen. Off gas generated by the air stripping process is passed through granular activated carbon, and is sent back to the in well air strippers for reuse. **Table 3.0-1** summarizes both the operating and planned remediation systems.

This section gives an overview of groundwater monitoring and remediation efforts at Brookhaven during calendar year 2003. The section 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.

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 shown. Results exceeding the corresponding groundwater standard or guidance criteria (see Section 1.1.1 [Regulatory Drivers]) are shaded. Inclusion of the complete results allows the reader to analyze them in detail. In addition, the entire report is included on the CD-ROM with active links to tables and figures.

Maps are provided that depict the areal extent and magnitude of the contaminant plumes.;t In most cases the 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. (Note: there is no standard for TVOCs.) Similarly, individual radiochemical plumes were contoured to their appropriate MCL. 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.

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 tothe existing well networks and,
- The installation of temporary wells during groundwater characterization efforts that helped to fill in data gaps.

During 2003, the contaminant plumes were tracked by collecting 2,510 groundwater samples obtained from 629 on-site and off-site monitoring wells. **Figure 3.0-2** provides a summary of the number of analyses performed by analytical method. Unless otherwise noted,, the extent of contamination for a given plume is depicted by primarily using CY 2003 data from permanent monitoring wells. In several cases, data from early 2004 were utilized. Contaminant plumes associated with the OU III Building 96, HFBR Tritium, and Magothy projects were further defined using temporary wells.

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 ES Monitoring Program are also evaluated.

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**.

Figure 3.0-2 Summary of Laboratory Analyses Performed for EM Program in 2003

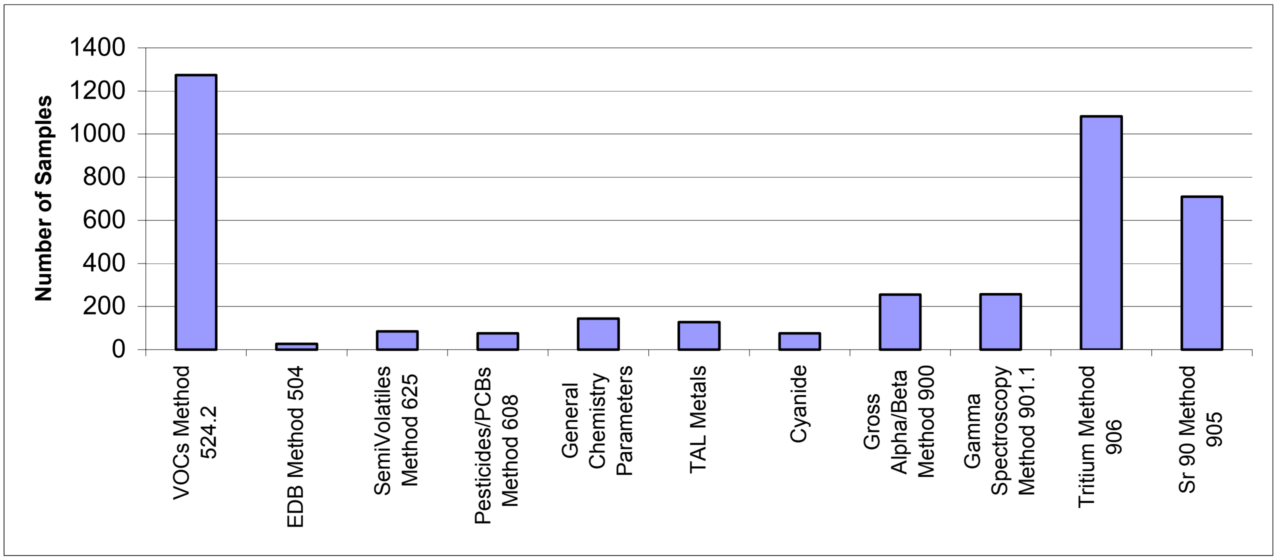


Table 3.0-1 Summary of Groundwater Remediation Systems at BNL

OU I	Operational	South Boundary	Pump and treat (A)	Basin
OU III	Spring 2004	North Street East (O)	Pump and treat (C)	Recharge wells
	Operational	Carbon tetrachloride	Pump and treat (C)	Basin
	Operational	Building 96	Re-circulation (C)	In-well
	Operational	Middle Road	Pump and treat (A)	Basin
	Operational	W. South Boundary	Pump and treat (A)	Basin
	Operational	Industrial Park (O)	Re-circulation (C)	In-well
	Summer 2004	LIPA (O)	Pump and treat (C)	Recharge wells
	Spring 2004	North Street (O)	Pump and treat (C)	Recharge wells
	Spring 2004	Industrial Park East (O)	Pump and treat (C)	Recharge wells
	Summer 2004	Airport (O)	Re-circulation (C)	In-well
	Fall 2004	BGRR Strontium-90	Pump and treat (I)	(To be determined)
	Pilot Study began Feb 2003	Chemical Holes Strontium-90	Pump and treat (I)	Dry wells
	Operational	South Boundary	Pump and treat (A)	Basin
	Stand-by	HFBR Tritium	Pump and recharge (*)	Basin
OU IV	Abandoned	1977 Spill	AS/SVE (C)	Not applicable
OU VI	Summer 2004	Ethylene dibromide (O)	Pump and treat (C)	Recharge wells

(A): Water treated using air stripping tower.
(C): Water or off-gas treated using activated carbon.
(I): Water treated using ion exchange.
(O): Treatment system located off site.
(*): Tritium cannot be removed from groundwater using conventional treatment methods. VOCs commingled with HFBR tritium plume were treated with carbon.

3.1 Operable Unit I

The two sources of groundwater contamination contained within 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 before off-site disposal until 1997, when a new WMF was constructed along East Fifth Avenue. Several hazardous materials spills were documented at the HWMF. This facility has been characterized, and soil remediation is scheduled to begin in 2004.

The Current Landfill and former HWMF plumes become commingled south of the HWMF. The commingling was partially caused by the pumping and recharge effects of the former Spray Aeration System, which operated from 1985 to 1990. This system was designed to treat VOC contaminated groundwater originating from the former HWMF. The VOC plume is depicted in **Figures 3.1-1** (plan view) and **3.1-2** (cross sectional view). 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 to the northwest of the Current Landfill (**Figure 3.1-1**).

A second system (North Street East System) is being built to treat the off-site portion of the plume (**Figure 3.0-1**). Groundwater pre-design characterization work was performed during 2001 as part of the planned North Street East groundwater remediation system. The purpose of this effort was to define the leading edge of the plume and the extent of the higher VOC concentrations in this area in support of remedial design. Eleven temporary vertical profile wells were installed and sampled as part of this effort. The data from these locations was considered in developing **Figure 3.1-1**. The construction of the off-site groundwater remediation system was started in 2003, and will begin operations in mid 2004.

Tritium is detected in several monitoring wells, but at concentrations below the 20,000 pCi/L drinking water standard. Strontium-90 is detected in on-site wells, several of which exceed the 8 pCi/L drinking water standard.

3.1.1 South Boundary Pump and Treat System

This section summarizes the operational and monitoring well data for 2003 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 to provide hydraulic control at the site boundary.

Quarterly reports were prepared with the operational data from January 1, 2003 through September 30, 2003. A monthly Discharge Monitoring Report (DMR) is submitted to EPA and NYSDEC for treated effluent water from the air-stripping tower..

3.1.2 System Description

Two groundwater extraction wells, EW-1 and EW-2, provide hydraulic control of the VOC plume. Groundwater is extracted at a total maximum flow rate of 700 gallons per minute (gpm). The actual rates vary during the extraction system's life, according to operational monitoring data. **Table 3.1-1** shows the depths of the extraction wells and pump settings.

Table 3.1-1. OU I Extraction Well Construction Data

Well	Screen Interval (Feet below grade)	Pump Setting (Feet below grade)
(EW-1, 115-27)	150-190	170
(EW-2, 115-43)	100-140	120

Each wellhead is enclosed in a reinforced concrete vault with the top slab at grade. The vaults are located along the southern boundary of the site. Piping within the vaults is schedule 80 PVC, transitioning to PVC water pipe before exiting through the vault's wall. The pipes are 4-inch (EW-1) and 6-inch (EW-2) diameter, increasing to 8- inches in the vault, and join an 8-inch diameter pipe, at the start of the common force-main to the treatment facility.

The groundwater treatment facility consists of a treatment control building and an air-stripping tower located north of Brookhaven Avenue between Fifth and Sixth Streets. The treatment facility is designed for limited automatic operation, defined as automatic equipment shutdown with manual restart. Any alarm condition will signal a common trouble alarm at BNL's Central Chilled Water Facility, and is followed up with a physical inspection of the main control panel to determine the source of the alarm.

The stripping tower is 6 feet in diameter and 48 feet tall, and is equipped with a minimum of 20 feet of 2-inch plastic packing. The design is based on the requirements to remove 1,1-dichloroethane (DCA). One of two centrifugal blowers supplies air to the tower at a normal flow rate of 6,550 scfm, providing an air/water ratio of 70:1 at the maximum water flow rate of 700 gpm.

The water discharged from the air-stripping tower flows by gravity to the adjacent recharge basin. The basin can receive a continuous flow of 1,500 gpm, and the design includes a sufficient factor of safety to account for OU I discharge, variations in subsurface soil, and fouling of the basin over time. Treated water from the OU III HFBR Tritium Pump and Recharge System was also discharged to this basin until the system went into standby mode on September 29, 2000. The OU III Middle Road System began partially discharging to this basin in October 2001.

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) located downgradient of the Current Landfill and former HWMF **(Figure 1-2)**. Supplemental data were obtained from monitoring wells sampled under the Current Landfill Post Closure Monitoring Program during October 2003. A discussion of monitoring well data specific to the Current Landfill source area is provided in **Appendix H**. The network is organized into core, perimeter and bypass wells. The wells are designated as follows:

- Background – background water quality results will be utilized 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 – data used to determine whether plume capture performance is being met.

Sampling Frequency and Analysis: The wells are monitored semiannually for VOCs, tritium, Strontium-90, and gamma spectroscopy (**Table 1-6**).

3.1.4 Monitoring Well/Vertical Profile 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 2nd quarter 2003. Due to changes incorporated into the EM Baseline at the end of September 2003, the OU I South Boundary program was changed from a second and fourth quarter sampling project to a first and third quarter sampling project. A consequence, the second round of sampling scheduled for 2003 was not fully completed. The primary VOCs detected in the on-site segment of this plume include chloroethane and DCA, the signature contaminants for the Current Landfill. 1,1,1-Trichloroethane (TCA), 1,1-dichloroethene (DCE), trichloroethene (TCE), and chloroethane are prevalent in the plumes' off-site (North Street East) segment. 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 concentrations (greater than 50 µg/L) are approximately 590 feet wide. The areas of the plume displaying the highest VOC concentrations (greater than 100 µg/L) are located approximately 980 feet downgradient of the former HWMF (well 98-59), and off-site, south of well 000-124. Contaminant concentrations in the vicinity of well 98-59 have remained persistently high during the treatment period, but have shown a downward trend since 2001.

Depiction of the extent of the plume south of well 000-124 is based on the eleven vertical profile wells installed during 2001. The current position of the leading edge of the plume was estimated using an average groundwater velocity for this area of 0.75 feet per day and retardation factor of 2.

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's boundary and off-site. TCA, DCE, TCE, chloroethane and chloroform are found in the mid to deep Upper Glacial off-site, south of North Street.

Gardiners Clay and the Upton Unit underlie the more permeable outwash deposits of the Upper Glacial aquifer from the source areas to the Princeton Avenue firebreak, but are absent south of this area. There, the Magothy Brown Clay unit lies immediately below the Upper Glacial aquifer and extends some distance to the south of North Street.

Data obtained from plume perimeter wells indicate that the VOC plume has shifted slightly to the west based on reduced concentrations in well 108-18. The plume remains bounded by the current network of wells. **Figure 3.1-3** gives the historical trends in VOC concentration for key plume core and bypass wells along the Current Landfill/HWMF/North Street East Plume. **Table 3.1-2** summarizes VOC detections in monitoring wells exceeding the NYS AWQS during 2003. **Appendix C** provides a complete set of 2003 analytical results for the 57 OU I South Boundary System Program wells. Significant findings for 2003 include:

- There were no detections of VOCs above NYS AWQS in upgradient perimeter wells during 2003.

- Plume core well 98-59 (**Figure 3.1-3**) began to show a steady 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 2003 result indicated that TVOC concentrations have dropped to 64 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 situated between the firebreak road and the extraction wells.. The TVOC concentration was 9 µg/L during May 2003, a marked decrease from concentrations greater than 100 µg/L prior to 1999.

- TVOC concentrations in plume core wells 115-14 and 115-31, both located adjacent to the extraction wells, continued to exhibit stable and decreasing trends, respectively. Concentrations ranged from 16 to 35 µg/L.

- TVOC concentrations in bypass wells 115-42 and 000-138 continued to decrease.

- TVOC concentrations continued to decline in off-site plume core well 000-124, dropping to 15 µg/L in 2003. The peak concentration in this well was 487 µg/L in 1998.

- The 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 just south of the Long Island Expressway (**Figures 3.1-1 and 3.1-2**).

- Declining TVOC concentrations in well 000-124, indicate that the high concentration slug of VOCs observed in the vicinity of well 000-124 during the 2001 characterization effort continues to migrate to the south.

3.1.5 Radionuclide Monitoring Results

The on-site monitoring wells were analyzed for tritium, strontium-90, gross alpha/beta and gamma spectroscopy semi-annually. Offsite wells were analyzed for tritium at a quarterly frequency and gross alpha/beta, gamma spectroscopy and strontium-90 annually. **Table 3.1-3** summarizes radionuclide detections in monitoring wells above detectable levels during 2003. The complete radionuclide results for these wells is provided in **Appendix C**.

During 2003, well 98-30 (located approximately 900 feet downgradient of the former HWMF) was the only on-site well that continued to show elevated tritium concentrations, with a maximum concentration of 19,400 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 98-30 and other select OU I South Boundary program wells are shown in **Figure 3.1-4**. Tritium concentrations in this well first began to increase in 2000, and eventually exceeded the 20,000 pCi/L drinking water standard in 2002.

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 result from the sample collected in May 2003 had a tritium concentration of 5,920 pCi/L.

Strontium-90 has historically been detected in three wells located within and downgradient of the former HWMF (88-26, 98-21, and 98-30) at concentrations above the 8 pCi/L drinking water standard. There are 10 wells (including six that are also part of the OU I South Boundary Monitoring Program) used to monitor strontium-90 contamination from the former HWMF **(Table 1-6)**. In 2001, additional groundwater characterization work was performed, and groundwater samples were collected at thirteen locations downgradient of the former HWMF. Strontium-90 was observed at several distinct depth intervals, suggesting that the strontium-90 was mixed within the aquifer as a result of the operations of the former spray aeration remediation system. The peak strontium-90 concentration observed during the 2001 characterization effort was 65.4 pCi/L. Details from the 2001 characterization can be found in the *2001 BNL Groundwater Status Report (BNL, 2002)*. The extent of strontium-90 concentrations greater than 8 pCi/L is shown in **Figure 3.1-5**. The extent of the plume for 2003 is estimated using the 2001 characterization study and data from permanent monitoring wells sampled during 2003. Sentinel monitoring wells were installed in 2002 downgradient of the leading edge of the plume. There were no strontium-90 detections in these wells in 2002 and 2003, indicating that the leading edge of the plume remains north of this area. The peak strontium-90 concentration observed during 2003 was 21 pCi/L, in well 88-26. Historical strontium-90 concentration trends for key monitoring wells are provided in **Figure 3.1-6**.

3.1.6 Systems 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 3.1-4** provides the effluent limitations for meeting the requirements of the State Pollution Discharge Elimination System (SPDES) permit equivalency. Furthermore, the effluent is sampled for metals, pesticides, PCBs, Strontium-90 and gross alpha/beta annually, although the permit does not require this.

Table 3.1-4. SPDES Parameter Effluent Concentrations for 2003, OU I South Boundary Pump and Treat System

Parameter	Threshold Value* (µg/L)	Maximum Measured Value (µg/L)
pH	9.0 SU	6.3-7.95 SU
Benzene	0.8	ND
Chloroform	7.0	ND
Chloroethane	5.0	ND
1,2-Dichloroethane	5.0	ND
1,1-Dichloroethene	5.0	ND
1,1,1-Trichloroethane	5.0	ND
Carbon Tetrachloride	5.0	ND
1,2-Dichloropropane	5.0	ND
Methylene Chloride	5.0	0.51
Trichloroethylene	5.0	ND
Vinyl Chloride	2.0	ND
1,2-Xylene	5.0	ND

* Maximum effluent concentration (µg/L) allowed – Equivalent to a SPDES Permit.
ND = Not detected above method detection limit of 0.50 µg/L.

The following is a summary of the OU I operations for 2003. BNL's Plant Engineering Division (PE) made routine maintenance checks on this system as well as performed non-routine maintenance and repairs. BNL's Environmental and Waste Management Services Division (EWMSD) collected the samples. Full details are recorded in the system's operation and maintenance log. The daily operations and maintenance inspection logs are available in the project files and the treatment facility.

January-September 2003:

The system operated normally from January to March 2003. Minor shutdowns were recorded for blower maintenance.

The system operated normally from April to September, with only two shut down periods due to construction near the main power feed to wells EW-1 and EW-2. These shut down periods occurred from August 11 through August 21, 2003, and then again from September 22 through September 24, 2003.

A total of 263,720,000 gallons of water was pumped and treated during the first three quarters of 2003.

October 2003:

The system operated normally, with no interruptions for a majority of the month. A total of 23,555,000 gallons were pumped and treated. Well EW-2 was discovered to be off on October 30. The well remained off for the remainder of the month to diagnose the problem. The system was sampled and all effluent discharges met the SPDES equivalency permit requirements.

November 2003:

The treatment system operated with only well EW-1, while trouble shooting of EW-2 was conducted. The system was off from November 3 through November 13, 2003 due to electrical work on the power supply to the wells. A total of 8,189,000 gallons were pumped and treated. All effluent concentrations met the equivalency permit requirements.

December 2003:

The system was operational with only EW-1 on-line. EW-2 was off due to motor problems. The system was down from December 2 through December 4, 2003 due to blower maintenance. A total of 10,926,000 gallons were pumped and treated. All effluent concentrations met the equivalency permit requirements.

3.1.7 Systems Operational Data

Extraction Wells

During 2003, 306,390,000 gallons were pumped and treated by the OU I system, with an average flow rate of 572 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells. VOC and tritium concentrations for EW-1 (115-43) and EW-2 (115-27) are provided in **Table F-1** in **Appendix F** (located on the enclosed 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 2003 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**. Selected VOC influent concentrations to the air stripper tower versus time are illustrated in **Figure 3.1-8**. The concentrations of TCA and DCA generally have decreased over the seven years of OU I South Boundary System operation; there was little change in other compounds.

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 equivalency permit conditions.

Cumulative Mass Removal

The mass of TVOCs 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 TVOCs removed by the treatment system vs. time was then plotted (**Figure 3.1-9**). It shows that 18.73 pounds of TVOCs were removed during 2003; cumulatively, 296.8 pounds have been removed since the system started. (Note: The 1996 RA V Design modeling estimated that the system would remove 260 to 300 pounds by 2006 to 2011). The data for this figure are summarized in **Table F-5**.

Air Discharge

Table 3.1-5 presents the VOC air emission data for the year 2003 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 period. 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.

Table 3.1-5. OU I South Boundary System Air Stripper VOC Air Emissions Data for 2003*

Parameter	Allowable ERP**	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Carbon Tetrachloride	0.016	<0.0002	<0.0002	<0.0002	<0.0002
Chloroform	0.0086	0.00042	0.00036	0.00034	0.00013
1,1 - Dichloroethane	10***	0.00123	0.00110	0.00108	0.00046
1,2 - Dichloroethane	0.011	<0.0002	<0.0002	<0.0002	<0.0002
1,1 - Dichloroethene	0.194	0.00009	<0.0002	<0.0002	<0.0002
Chloroethane	10***	0.00063	0.00049	0.00047	0.00033
1,1,1 - Trichloroethane	10***	0.00024	0.00020	0.00019	0.00007
Trichloroethene	0.119	0.00014	<0.0002	0.00013	<0.0002

* Actual Emission Rate reported as the average rate (lb/hr) for each quarter.
** Emission Rate Potential (ERP) based on NYSDEC Air Guide 1 Regulations.
***6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls.

Figure 3.1-10 compares the tritium concentrations in the air-stripper's influent and effluent since the system started operations in 1996. They are essentially identical (within measurement error), indicating that tritium was not transferred to air during the stripping process.

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

Recharge Basin

There are nine sentinel monitoring wells in the immediate area surrounding the RA V recharge basin that are monitored for tritium as part of the HFBR Tritium monitoring program (**Figure 1-2**). Until September 29, 2000, this basin also received approximately 125 gpm of effluent from the OU III HFBR Tritium Pump & Recharge system, which contributed to the total tritium concentration being recharged. These wells are used to monitor water quality and water levels to assess the impact of the recharge basin on the aquifer. **Appendix C** (located on the enclosed CD-ROM) contains the data for these wells. All tritium detections were below 1,000 pCi/L during 2003. The highest detection of tritium was 794 pCi/L in well 76-171. Beginning November 1, 2001 the RA V recharge basin began receiving 650 gpm of treated groundwater from the 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 their further migration across the site's southern boundary. No permit equivalencies 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 for this system resulting from 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. 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 reveals that there have been no significant increases in VOC concentrations during 2003; thus, we conclude that the plume has not grown and continues to be controlled.

Groundwater elevation data is obtained from many of the OU I south boundary monitoring program wells. Groundwater contour maps were generated from these data (**Figures 2-4** and **2-5**). The capture zone for the OU I South Boundary Pump and Treat System is indicated in **Figure 3.0-1**. The capture zone depicted is inclusive of 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 modeled in 2002 (BNL 2003) and the system continues to be effective in removing VOCs from the deep Upper Glacial aquifer. However, the aquifer is not being restored at the planned rate.

As reported in the 2002 BNL Groundwater Status Report (BNL 2003), modeling performed during the initial design of the system was updated. The revised model indicates that, while capture has been maintained, there are two areas of persistent contamination. The groundwater located at well 98-59 continues to show elevated levels of VOCs not predicted in the Camp Dresser & McKee (CDM) model (1995, 1996). Also, even though the Current Landfill is capped, it remains a weak source of contamination. TVOC levels as high as 104 µg/L were detected at its downgradient edge during 2003. Concentrations in groundwater are declining in this area; however, it will take several more years to fully flush out the contaminants in the lower vadose zone beneath the landfill cap. The differences in the CDM model and the 2002 model in the area of well 98-59 are primarily due to the use of more accurate horizontal and vertical hydraulic conductivity values and retardation factors in the 2002 model that were not available in 1995 and 1996.

The updated model (without dispersion) predicts that 22 years of additional treatment (27 years of total treatment) with the existing system will be required to capture the contamination trapped in the Upton Unit (near well 98-59). The CDM model predicted that the system would only need to run for 7 to 14 years before cleanup goals were achieved.

The addition of a new extraction well in the area of 98-59 would greatly reduce the time necessary to reach the clean-up goals of this system. With the installation of a new extraction well, the model predicts that only four additional years of treatment (9 years of total treatment) would be needed to reach cleanup goals.

The updated model also looked at a third option. If the existing pump and treat system were to cease after 10 years of treatment (2007), the model predicts that 20 years of natural attenuation (2027) will reduce the peak concentration of TVOC to about 38 µg/L. The model predicts this peak concentration would still be located within the BNL property boundary. Based on these model predictions, it is reasonably possible that 10 years of operation of the existing system combined with 20 years of Monitored Natural Attenuation (MNA) could achieve the cleanup goals. A more detailed engineering study should be performed to assess life-cycle economics compared with other options discussed above.

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. Asymptotic conditions of target TVOCs in plume core wells can indicate that the practical limits of treatment have been reached. The average TVOC concentrations continue to decline however, a number of individual wells continue to exceed groundwater standards. The Mann-Kendall statistical test also shows a continuing decreasing trend. **Figure 3.1-12** plots the mean concentration of each plume core well computed from measurements since 1997. Kendall-Mann is a nonparametric trend analysis (Gilbert, 1987) used to aid in determining the slope in groundwater quality data. It is particularly useful when the residuals from a regression analysis are not normally distributed, or for an unknown distribution. Aquifer cleanup continues to be demonstrated based on the continued decreasing slope to the trend of average TVOC concentrations in plume core wells. Changes in the makeup of the plume are shown in **Figure 3.1-13**, 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 presently less than 50 µg/L and showing a decreasing trend (**Figure 3.1.-12**).

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

One of ten plume core wells continues to have TVOC concentrations exceeding 50 µg/L. This is well 98-59 located in the hot spot south of the former HWMF.

4d. During pulsed operation of the system, is there significant concentration rebound in the 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 by 2030?

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

3.1.9 Recommendations

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

- A baseline of over six years of groundwater data has been obtained from many of the OU I South Boundary Program wells, and it has been demonstrated that the system is functioning as planned. The routine operation and maintenance monitoring frequency implemented in the 4th quarter of 2003 should be maintained. Plume core and perimeter wells are monitored on a semi-annual frequency. Sentinel, and bypass wells are sampled at a quarterly frequency.

- Update the model and complete an engineering study in 2004 to evaluate the life-cycle economics of the following options:

    - Evaluate the continued operation of the treatment system.
    - Evaluate the installation of a third extraction well near well 98-59.
    - Evaluate monitored natural attenuation.

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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), and includes Building 96, Building 208, the Alternating Gradient Synchrotron (AGS) area, 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, tetrachloroethylene (PCE), and Carbon Tetrachloride. The primary OU III VOCs detected in on-site monitoring wells include Carbon Tetrachloride, TCA, and PCE. Carbon Tetrachloride and PCE are the main contaminants detected in off-site groundwater.

The OU III VOC plume extends from the AGS/Waste Concentration Facility (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 50 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. Onsite portions of the plume displaying the highest VOC concentrations during 2003 were south of Building 96, with TVOC concentrations up to 1,312 μg/L, continuing south to the Middle Road with TVOC concentrations of 1,997 μg/L, and the south boundary with TVOC concentrations up to 857 μg/L. TVOC levels range up to 772 μg/L (primarily Carbon Tetrachloride and PCE) 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 2003 is provided in **Figure 3.2-4**.

Sections 3.2.1 through 3.2.6 summarize and evaluate the groundwater monitoring and system operations data for the OU III operational groundwater treatment systems. Sections 3.2.7 through 3.2.14 summarize the various OU III groundwater-monitoring programs for areas not currently addressed by groundwater treatment systems (i.e., North Street, Long Island Power Authority (LIPA)/Airport etc.).

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3.2.1 Carbon Tetrachloride Pump and Treat System

A report entitled *Petition To Shut Down, OU III Carbon Tetrachloride Treatment System* (BNL, April 2004) is included as **Appendix I**. This report demonstrates that the goals for this system outlined in both the OU III ROD and Carbon Tetrachloride OU III *Final Action Memorandum Carbon Tetrachloride Tank Groundwater Removal Action* (BNL, January 1999) have been satisfied. An analysis of the treatment system and monitoring data for 2003 is included in Appendix I. The complete groundwater monitoring program analytical results are included in **Appendix C**.

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3.2.2 Building 96 Air Stripping System

This section summarizes the 2003 operational data from the OU III Building 96 source control system, which consists of recirculation wells with air stripping treatment, and presents conclusions and recommendations for future operation. The system began operation in February 2001. This summary is prepared annually and presents the operational data from January 1 through December 31, 2003. The analytical information from monitoring wells and characterization work is evaluated in detail.

3.2.2.1 System Description

The Building 96 groundwater treatment system consists of four recirculation treatment wells (RTW-1 through RTW-4) housed in individual treatment sheds. Construction details for the treatment system components are contained in as-built drawings. The wells used in the system are referred to as recirculation treatment wells because water is withdrawn from, and recharged to, the aquifer in the same well. Contaminated groundwater is drawn from the aquifer via a submersible well pump positioned in a lower well screen that is set near the base of the contaminant plume. The groundwater hen 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..

An additional feature of the recirculation well technology, and the reason it was chosen for the Building 96 area, is its relatively small, localized impact on aquifer hydraulic heads. Groundwater is returned to the aquifer in the same well, creating a zone of influence around the well without generating a large drawdown that may impact local groundwater flow. Further, since groundwater is returned to the aquifer through the same well just above the point of extraction, there are no large mounding effects that typically occur from discharges to standard recharge basins.

The Building 96 system removes contaminants, from the groundwater (liquid phase) to the vapor phase via air stripping in a low profile stripping tray adjacent to each wellhead inside the treatment sheds. The vapor phase contaminants are then passed through a moisture-knockout drum in each treatment shed, and piped to Treatment Shed No.3 where the contaminated vapor streams from the four treatment sheds are combined in a common pipe manifold. The combined VOC contaminated vapor stream is passed through an electric reheat coil (duct heater) to lower relative humidity, and then through a series of Granular Activated Carbon (GAC) filters to remove VOCs. The clean air is discharged to the atmosphere.

Treatment Well RTW-1 is located in the northern most treatment shed in the area having highest concentrations of VOCs in groundwater. Treatment Wells RTW-2, 3 and 4 are located farther south (hydraulically downgradient), in an east-west line to intercept, capture and treat the groundwater plume moving south from the vicinity of RTW-1.

Recirculation Treatment Wells

The major component of the groundwater treatment system is the four recirculation treatment wells (RTW). RTW-1 is located in the area containing the highest VOC concentrations in the Building 96 area and the other three wells, RTW-2 through RTW-4 (from west to east), provide hydraulic control of the VOC plume. **Figure 3.2.2-1** shows the RTW locations.

The groundwater recirculation wells provide hydraulic control and create a re-circulation cell. A portion of the treated groundwater circulates through the cell and back into the extraction screen, while the balance flows to the south in the direction of regional flow. Recirculation is not necessary because the air stripping treatment achieves MCLs. The degree of re-circulation and therefore, the extent of the capture zone, are influenced by the well pumping rate, the distance between the extraction and recharge screens, and the hydraulic parameters of the aquifer. Of these, only the pumping rate can be controlled during system operation.

Each treatment well is 8-inches in diameter with two separate 10-foot long, 304 stainless steel screens. The wells are constructed with a minimum three-inch filter pack. An inflatable packer separates the two well screens; it is inflated through an airline that runs to the wellhead and is fitted with a pressure gauge. The submersible pump is located below the packer to draw water in from the lower screen.

Groundwater is extracted at each treatment well utilizing stainless steel submersible pumps operating on a 208 volt, 3-phase power supply. RTW-1 was designed to operate at a flow of 30 gpm while wells RTW-2, 3 and 4 were designed to operate at 20 gpm. Therefore, the pump at RTW-1 is rated at 1 hp while the pumps for RTW-2 3 and 4 are rated at ¾ hp. The flow rate at each RTW can be controlled from within the treatment sheds by adjusting the butterfly throttling valves. Discharge piping is 2 inches in diameter at RTW-1 and 1-1/2 inches at RTW-2, 3 and 4. **Table 3.2.2-1** shows the depths of the recirculation wells and pump settings.

Table 3.2.2-1. OU III Building 96 Recirculation Well Construction Data

Well	Well Depth (bls)	Influent Screen Depth (bls)	Effluent Screen Depth (bls)	Pump Intake Setting (bls)
RTW-1	61	48-58	25-35	52
RTW-2	61	48-58	25-35	52
RTW-3	61	48-58	25-35	52
RTW-4	61	48-58	25-35	52

bls = below land surface.

Air Treatment Facility

Several components comprise the air treatment system. Air lines run below grade from each treatment shed to Treatment Shed No. 3 carrying VOC laden air. Each air line joins to a common pipe header, which is connected to a duct heater. After the air passes through the duct heater it flows through two vapor phase GAC filter vessels, piped in series, before it is released.

Adjusting the blower effluent damper at the individual treatment sheds, or by adjusting the gear operated butterfly valves in Treatment Shed No. 3 can control the airflow to the stripping tray at each well. The air pipe and valve configuration enables increased airflow to wells exhibiting higher VOC concentrations, which results in higher removal efficiencies. Airflow meters are located on the influent line to each blower, with a fifth airflow meter located on the discharge line from the GAC filter vessels. After the stripping tray, air piping is connected to a knockout drum inside each treatment shed to collect moisture. After the knockout drum, the air piping runs below grade and travels to Treatment Shed No. 3 where it connects to a common header, before passing through the duct heater.

Condensate may accumulate in the below grade air lines and condensate pumps are employed to remove standing water. The pumps are installed in the air lines prior to the duct heater and are located in Treatment Shed No. 3. This system removes condensate from the air lines, allowing for unobstructed airflow from Treatment Sheds No. 1, 2, and 4. The pumps are operated by an adjustable timer and can also be triggered manually. Condensate removed from the air lines is pumped into the top of the RTW-3 air stripper tray for treatment and subsequent recharge.

The duct heater air dehumidification system is self-controlling. This system lowers the relative humidity by heating the air prior to entering the GAC vessels. This lowering of the relative humidity of the air is necessary to prolong the life of the GAC bed and to minimize the pressure loss through the filters. When the relative humidity of the air "down stream" of the duct heater rises above an adjustable set point, the heater control panel will increase the output of the heating element, so long as the temperature remains below the emergency high temperature setting. The set point should be adjusted to a minimum temperature of approximately 30 degrees above the ambient air temperature for proper dehumidification.

Air leaves the duct heater and travels through two vapor phase GAC filter vessels, piped in series, to remove VOCs from the air stream. Each filter vessel contains 13,600 pounds (lbs) of GAC. The GAC filters are located outside of Treatment Shed No. 3.

3.2.2.2 Groundwater Monitoring

Well Network: The monitoring network of 21 wells was designed to monitor the VOC plume originating from this source area, and the effectiveness of the groundwater remediation system (**Figure 1-2**).

Sampling Frequency and Analysis: The wells are sampled quarterly, and samples are analyzed for VOCs (see **Table 1-6**).

3.2.2.3 Monitoring Well Results

Complete VOC results are provided in **Appendix C** (located on the accompanying CD-ROM). VOC concentrations exceeding NYS AWQS during 2003 are summarized in **Table 3.2.2-2**.

The fourth quarter 2003 plume is shown on **Figure 3.2.2-1**. The 2002-2003 geoprobe characterization data was also considered in determining the 2003 plume contours. VOC trends are summarized in **Figure 3.2.2-2**. A cross section (D-D') is provided as **Figure 3.2.2-3**.

3.2.2.3.1 Installation of New Monitoring Wells

Four (4) additional monitoring wells (085-335, 095-294, 095-295, 095-296) were installed during 2003 to assist in monitoring VOC concentrations north and west of the existing system. The locations are shown on **Figure 1-2.**

3.2.2.4 Systems 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 GAC units and demonstrate when a carbon change-out is required. Air sampling results are included in **Table F-6** in **Appendix F**.

Influent and effluent water samples are collected monthly from each of the four re-circulation wells; all samples are 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.

System Operations

The following summarizes the system's operations for 2003. BNL's EWMSD performs daily checks on the system and undertakes system sampling. BNL's PE Division carries out routine and non-routine maintenance. Details of these activities are given in the system's operation and maintenance manual. The daily operations and maintenance logs are available in the project files.

January-September 2003:

The influent concentrations observed in wells RTW-2 and RTW-4 decreased to levels below the NYS AWQS. Concentrations observed in RTW-3 had shown a significant decrease and were averaging less than 10 µg/L. However, concentrations in RTW-1, the most upgradient well, had leveled off at approximately 50 µg/L TVOC's.

Based upon the reduction of influent VOC concentrations, the system was deactivated on May 18, 2003 to begin Pulse Pumping Operation, as described in *BNL Modification OU III Bldg. 96-05* (BNL 2003). A pulse pumping cycle consisted of deactivation of the system for a period of 6 weeks, followed by operation for a period two weeks. After only two complete Pulse cycles, a significant rebound of VOC concentrations was observed in RTW-1 and several monitoring wells. Therefore, on September 15, 2003 the system was placed back into full-time operation.

October 2003:

The system was down between October 18th and the 21st due to a power interruption. Influent and effluent water and air samples from the treatment system were collected on September 29, 2003. The effluent air samples were much lower than the DAR-1 Air Toxics Assessment limits. Effluent water samples were at or lower than one half the DWS or non-detectable. The average system flow rate for October 2003 was approximately 84 gpm.

November 2003:

Treatment well RTW-2 went off-line during the second week in November due to a pump/motor problem. Influent and effluent water samples from the treatment system were collected on November 1, 2003. Effluent water samples were at or lower than one half the DWS or non-detectable. The average system flow rate for November 2003 was approximately 64 gpm.

December 2003:

The system was down from December 5th through the 12th, and the 14th through the 15th, due to airflow faults caused by significant snow/ice accumulations. Influent and effluent water samples from the treatment system were collected on December 1, 2003. Effluent water samples were at or lower than one half the DWS or non-detectable. The average flow rate for December 2003 was approximately 62 gpm.

During 2003, approximately 29 million gallons of groundwater were pumped and treated by the Building 96 system.

3.2.2.5 Systems Operational Data

Re-circulation Well Influent and Effluent

Table F-7 in **Appendix F** lists the influent and effluent TVOC concentrations for each of the four re-circulation wells.

Throughout 2003, effluent concentrations in all re-circulation wells were, at or below, one half the DWS, or non-detectable.

Cumulative Mass Removal

Mass-balance calculations were made to determine the mass of VOCs removed from the aquifer by the pumping wells, during this period of operation. 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-8** in **Appendix F**. During 2003 the treatment system removed approximately 9.25 pounds of VOCs. To date, the system removed approximately 55 pounds of VOCs. **Figure 3.2.2-4** plots the total pounds of TVOCs removed vs. time.

Air Treatment System

Air samples were collected monthly from the GAC vessels before treatment (influent), between the two vessels (mid-point), and after the second vessel (effluent). The findings are utilized to monitor the efficiency of the GAC units and to determine when a carbon change-out is required (**Table F-6** in **Appendix F**). Airflow rates, measured for each air-stripping unit inside the treatment building, show that they typically range between 250 and 450 cfm for each of the four wells. Assuming a total airflow rate of 1200 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.

Although the concentrations in the GAC air effluent have been well within the DAR-1 Toxics Assessment, the presence in the midpoint and effluent of benzene compounds not present in the influent or the groundwater is a concern. As long as the concentrations remain 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 9.25 pounds of VOCs during 2003. Discharge concentrations to the aquifer have been non-detected or up to one-half the DWS. Twenty nine (29) million gallons of groundwater were treated during the year.

Based on data from the permanent monitoring well network, significant concentrations of VOCs remain upgradient of the existing system. A plot of average plume core monitoring wells over time is shown in **Figure 3.2.2-5**.

Figure 3.2.2-4 shows the actual removal of VOC mass over time versus the model predictions. Source remediation, as measured by mass removal, is on going. However, a continuing source of VOCs remains in the saturated silty zone upgradient of the existing system. The presence of a continuous source area was not included in the assumptions made during the design of the system. But a continuing source was identified as a possible future issue.

The change in the plume distribution from 2000 to 2003 is shown in **Figure 3.2.2-6**. Concentrations throughout the southern extent of the plume have declined significantly since the pre-design characterization. This is attributable to the operation of the system. However, according to the permanent monitoring well data, a portion of the aquifer upgradient of RTW-1, in the saturated silty layer, continues to show high VOC concentrations up to 2,025 µg/L in well 085-335 (January 2004).

Building 96 Assessment

- **Figure 3.2.2-4** is a model predicted cumulative mass removal curve for the Building 96 system resulting from pumping the wells through the end of 2007 under the existing pumping scheme. This modeling projection suggested that the RTW–2, RTW-3 and RTW-4 would reach a very low and asymptotic contaminant removal rate by the end of 2003. This has in fact occurred based on the 2003 monitoring well data.

- Monitoring well data in the vicinity of RTW-1 shows little reduction in aquifer contamination concentration. According to the AG&M modeling (AGM 1999), assuming a non-continuing source scenario, the concentration in the RTW-1 area was predicted to be less than 2,000 µg/L TVOC after one year of operation. After 3 years of operation the measured concentrations in the RTW-1 area are as high as 3,718 µg/L TVOC (in Geoprobe well 85-313), which was screened near the shallow silt layer thought to contain a residual source of VOCs. Permanent monitoring well data from this zone shows elevated VOC concentrations up to 2,025 µg/L (January 2004). This verifies a continuing source upgradient of RTW-1. An evaluation will be performed in FY04 to assess its significance, and to assure it presents no significant risk to the OU III cleanup goal.

- The monitoring data continue to show a "crescent" pattern of contamination in the RTW-1 area, with the largest prong of contamination in a southwest direction. This pattern is generally consistent with the AG&M (1999) predictions, and concentrations have declined significantly during 2003. The only exception to this general pattern is a detection of 585 µg/L in well 095-161 in the eastern lobe of the plume in the fourth quarter. VOC concentrations in this well had been non-detect since 2001, and returned to non-detect in January 2004.

- There is a question that the nearby carbon tetrachloride extraction well EW-15 may capture this contamination in the southwest prong. Modeling performed as part of the 2002 Annual report predicts that EW-15 in the carbon tetrachloride treatment system will not capture the southwest prong of contamination from the RTW-1 area. Additional evaluation of the potential impact of well EW-15 is being performed. Continued monitoring will also be performed. As discussed in the 2002 Annual Report this contamination will not be treated by RTW-2, 3, or 4 but is expected to travel to the OU III Middle Road system where it will be captured in about 2014.

- RTW-1, 2, 3, and 4 ended the pulsed operation period on September 15, 2003 and were pumped at their design rates for the remainder of 2003.

The performance of the OU III Building 96 Air Stripping system can be evaluated based on three major decisions identified for this system after applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual detections of PCE, 1,1,1-TCA or any other contaminants in wells associated with this monitoring network during 2003 that would have triggered the BNL Groundwater Contingency Plan.

2. Have the source control objectives been met?

The plan for this system is to remove approximately 57 pounds of VOCs, and 46 have been removed to date. **Figure 3.2.2-4** shows the actual removal of VOC mass over time versus the model predictions. Source remediation, as measured by mass removal, is continuing as predicted except for the effects of the silty zone. The change in the plume distribution from 2000 to 2003 is shown in **Figure 3.2.2-6**.

Concentrations throughout most of the plume have declined significantly since the pre-design characterization. This is attributable to the operation of the system. The average concentration of TVOCs in plume core wells over time is shown in **Figure 3.2.2-5**. However, according to the Geoprobe data, a portion of the aquifer upgradient of RTW-1, in the silty layer, continues to show elevated VOC concentrations up to 3,718 µg/L. Permanent monitoring well data from this zone shows elevated VOC concentrations up to 2,025 µg/L (January 2004). Concentrations in the western lobe monitoring wells have declined significantly since 2002 due to downgradient migration of the contaminants. This contamination will not be treated by RTW-2, 3, or 4 but is expected to travel to the OU III Middle Road system where it will be captured in about 2014**.** The pulse of contamination in eastern well 095-161 detected in the fourth quarter is expected to migrate to the vicinity of RTWs –2, –3, and –4 by late 2004.

3. Have asymptotic conditions been met?

Yes. Based on the Mann-Kendall test (**Figure 3.2.2-5**), asymptotic conditions have been met for the mean TVOC concentrations in core wells. The Mann-Kendall test was performed on the last 18 months of data based on the time required for contamination to reach the extraction wells from the source area.

3.2.2.7 Recommendations

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

- Monitoring wells will continue to be monitored at a quarterly frequency over the next year. In addition, the three down gradient extraction wells (RTWs -2, -3, and –4) will be monitored monthly even if they are placed in standby mode.

- The system will continue to operate as designed until an engineering evaluation can be performed during 2004.

- An engineering study of treatment technologies will be performed during 2004 to address the silty zone continuing source. The Building 96 operations and maintenance manual will be modified according to the results of the study. Treatment technologies such as enhanced bioremediation, chemical oxidation, silty layer excavation, soil washing, additional pumping wells, among others were screened for applicability. The proposed remedy resulting from the screening process is chemical oxidation by *in situ* permanganate addition to completely oxidize the VOC contaminants. Pilot testing to determine the appropriate amount of permanganate and the best delivery method is also recommended. In addition, the evaluation recommends placing RTWs -2, -3, and -4 in standby mode while continuing to operate RTW -1 at its design rate to provide hydraulic control of the source area during treatment. If concentrations in wells RTW 2, 3, and 4 show a significant increase in VOCs, they will return to operational mode. The final evaluation report will be provided under a separate cover.

- Up to 5 geoprobes will be installed in 2004 to verify the extent of the eastern and western prongs of the plume.

3.2.3 Middle Road Pump and Treat System

The Middle Road system began operating on October 23, 2001. This section summarizes the operational data from the Middle Road groundwater pump and treat system for 2003, and presents conclusions and recommendations for future operation. The analytical data from the monitoring wells also is evaluated in detail. In addition, a monthly DMR is submitted to EPA and NYSDEC for treated effluent water from the air-stripping tower.

3.2.3.1 System Description

Recovery Wells

Six groundwater extraction wells, RW-1 through RW-6, hydraulically control the VOC plume (**Figure 3.2.3-1**). Groundwater currently is extracted at an average flow rate of approximately 600 gpm, although rates vary during the system's life, based on operational monitoring data. Each well is 8-inches in diameter with a 30 to 40 foot long, 304 stainless-steel screen, and a minimum 3-in. filter pack surrounding it. The slot sizes for each well screen vary from 10 to 20 slot, based on the results of sieve analyses from the Pre-Design Characterization. The wells vary in depth from 130 to 268 feet.

VOC concentrations in groundwater along BNL's Middle Path are stratified vertically and horizontally. The six recovery wells are screened at the depths showing the highest VOC concentrations. The pipe and valve configuration enables pumping rates to be increased at wells exhibiting higher VOC concentrations, and recovery wells to be added, if required. Beginning in October 2003, the extraction well sampling schedule was reduced from a monthly to a quarterly basis. In addition, on September 30, 2003, extraction wells RW-4 and RW-5 were placed in the stand-by mode due to low concentrations of VOCs.

Groundwater is extracted utilizing stainless-steel submersible pumps operating on a 480 volt, 3-phase power supply. The pumps have check valves at the discharge. The discharge piping is 4-inch carbon steel pipe up to a pit-less adapter, and then 4-inch PVC piping to the well house. **Table 3.2.3-1** shows the depths of the extraction wells and the pump settings.

Table 3.2.3-1. Middle Road Extraction Well Construction Data

Well #, (Site Id)	Screen Interval (Feet below grade)	Pump Setting (Feet)
RW-1, (113-23)	90-130	110
RW-2, (113-24)	170-200	185
RW-3, (113-25)	228-268	248
RW-4, (113-26)	150-180	165
RW-5, (113-27)	150-180	165
RW-6, (106-66)	188-218	205

Well House

The well house is situated along Middle Path in the center of the southern portion of the site to the west of the recovery wells. Each of the six pump discharge lines is reduced from 4-inch to 3-inch diameter just before it enters the well house. Inside the well house, each pump discharge line contains a gate valve to isolate the line, a propeller-type flow meter, a check valve, and a butterfly valve to control flow. High and low-level pressure switches and a sampling port also are located on each line before the gate valve. After the butterfly valve, the piping manifolds into a 10-inch discharge line that conveys the water to the treatment facility.

Treatment Facility

The groundwater treatment facility consists of a treatment control building and an air- stripping tower system, and is located just northwest of Rochester Street and Princeton Avenue. The facility is designed for limited automatic operation, defined as automatic equipment shutdown with manual restart. Any alarm condition will signal a common trouble alarm at BNL's Central Chilled Water Facility requiring a physical inspection of the main control panel to determine the source of the alarm. The treatment building also houses a 150-gallon riser drain tank used to temporarily capture drained water from the tower's influent line if the air-stripping tower is shut down during cold weather. Two re-injection pumps send the drained water back into the stripping tower's influent line when the system is placed back in operation.

Air-Stripping Tower

The packed air-stripping tower removes VOCs from the groundwater to meet the discharge criteria. The stripping tower is 6 feet in diameter and 52 feet tall. It is equipped with a minimum of 39 feet of 2-inch plastic packing, configured in two separate beds. The tower's internals include five influent spray nozzles, water distribution trays for the two media beds, packing support/air distributor for the two media beds, a mist eliminator, screened air exit, and water redistribution rings. The 39-foot height of the packing media is based on the requirements to remove TCA. The efficiency of removing other VOCs of interest is greater than the required minimum, and effluent concentrations are lower than NYSDEC permitted levels. A centrifugal blower supplies air to the tower at an average flow rate of 3,200 cfm, providing an air to water ratio of 34:1 at the maximum water flow rate of 700 gpm.

Recharge Basin

The water discharged from the air-stripping tower flows by gravity through 10-inch diameter PVC piping to either of two recharge basins. A buried house trap in the piping has a 30-inch water seal to prevent air, under pressure in the stripping tower, from discharging through this line. The discharge piping splits to convey the water to either the OU III recharge basin, or to the existing HP recharge basin. A gate valve in the line to each basin controls the flow to the basin.

The OU III basin can receive a continuous flow of greater than 850 gpm; this figure includes a sufficient factor of safety to account for variations in subsurface soil and fouling of the basin over time. The existing HP recharge basin provides backup for the discharge facilities during maintenance of the primary OU III basin.

A new discharge pump station was constructed to distribute the flow of water into both the OU III and RA V recharge basins. The pump station balances the flow between the two basins, therefore managing the flow of groundwater recharge.

3.2.3.2 Groundwater Monitoring

<u>Well Network</u>: The Middle Road Monitoring Program consists of a network of 23 monitoring wells located along the road between the Princeton Avenue fire break road and the OU III South Boundary Pump and Treat System (**Figure 1-2**). The wells are designated as follows:

- Plume Core – utilized to monitor the high concentration or core area of the plume. In addition, plume core wells will be used to provide data for measuring the performance of the system.

- Plume Perimeter – used to define the extent of the plume both horizontally and vertically.
- Bypass Detection –used to determine whether the plume capture performance objective is met.

Sampling Frequency and Analysis: The 23 Middle Road wells are monitored and the samples are analyzed for VOCs. Nine of the wells are sampled quarterly, and the remainder are sampled semi-annually. Several wells that also are part of the OU III HFBR Tritium Monitoring Program are also monitored for tritium (**Table 1-6**).

3.2.3.3 Monitoring Well Results

The complete VOC results are shown in **Appendix C** (located on the enclosed CD-ROM). VOC results exceeding the NYS AWQS are summarized in **Table 3.2.3-2**.

The highest plume concentrations are found in the vicinity of extraction wells RW-2 and RW-3, based on influent data for these wells and available monitoring well data. 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 1,997 µg/L. VOC concentrations have been declining throughout 2003 (**Figure 3.2.3-2**). 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 located approximately 2,000 feet upgradient of RW-1 near Princeton Avenue TVOC concentrations have decreased from 1,794 µg/L during 2001, to a low of 258.1 µg/L in the first quarter of 2003 (**Figure 3.2.3-2)**.

- TVOC concentrations in plume core wells further to the east along Princeton Avenue were generally below 100 µg/L in 2003. TVOC concentrations decreased in well 105-44 from 423 µg/L in 2001 to 20 µg/L in the fourth quarter of 2003 (**Figure 3.2.3-2)**.

Figure 3.2.3-3 shows the vertical distribution of contamination running along an east-west line through the extraction wells; the location of this cross section (E-E') 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 Systems 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 3.2.3-3**).

Beginning in October 2003, the extraction well sampling schedule was reduced from a monthly to a quarterly basis. In addition, on September 30, 2003, extraction wells RW-4 and RW-5 were placed in stand-by mode due to low concentrations of VOCs. All samples were analyzed for VOCs by EPA method 524.2.

Table 3.2.3-3. SPDES Equivalency Permit Levels January 1 - December 31, 2003
OU III Middle Road Air Stripping Tower

Parameters	Permit Limit (μg/L)*	Max. Observed Value (μg/L)
pH (range)	6.5 - 8.5	6.3 - 8.18
Carbon Tetrachloride	5.0	ND
Chloroform	7.0	ND
1,1-Dichloroethane	5.0	ND
1,2-Dichloroethane	5.0	0.26 J
1,1-Dichloroethylene	5.0	ND
cis-1,2-Dichloroethylene	5.0	ND
trans-1,2-Dichloroethylene	5.0	ND
Tetrachloroethylene	5.0	ND
1,1,1-Trichloroethane	5.0	ND
Trichloroethylene	5.0	ND
1,2-Xylene	5.0	ND
Sum of 1,3 & 1,4 Xylenes	10.0	ND

***Maximum effluent allowed by Requirements Equivalent to a SPDES Permit.**
J = Estimated value below the method detection limit.
ND = Not detected above method detection limit of 0.50 μg/L.

System Operations

The following summarizes the systems operations for 2003. BNL's PE Division performs nonroutine maintenance and repairs and made routine maintenance checks on this system. The historical Operating Parameters Data Sheets are available in the system project files while the current month's data can be found in the treatment system buildings. The following paragraphs summarize the Middle Road System operations for 2003.

January –September 2003:

Due to the failure of the electrical starter, extraction well RW-4 was off-line from June 26th through July 9th. As a result of the Northeast Blackout the system was off-line from August 14th through the 27th, due to failure of the control panel.

Extraction well RW-2 was off-line between June 28th and July 10th due to a faulty pressure switch.

October 2003:

The system pumped and treated approximately 20 million gallons of water in October. The average flow rate for the system was 437 gpm. Influent and effluent waters to the treatment system were sampled on October 1st, and the effluent met all SPDES equivalency permit requirements.

November 2003:

The Middle Road system pumped and treated approximately 18 million gallons of water in November. The average flow rate for the system was 408 gpm. Influent and effluent waters to the treatment system were sampled on November 3rd, and the effluent concentrations met all equivalency permit requirements.

December 2003:

Approximately 14 million gallons of water were pumped and treated in December. The average flow rate for the system was 323 gpm. The influent and effluent waters to the treatment system were sampled on December 1st, and the effluent concentrations met all equivalency permit requirements.

Approximately 278 million gallons of water were pumped and treated in 2003 by the OU III Middle Road System.

3.2.3.5 Systems Operational Data

System Influent and Effluent

All parameters in the SPDES equivalency permit limits were within the specified ranges during 2003. The effluent data were either below the method detection limit, or below the regulatory limit specified in the equivalency permit.

Figure 3.2.3-4 plots the concentrations of TVOC, TCA, and PCE in the influent to the system's air-stripper tower vs. time. The influent's overall water quality showed an increase in VOC concentrations over the reporting period, particularly during the fourth quarter. The increase in the fourth quarter is due to shutting down wells RW-4 and RW-5. The average TVOC concentration in the influent during 2003 was 66.23 µg/L (see **Table F-9, Appendix F**). The system influent was also sampled for tritium. Tritium was not detected above the reporting limit in any sample during 2003. The results from sampling the influent and effluent are summarized in **Tables F-9** and **F-10**, 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 545 gpm during 2003 (**Table 2-3,** and **Table F-11**). The cumulative total of VOCs removed was approximately 365 pounds since the system began start-up testing on October 23, 2001. The cumulative total of TVOCs removed vs. time is plotted in **Figure 3.2.3-5**. For 2003, the a total of 147 pounds of VOCs were removed.

Air Discharge

Table 3.2.3-4, below, shows the air-emission data from the system for the OU III Middle Road tower over 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-12**). The concentration of each constituent was averaged for 2003, and those values were used in determining the emission rate. All air emissions were below allowable levels.

Table 3.2.3-4. Air Emission Rates January 1, 2003 - December 31, 2003

Parameter	**Allowable ERP***	**Actual*** **
Carbon Tetrachloride	**0.022 lb/hr**	**0.0011 lb/hr**
Chloroform	**0.0031 lb/hr**	**0.0002 lb/hr**
1,1 - Dichloroethane	**10 lb/hr****	**0.0000 lb/hr**
1,2 - Dichloroethane	**0.008 lb/hr**	**0.0000 lb/hr**
1,1 - Dichloroethylene	**0.034 lb/hr**	**0.0003 lb/hr**
cis-1,2-Dichloroethylene	**10 lb/hr****	**0.0002 lb/hr**
Trans-1,2-Dichloroethene	**10 lb/hr****	**0.0000 lb/hr**
Tetrachloroethylene	**0.387 lb/hr**	**0.0146 lb/hr**
1,1,1 - Trichloroethane	**10 lb/hr****	**0.0012 lb/hr**
Trichloroethylene	**0.143 lb/hr**	**0.0004 lb/hr**

*** ERP based upon NYSDEC Air Guide 1 Regulations.**
**** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls.**
***** Actual Emission Rate reported as the average rate for January 1 through December 31, 2002.**

Extraction Wells

Beginning in October 2003, the extraction well sampling schedule was reduced from a monthly to a quarterly basis. In addition, on September 30, 2003, extraction wells RW-4 and RW-5 were shutdown and placed on stand-by due to low concentrations of VOCs. All samples are analyzed for VOCs by EPA method 524.2.

Decreasing VOC concentrations were observed in four of the six extraction wells. (**Table F-13**, **Appendix F**). RW-1 showed a slight increase in VOC concentrations while the concentrations in RW-2 remained relatively constant. During 2003, the highest TVOC concentration was 339 µg/L in RW-2. Historically, the highest concentrations have been observed in RW-1 and RW-2 on the western portion of the plume.

3.2.3.6 System Evaluation

The system has been in operation since October 24, 2001. Groundwater level mapping indicates that the system is creating a cone of depression that is consistent with the design estimates. Hence, it can be inferred 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 2003.

2.Has the plume been controlled?

Yes. VOC concentrations in plume perimeter wells remained stable at low concentrations during 2003 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 2-4** and **2-5**). The capture zone for the OU III Middle Road System is depicted in **Figure 3.0-1**. The capture zone is inclusive of 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 system is operating as planned based on the mass removal of VOCs. Monitoring wells began showing decreasing concentration trends during 2002, and this trend continued in 2003.

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 due to this system is still in the early stages. Mann-Kendall tests were not performed at this time. Monitoring and extraction wells began showing 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, see question 4a.

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

Three of the fourteen 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? Specifically, have MCLs been achieved (expected by 2030)?

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

3.2.3.7 Recommendations

The following is the recommendation for the OU III Middle Road Pump and Treat System and groundwater monitoring program:

- A baseline of over six years of groundwater data has been obtained from many of the OU III Middle Road Program wells. A routine operation and maintenance monitoring frequency was implemented in August 2003 and should be maintained for 2004.

- Extraction wells RW-4 and RW-5 will continue in standby mode during 2004. The wells will be restarted should extraction well or monitoring well data indicate that VOC concentrations are showing significant rebound.

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 2003, and gives conclusions and recommendations for future operation. This system began operation June 17, 1997. The analytical information from monitoring wells is evaluated in detail. In addition to this report, a monthly DMR is submitted to the EPA and NYSDEC for treated effluent water from the air-stripping tower.

3.2.4.1 System Description

Recovery Wells

Seven groundwater extraction wells, EW-3 through EW-8 and EW-12, hydraulically control of the VOC plume (**Figure 3.2.4-1**). EW-12 began operation in December 1999. Groundwater is currently extracted at a total maximum flow rate of about 650 gpm. The actual rates vary during the extraction systems life, based on operational monitoring data. Each well is 8-inches in diameter with a 30 to 40 foot long, 20 slot, 304 stainless-steel screen, and they vary in depth from 190 to 250 feet.

VOC concentrations in groundwater along the site's southern property line are stratified vertically and horizontally. The seven recovery wells are screened at the depths showing the highest VOC concentrations. The pipe and valve configuration will enable pumping rates to be increased at wells exhibiting higher VOC concentrations, and recovery wells to be added, if required in the future. The extraction wells are sampled quarterly.

Groundwater is extracted by stainless-steel submersible pumps operating on a 480 volt, 3-phase power supply. The pumps have check valves at the discharge. The discharge piping is 3-inch carbon steel pipe up to a pitless adapter, and then 4-inch PVC piping to the well house. The depths of the extraction wells, and pump settings, are shown in **Table 3.2.4-1**.

Table 3.2.4-1 OU III South Boundary System Extraction Well Construction Data

Well #, (Site ID)	Screen Interval (Feet below grade)	Pump Setting (Feet below grade)
EW-3, (121-17)	150-190	170
EW-4, (121-16)	160-180 and 190-200	190
EW-5, (121-15)	160-200	180*
EW-6, (122-14)	160-200	180
EW-7, (122-13)	170-210	190
EW-8, (122-12)	190-210 and 230-250	220
EW-12, (122-30)	180-220	200

* = Pump intake was lowered to a depth of 190 feet below grade on January 17, 2003

Well House

The well house is situated along the southern boundary of the site to the west of the wells. Each of the seven pump discharge lines is reduced from 4-inch to 3-inch diameter just before it enters the well house. Inside the well house, each pump discharge line contains a gate valve to isolate the line, a propeller-type flow meter, a swing-type check valve, and a butterfly valve to control flow. High and low-level pressure switches and a sampling port also are located on each line before the gate valve. After the butterfly valve, the piping manifolds into a 10-inch discharge line that conveys the water to the treatment facility.

Treatment Facility

The groundwater treatment facility consists of a treatment control building and an air-stripping tower system, and is located just northwest of Rochester Street and Princeton Avenue. The facility is designed for limited automatic operation, defined as automatic equipment shutdown with manual restart. Any alarm condition will signal a common trouble alarm at BNL's Central Chilled Water Facility requiring physical inspection of the main control panel to determine the source of the alarm. The treatment building also houses a 110-gallon riser drain tank used to temporarily capture drained water from the tower's influent line if the air-stripping tower is shut down during cold weather. Two re-injection pumps send the drained water back into the stripping tower's influent line when the system is placed back in operation.

Air-Stripping Tower

The packed air-stripping tower removes VOCs from the groundwater to meet the discharge criteria. The stripping tower is 6 feet in diameter and 52 feet tall, and equipped with a minimum of 39 feet of 2-inch plastic packing, configured in two separate beds. The tower's internals include five influent spray nozzles, water distribution trays for the two media beds, packing support/air distributor for the two media beds, a mist eliminator, screened air exit, and water redistribution rings. The 39-foot height of the packing media is based on the requirements to remove TCA. The efficiency of removing other VOCs of interest are greater than the required minimum, and effluent concentrations will be lower than NYSDEC permitted levels. A centrifugal blower supplies air to the tower at a normal flow rate of 3,100 cfm, providing an air to water ratio of 27:1 at the maximum water flow rate of 850 gpm, and 31:1 at the more typical rate of 750 gpm.

Recharge Basin

The water discharged from the air-stripping tower flows by gravity through 10-inch diameter PVC piping to either of two recharge basins. A buried house trap in the piping has a 30-inch water seal to prevent air, under pressure in the stripping tower, from discharging through this line. The discharge piping splits to convey the water to either the OU III recharge basin, or to the existing HP recharge basin. A gate valve in the line to each basin controls the flow to the basin.

The OU III basin is sized to receive a continuous flow of more than 850 gpm; this value includes a sufficient factor of safety to account for variations in subsurface soil and fouling of the basin over time. The existing HP recharge basin provides backup discharge facilities during maintenance of the primary OU III basin. With the addition of the Middle Road system, water is also diverted to the RA V basin.

3.2.4.2 Groundwater Monitoring

<u>Well Network</u>: 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 3.2.4-2**).

<u>Sampling Frequency and Analysis</u>: The South Boundary wells are sampled and analyzed for VOCs at frequencies detailed in **Table 1-6**.

3.2.4.3 Monitoring Well Results

Appendix C has the complete groundwater monitoring results for 2003 (located on the enclosed CD-ROM). **Table 3.2.4-2** summarizes VOC results exceeding the NYS AWQS.

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 3.2.4-2**). VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary as depicted in **Figures 3.2-2 and 3.2.4-2**.

The plume core wells continued to show the same trend of decreasing VOC concentrations that were observed following the start-up 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 3.2.4-3,** which is a cross-section (F-F') drawn along the south boundary and incorporating the extraction wells. The VOC concentration trends for specific key plume core wells are shown in **Figure 3.2.3-2**.

- Plume core well 114-07 is located just upgradient of EW-12. The original purpose of this well was to monitor VOC concentrations on the eastern plume perimeter, outside the capture zone of EW-8. Increasing VOC concentrations in this well during 1998 prompted the addition of EW-12, which began pumping in December 1999. TVOC concentrations in 2003 have remained near or below the NYS AWQS with no VOCs exceeding NYS AWQS since 2001.

- 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 start-up 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 decreased to non-detectable levels by 2002.

- Plume core well 122-04 is located between EW-7 and EW-8, and slightly upgradient. TVOC concentrations in this well displayed a dramatic decrease from 1998 to early 2000, during which they dropped to below 5 µg/L for seven consecutive quarters. The increasing trend begun in 2000 continued during 2001, with concentrations rising above 200 µg/L in response to a slug of higher VOC concentrations reaching the site boundary. Concentrations decreased again in 2002, with TVOC concentrations continuing to remain below 20 µg/L in 2003.

- Plume core well 121-23 is located immediately downgradient from EW-5. TVOC concentrations have fluctuated somewhat since 1998. The TVOC concentration spiked to over 850 µg/L during the fourth quarter of 2002 and second quarter of 2003, before decreasing to 457 µg/L during the fourth quarter 2003. Once again, 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.

- 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. Concentrations stabilized between 12 µg/L and 33 µg/L during 2002 and 2003. Samples from well 121-14 (which is located in the same cluster but screened deeper) showed a TVOC concentration spike to 1471 µg/L during the fourth quarter of 2002, before decreasing back to between 51µg/L and 71µg/L in 2003. PCE is the primary compound in wells 121-13, 121-23, EW-4, and EW-5. This contamination is being captured by the treatment system.

- Plume core well 121-10 is situated upgradient of EW-3. TVOC concentrations decreased dramatically from a high of 1,458 µg/L in 1998, and have remained between 1 µg/L and 10 µg/L since the third quarter of 1999. No VOCs were reported above NYS AWQS in 2002 and 2003.

- Plume core well 121-11 is situated upgradient of EW-3. TVOC concentrations increased from a low of 107 µg/L in May 2002, to a high of 275 µg/L in October 2003.

- Plume core well 122-05 is located west of EW-8. TVOC concentrations have remained stable at approximately 50 µg/L since October 2001.

- By-pass 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.

3.2.4.4 Systems 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 on a quarterly basis. All samples are analyzed for VOCs. The effluent sampling parameters of pH and VOCs are done in accordance with SPDES permit equivalency requirements (**Table 3.2.4-3**). 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 equivalency permit requirements except pH. One pH reading was below the lower limit by 0.2 units. This result is consistent with naturally occurring pH levels in groundwater. However, since this reading was not repeated, it may be an error.

Table 3.2.4-3. SPDES Permit equivalency Levels January 1 - December 31, 2003
OU III South Boundary Air Stripping Tower

Parameters	Permit Limit (μg/L)*	Max. Observed Value (μg/L)
pH (range)	6.5 - 8.5 SU	6 .3 - 7.95 SU
Carbon Tetrachloride	5.0	ND
Chloroform	7.0	ND
1,1-Dichloroethane	5.0	ND
1,2-Dichloroethane	5.0	0.47 J
1,1-Dichloroethylene	5.0	ND
cis-1,2-Dichloroethylene	5.0	ND
trans-1,2-Dichloroethylene	5.0	ND
Tetrachloroethylene	5.0	ND
1,1,1-Trichloroethane	5.0	ND
Trichloroethylene	5.0	ND
1,2-Xylene	5.0	ND
Sum of 1,3 & 1,4 Xylenes	10.0	ND

***Maximum effluent allowed by Requirements Equivalent to a SPDES Permit.**
J = Estimated value below the method detection limit.
ND = Not detected above method detection limit of 0.50 μg/L.

OU III South Boundary System Operations

The following summarizes system operations for 2003. BNL's PE Division performed nonroutine maintenance and repairs and made routine maintenance checks on this system. The historical Operating Parameters Data Sheets are available in the system project files while the current month's data can be found in the treatment system buildings.

January –September 2003:

Extraction well EW-6 was off-line from December 18, 2002 through January 14, 2003 due to a faulty pump motor. The well was re-developed and a new pump and motor were installed. Extraction well EW-5 was placed off-line from January 14th through the 17th, in order to lower the pump intake to a depth of 190 feet below land surface.

On March 13th, the pump in EW-6 was upgraded with a pump capable of producing an increased flow rate. EW-7 was out of service from July 28th through August 12th due to pump motor failure. The system was off-line from August 14th through the 19th, due to programming malfunctions that occurred as a result of the Northeast Blackout.

The OU III South Boundary system treated approximately 272,000,000 gallons of groundwater during the first three quarters of 2003. All system effluent concentrations met equivalency permit requirements, except for pH.

October 2003:

The quarterly extraction well sampling was performed on October 1, 2003. The South Boundary System pumped and treated approximately 29,000,000 gallons of water in October. The average flow rate for the system was 659 gpm. Influent and effluent waters to the treatment system were sampled on October 1, 2003, and the effluent met all SPDES equivalency permit requirements.

November 2003:

The South Boundary system pumped and treated approximately 28,000,000 gallons of water in November. The average flow rate for the system was 649 gpm. Influent and effluent waters to the treatment system were sampled on November 3, 2003. All effluent concentrations met equivalency permit requirements.

December 2003:

The system was off-line from December 8th through the 10th, due to a broken blower belt likely caused by snow and ice accumulation.

Approximately 24,000,000 gallons of water were pumped and treated in December. The average flow rate for the system was 547 gpm. The influent and effluent waters to the treatment system were sampled on December 1, 2003. All effluent concentrations met equivalency permit requirements.

Approximately 353 million gallons of water were pumped and treated in 2003 by the OU III South Boundary System.

3.2.4.5 Systems Operational Data

System Influent and Effluent

All parameters in the SPDES equivalency permit conditions were within the specified ranges during 2003. The effluent data were either below the method detection limits, or below the regulatory limit specified in the equivalency permit .

Figure 3.2.4-4 plots the concentrations of TVOC, TCA and PCE in the influent to the systems air-stripper tower vs. 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 65.82 μg/L; a slight decrease from 78.37 μg/L for the same period last year. The system was sampled monthly for tritium. Tritium was not detected above the reporting limit in any sample during 2003. System influent and effluent sampling results are summarized in **Tables F-14** and **F-15**, 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 675 gpm from January 1, 2003 through December 31, 2003 (see **Table 2-3** and **Table F-16**). The cumulative total of TVOCs removed by the treatment system vs. time is plotted in **Figure 3.2.4-5**. The total for 2003 was approximately 183.7 pounds. Cumulatively, the system removed approximately 2,104.35 pounds since it was started on June 17, 1997.

Air Discharge

Table 3.2.4-4, 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- 17**). The concentration of each constituent was averaged for the period, and that value was used in the calculation. All air emissions were below allowable levels.

Table 3.2.4-4. OU III South Boundary Air Stripping Tower
Air Emission Rates January 1, 2003 - December 31, 2003

PARAMETERS	ALLOWABLE ERP*	ACTUAL***
Carbon Tetrachloride	.022 lb/hr	.0027 lb/hr
Chloroform	.0031 lb/hr	.0006 lb/hr
1,1 - Dichloroethane	10 lb/hr**	.0001 lb/hr
1,2 - Dichloroethane	.008 lb/hr	.0006 lb/hr
1,1 - Dichloroethylene	.034 lb/hr	.0008 lb/hr
cis-1,2-Dichloroethylene	10 lb/hr**	.0003 lb/hr
Trans-1,2-Dichloroethylene	10 lb/hr**	.0000 lb/hr
Tetrachloroethylene	.387 lb/hr	.0135 lb/hr
1,1,1 - Trichloroethane	10 lb/hr**	.0030 lb/hr
Trichloroethylene	.143 lb/hr	.0005 lb/hr

Actual Emission Rate reported as the average rate for the period of operation.
* ERP based upon NYSDEC Air Guide 1 Regulations.
** 6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls.
*** Actual Emission Rate reported as the average rate for January 1 through December 31, 2003.

Extraction Wells

As discussed in the 2002 BNL Groundwater Status Report, the concentrations of VOCs detected in well EW-12 had been below NYS AWQS for over one year. VOC concentrations remained below NYS AWQS in 2003. Beginning in October 2003, this extraction well was placed in standby mode. The well will continue to be sampled on a quarterly basis, and if concentrations of VOCs in this or nearby monitoring wells show a significant rebound, the well may be placed back on-line.

In general, the extraction wells continued to show slowly decreasing VOC concentrations during 2003, (**Figure 3.2.4-6**). **Table F-18** 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 by-pass wells continued to show stable or decreasing VOC concentrations. The system operated at an average of 675 gpm during 2003. There was some minor downtime due to electrical problems and the start-up of the OU III Western South Boundary system. No permit equivalency standards were exceeded except pH 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 2003.

2. Has the plume been controlled?

Yes. Because 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 reveals that there have been no significant VOC concentration increases in these wells during 2003. In addition, groundwater level measurements indicate the presence of a cone of depression that is consistent with estimates prepared during the design. Therefore, we conclude that there has been no plume growth, and the plume continues to be controlled.

The capture zone for the OU III South Boundary Pump and Treat System is depicted in **Figure 3.0-1**. The capture zone depicted is inclusive of 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 within 35 pounds or 2 % of what was predicted using the groundwater model (**Figure 3.2.4-7**). **Figure 3.2-4** compares the OU III plume from 1997 to 2003. 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 2003, it had operated for approximately 6.5 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 upon the partition coefficient of the contamination, the rate of desorption (i.e., linear or non-linear) 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 5-10 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 that treatment 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 after showing a marked increase at the end of 2002 (**Figure 3.2.4-8).**

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

No. The mean plume core well TVOC concentration was approximately 100 µg/L in the fourth quarter of 2003. This was primarily due to a high concentration slug reaching the eastern portion of the OU III south boundary area.

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?

No. MCLs have not been achieved for individual VOCs in plume core wells. Based upon model 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 baseline of over five years of groundwater data has been obtained from many of the OU III South Boundary Program wells. 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.

- Monitor the OU III South Boundary Magothy wells at a quarterly (Start-up mode) frequency in 2004.

- 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 will continue in standby mode during 2004. The well will be restarted should monitoring well data indicate that VOC concentrations are showing significant rebound.

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

Two groundwater extraction wells, WSB-1 and WSB-2, provide hydraulic control of the VOC plume. Groundwater is extracted at a total maximum flow rate of 300 gpm. The actual rates vary according to operational monitoring data. **Table 3.2.5-1** shows the depths of the extraction wells and pump settings.

Table 3.2.5-1. Western South Boundary Extraction Well Construction Data

Well	Screen Interval (Feet below grade)	Pump Setting (Feet Below Grade)
(WSB-1, 126-12)	140-160	105
(WSB-2, 127-05)	150-170	95

Each wellhead is composed of a pitless adapter at the ground surface which is then piped to an enclosed reinforced concrete vault with the top slab one foot above grade. These vaults house the flow meters, pressure gauges, and electrical disconnects for the wells. The wells and vaults are located along the southern boundary of the site. Piping within the vaults is schedule 40 PVC, transitioning to Blue Brute PVC Class water pipe before exiting through the vault's wall. The pipes are 4-inch diameter, and join a 6-inch diameter pipe, at the start of the common force-main to the treatment facility.

The groundwater treatment facility consists of a treatment control building and an air-stripping tower located at the west end of Middle Path. The treatment facility is designed for limited manual operation, defined as automatic equipment shutdown with manual restart and automatic restart in the event of low power supply. Any alarm condition will signal an alarm at the Treatment Building and a common trouble alarm light on the building.

The stripping tower is 4 feet 6 inches in diameter and 33 feet tall, and is equipped with a minimum of 25 feet of 2-inch plastic packing. One centrifugal blower supplies air to the tower at a normal flow rate of 2,005 cfm, providing an air/water ratio of 50:1 at the maximum water flow rate of 300 gpm.

The water discharged from the air-stripping tower flows by gravity to the adjacent recharge basin to the west. The basin can receive a continuous flow of 300 gpm. However, scaling and silt in this area was heavier than expected and the basin requires periodic scraping throughout the year.

3.2.5.2 Groundwater Monitoring

Well Network: A network of seventeen wells is used to monitor this portion of the OU III plume. Their locations are shown in **Figure 1-2**.

Sampling Frequency and Analysis: The wells are sampled quarterly and analyzed for VOCs. Details are provided in **Table 1-6**.

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. Maximum TVOC concentrations during 2003 were in well 126-11 at 49 µg/L during the first quarter. VOC results exceeding NYS AWQS are summarized in **Table 3.2.5-2**. Fourth quarter well data is posted on **Figure 3.2-1**. The complete results are in **Appendix C** (located on the enclosed CD-ROM).

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. Groundwater monitoring for this system was initiated in 2002. There has not been a sufficient period of time to develop long term contaminant concentration trends.

3.2.5.4 Systems Operations

The extraction wells are currently sampled every month. The influent and effluent of the air-stripper tower are sampled twice per month. All samples are analyzed for VOCs. In addition, the effluent sample is analyzed for pH and tritium twice a month. **Table 3.2.5-3** provides the effluent limitations for meeting the requirements of the State Pollution Discharge Elimination System (SPDES) permit equivalency.

Table 3.2.5-3. SPDES Parameter Effluent Concentrations for 2003 Western South Boundary Pump and Treat System

Parameter	Threshold Value* (µg/L)	Maximum Measured Value (µg/L)
pH	6.5-8.5 standard units	6.5-8.14 standard units
Carbon Tetrachloride	5	<MDL**
Chloroform	7	<MDL
Dichlorodifluoromethane	5	<MDL
1,1-Dichloroethane	5	<MDL
1,1-Dichloroethylene	5	<MDL
Methyl Chloride	5	0.68
Tetrachloroethylene	5	<MDL
Toluene	5	<MDL
1,1,1-Trichloroethane	5	<MDL
1,1,2-Tricholorethane	5	<MDL
Trichloroethylene	10	<MDL

* Maximum effluent concentration (µg/L) allowed – Equivalent to a SPDES Permit.
** Minimum Detection Limit (MDL) = 0.5 µg/L

The following is a summary of the OU III operations for 2003. BNL's PE performed routine maintenance checks on this system daily, in addition to their routine and non-routine maintenance. BNL's EWMSD collected the system samples. Full details are recorded in the system's operation and maintenance log.

The daily operations and maintenance inspection logs are available in the project files and the treatment facility.

January-September 2003:

The treatment system operated normally from January to March, with only minor problems with communications to WSB-2. On March 24 through March 28, 2003 the system was shut down so that the recharge basin could be drained and scraped of scaling.

From April to September the system operated normally with only two shut downs recorded. The first occurred on August 14 through August 19, 2003 due to the Northeast Blackout. The second occurred on September 2 through September 15, 2003 so that the recharge basin could be drained and scraped of scaling.

A total of 100,029,000 gallons of water were pumped and treated during the first three quarters of 2003.

October 2003:

The system operated normally, with no interruption. A total of 13,027,000 gallons were pumped and treated. The extraction wells and the treatment system influent and effluent were sampled in October 2003. All effluent discharges met the SPDES equivalency permit requirements.

November 2003:

The system operated normally, with no interruptions. A total of 13,000,000 gallons were pumped and treated. The extraction wells and the treatment system influent, and effluent were sampled in November 2003. All effluent discharges met the equivalency permit requirements.

December 2003:

The system operated normally, with no interruptions. A total of 12,705,000 gallons were pumped and treated. The extraction wells and the treatment system influent, and effluent were sampled in December 2003. All effluent discharges met equivalency permit requirements.

3.2.5.5 Systems Operational Data

Extraction Wells

During 2003, 138,761,000 gallons were pumped and treated by the OU III Western South Boundary system, with an average flow rate of 260 gpm. **Table 2-3** gives monthly pumping data for the two extraction wells. VOC and tritium concentrations for WSB-1 (126-12) and WSB-2 (127-05) are provided in **Table F-19** in **Appendix F** (located on the enclosed 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

TCA, DCE, chloroform, freon, and TCE influent concentrations to the air stripper tower versus time are illustrated in **Figure 3.2.5-2**. The concentrations of TCA and DCA decreased slightly during 2003(**Tables F-20 and F-21, 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 OU III 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 (**Table F-22, Appendix F**). The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.2.5-3**). The calculation shows that 11.66 pounds of TVOCs were removed during 2003 and a total of 21.5 pounds has been removed since the startup of the system.

Air Discharge

Table 3.2.5-4 below presents the VOC air emission data for the year 2003 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 period. 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 3.2.5-4. OU III Western South Boundary System Air Stripper VOC Air Emissions Data for 2003*

Parameter	Allowable ERP**	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Carbon Tetrachloride	0.016	<0.0002	<0.0002	<0.0002	<0.0002
Chloroform	0.0086	0.00031	0.00034	0.00033	0.00028
1,1 - Dichloroethane	10***	<0.0002	<0.0002	<0.0002	<0.0002
1,2 - Dichloroethane	0.011	<0.0002	<0.0002	<0.0002	<0.0002
1,1 - Dichloroethene	0.194	0.00021	0.00019	0.00021	0.00019
Chloroethane	10***	<0.0002	<0.0002	<0.0002	<0.0002
1,1,1 - Trichloroethane	10***	0.00037	0.00038	0.00037	0.00031
Trichloroethene	0.119	0.00019	0.00020	0.00020	0.00018

* Actual Emission Rate reported as the average rate (lb/hr) for each quarter.
** ERP based on NYSDEC Air Guide 1 Regulations.
***6 NYCRR Part 212 restricts emissions of VOCs to a maximum of 10 pounds per hour without controls.

3.2.5.6 System Evaluation

The system has only been fully operational since September 2002. Based on groundwater elevation measurements and mapping it appears that hydraulic control of the plume has been achieved in this area (**Figure 3.0-1**). The BNL Groundwater Contingency Plan was not triggered during 2003. The decision rules, developed as part of the groundwater DQO process, will be used to evaluate the system operation s over times.

3.2.5.7 Recommendations

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

- Groundwater monitoring will continue in start-up phase mode (quarterly sampling) through second quarter 2004. Thereafter, the sampling frequency will revert to O&M phase (semi-annual for plume core wells and quarterly for perimeter and sentinel wells).

- Complete the connection of wireless alarm communications to central on-site location.

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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 2003, and presents conclusions and recommendations for its future operation. The system began operation on September 27, 1999. This summary is prepared annually and presents the operational data from January 1 through December 31, 2003.

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 below ground 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 units in series to remove the VOCs. Treated air is then re-circulated back to the wellhead. The carbon units, system blower, and the system control panel are all housed in a one story, masonry treatment building.

The system treatment wells are referred to as "UVB" wells, which is a German abbreviation for vacuum extraction well. Groundwater is treated below grade within a well vault and returned to a contaminated segment of the aquifer (via the same well from which it is withdrawn). Therefore, a NYSDEC SPDES permit equivalent is not required. The simultaneous withdrawal and recharge of groundwater from a single well causes a flow cell to form near the treatment well. This localized change in the aquifer flow field takes the shape of a three-dimensional recirculation cell that is the mechanism by which hydraulic control is achieved.

The seven groundwater treatment wells are designated from west to east as UVB-1 through UVB-7 (**Figure 3.2.6-1)**. Collectively, they hydraulically control and treat the off-site portion of the OU III VOC plume between the BNL southern boundary and the Parr Industrial Park. Each of the seven treatment wells are constructed with eight (8) inch diameter steel casing and two (2), 20 foot long, stainless steel screens separated by an inflatable packer. One, three (3) horsepower submersible well pump is installed below the packer in each well to draw water into the well through the lower screen.

Well casing, about 25 feet to 35 feet in length, separates the screen zones in each well. The well screens are strategically placed to intercept and contain the full vertical extent of the contaminant plume. Therefore, screen zone depths differ from well to well based upon the plume configuration at each location. **Table 3.2.6-1** summarizes construction information for the recirculation wells.

Table 3.2.6-1. OU III Industrial Park System UVB Well Construction Data

Well	Well Depth (ft bls)	Grade at Well (ft msl)	Screen Depths Top / Bottom (ft bls)	Pump Intake Setting (ft bls)
UVB-1	243	83.0	165-185 / 220-240	229
UVB-2	218	79.5	140-160 / 195-215	204
UVB-3	220	74.0	142-162 / 197-217	179
UVB-4	193	72.0	125-145 / 170-190	184
UVB-5	203	71.0	125-145 / 180-200	179
UVB-6	215	82.0	140-160 / 192-212	214
UVB-7	228	82.0	150-170 / 205-225	219

ft bls = feet below land surface
ft msl = feet above mean sea level

The sizing of the groundwater treatment system was based upon a nominal hydraulic capacity of 60 gpm for each stripping tray with the capacity to operate at a maximum of 80 gpm. To permit independent flow rate control, variable frequency drives were used for the well pumps. Flow rates for each individual well can be controlled from a programmable logic controller (PLC) located in the treatment and control building.

Air Treatment Facility

The air treatment system is a closed loop system that provides airflow to the UVB wells for the stripping process. The air treatment equipment, which consists of a blower, a dehumidification unit, a duct heater and two 13,600 pound GAC units, are housed in the treatment and control building. Individual air suction and return lines run underground from the building to each UVB well. A single blower provides the airflow for all seven wells. Like the submersible well pumps, the system blower has a variable frequency drive motor that is controlled from the PLC to regulate the output of the blower. The airflow to individual UVB wells can be controlled by adjusting the blast gates on the influent and effluent manifolds within the building, and by adjusting gear operated butterfly valves in the valve vault adjacent to each UVB well.

Contaminated air from the UVB wells is combined in a common header and passed through the dehumidification system and duct heater to remove moisture. Compressors, located on an exterior slab adjacent to the west wall of the building, circulate a chilled water-glycol solution through two banks of coils. As the contaminated air stream passes over the cold coils, moisture condenses out and collects in a drip pan. The drip pan drains via gravity to a sump where a sump pump transfers this condensate to the UVB-4 air-stripping tray for treatment.

Two (2) GAC filter vessels (piped in series) are utilized to remove VOCs from the air stream. After the air leaves the GAC filter units, it is re-circulated to the UVB wells and again used in the air stripping process. A clean air relief port allows removal of clean air from the air-piping loop if necessary.

3.2.6.2 Groundwater Monitoring

Well Network: The monitoring well network consists of 40 wells and is designed to monitor the VOC plume(s) 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 plume(s). The wells are located throughout the industrial park, and on Carleton Drive as shown in **Figure 1-2**. The wells were installed as single, doublets and triplets and are constructed of both two and four inch diameter PVC. Screen depths vary to capture contaminant concentrations at multiple levels, and to obtain water quality data above the treatment well effluent depth, at the effluent depth, and at the treatment well influent depth.

Sampling Frequency and Analysis: The frequency of sampling each well is dependent on the well's position within the plume and it's proximity to other wells. In general, plume core and perimeter wells are either sampled annually or semiannually and analyzed for VOCs. Bypass detection and Magothy wells are sampled quarterly and analyzed for VOCs (**Table 1-6**).

3.2.6.3 Monitoring Well Results

The complete results are included in **Appendix C** (located on the enclosed CD-ROM). **Table 3.2.6-2** summarizes VOC detections exceeding the NYS AWQS.

VOC concentrations in the plume perimeter wells monitoring the width of the plume (000-245 and 000-272) continued to remain below NYS AWQS during 2003. Based upon these data, the plume is effectively bounded by the current well network. **Figure 3.2.4-2** shows the plume distribution based on fourth quarter 2003 data. The vertical extent of contamination is shown in **Figure 3.2.6-2**. The location of this cross section (G-G') is illustrated in **Figure 3.2-1**.

The highest TVOC concentrations in the Industrial Park area observed in 2003 were between remediation wells UVB-6 and UVB-7 in 2003. Increased concentrations were noted in several wells in the central and eastern portions of the system in 2003. The maximum concentration during 2003 was 772 µg/L during the first quarter in well 000-249, which is located between UVB-1 and UVB-2. This is down from the maximum concentration in 2003 of 1,262 µg/L in well 000-262, which is located between UVB-4 and UVB-5 in the center of the industrial park system. In general, VOC concentrations decreased in Industrial Park monitoring wells during 2003.

- Plume core wells 000-253 (located just east of UVB-1), 000-256 (located between UVB-1 and UVB-2) and 000-259 (located between UVB-2 and UVB-3) generally showed stable or decreasing VOC concentrations during 2003 (**Figure 3.2.6-3**).

- There had been a steady decline in VOC concentrations in plume core well 000-112 (located immediately upgradient of UVB-1 and UVB-2) from 1999 through early 2002 before a spike back up in concentrations during the latter portion of 2002. TVOC concentrations resumed a decreasing trend during 2003. These concentration changes are probably due to the inherent variability in the distribution of VOC concentrations within the plume.

- Plume core well 000-262 (located between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002 and this trend continued during 2003 (**Figure 3.2.6-3**). This well peaked at 2,175 µg/L in 2001 and was at 267 µg/L in the fourth quarter of 2003.

- VOC concentrations in 000-268 (located between UVB-6 and UVB-7) fluctuated between 119 µg/L and 582 µg/L during 2003. The data indicates 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 2003. Well 000-431 and 000-432 were installed in 2002 as recommended in the 2001 Groundwater Status Report to supplement the Industrial Park bypass monitoring network. They 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 have decreased from 32 µg/L to 4 µg/L during 2003. VOC contamination in the vicinity of 000-431 was present prior to the start-up of the system. This suggests 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. All these wells had VOC concentrations since sampling began in December 1999 indicating that contamination was present prior to the start-up of the treatment system. Concentrations of VOCs in these wells have been relatively stable to decreasing since sampling began. This trend continued in 2003.

- 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 Systems Operations

Operating Parameters

The influent and effluent of the carbon vessels are sampled once per quarter and analyzed for VOCs. These samples monitor the GAC units for a VOC break-through to determine when a carbon change-out is required. Since the system utilizes a closed-loop air system, no air permit equivalencys are required for its operations.

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 well's removal efficiency and performance. Based on these results operational adjustments are made to optimize the system's performance.

System Operations

The following summarizes the systems operations for 2003. BNL's PE Division carries out routine maintenance checks daily on the system, in addition to routine and non-routine maintenance. The EWMSD collects the treatment system samples. Details of these activities are given in the system's operation and maintenance manual. The daily operations and maintenance inspection logs are available in the treatment system building.

January – September 2003:

The system was off from January 27 and 28 due to the disconnection of a Fernco Valve on the main air line. Well UVB-5 was off February 3 through 11 and February 24 due to an over-temperature fault reading on the line filter. Well UVB-5 was off March 4 through March 6 for an over-temperature fault. The cooling fan for that line filter was replaced March 13. Well UVB-2 was off from March 6 through March 10 for an electrical problem. Well UVB –1 was off April 28-30 due to an electrical problem. Well UVB-1 was off almost the entire month of May due to an electrical problem. Well UVB-6 was off from May 6 through May 8 for an electrical problem. Well UVB-1 was off from June 1 to June 20 to replace the pump in the extraction well. The system was found off on July 1 and July 21 due to thunderstorms and was restarted those same days. The system was also shut down on July 2 for a carbon change-out and restarted July 7 due to holiday closures of the laboratory. The system was off from August 14 through August 18 due to the Northeast Blackout. UVB-2 was off August 4 through August 8 and the 19 to the 26 due to an electrical problem. Well UVB-1 was off from August 25 through September 4 also for an electrical problem. Well UVB-2 was off from September 15 to September 17 for an over temperature fault. Well UVB-1 was off from September 19 to September 30 due to a high water level reading.

October 2003

The system was operational for the entire month of October with the exception of UVB-1, which was off the entire month due to fouling of the injection screen on the well. All other wells operated at 60 gpm.

November 2003

The system was operational for the entire month of November with the exception of UVB-1, which was off from November 1 to November 17 due to well maintenance. Well UVB-2 was off from November 6 to November 30 due to an electrical problem. All other wells operated at 60 gpm for the remainder of the month.

December 2003

The system was operational for the entire month of December with the exception of UVB –2, which was off December 2-4 and December 9 tthrough 18 due to an electrical problem. All other wells operated at 60 gpm.

In 2003, approximately 187,000,000 gallons of groundwater were pumped and treated.

3.2.6.5 Systems Operational Data

Recirculation Well Influent and Effluent

During 2003, influent TVOC concentrations in all wells remained stable (**Figure 3.2.6-4**). The corresponding effluent well concentrations (**Figure 3.2.6-5**) showed decreasing and stable TVOC concentrations for the year. The concentrations in UVB-1 have decreased significantly since start-up in 1999.

During the fourth quarter of 2003, the average removal efficiency for VOCs was 90.9% and overall for 2003, it was 91.5% (**Table F-23**, **Appendix F**). A summary of VOCs with concentrations above NYS AWQS in the effluent samples is provided as **Table 3.2.6-3**.

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-24** summarizes this data and is included in **Appendix F**. Flow averaged from 54 to 60 gpm for the wells from January 1, 2003 through December 31, 2003. **Figure 3.2.6-6** plots the total pounds of TVOCs removed by the treatment system vs. time. During 2003, 117 pounds were removed.

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 change-out 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 512 cfm for the seven wells in the fourth quarter, and 535 cfm during 2003 (**Table F-25, Appendix F**).

3.2.6.6 System Evaluation

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 2003.

2. Has the plume been controlled?

Yes. Because 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 well data reveals that there have been no significant VOC concentration increases in these wells during 2003. Therefore, we conclude that there has been no plume growth and the plume continues to be controlled.

Groundwater elevation data is obtained quarterly from many of the OU III Industrial Park 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 2-3** and **2-4**). The capture zone for the OU III Industrial Park System is depicted in **Figure 3.0-1**. The capture zone depicted is inclusive of 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 treatment system is effectively removing contamination. The current estimate for treatment system operations is 12 years, which is significantly longer than what was specified in the design (7 years). The OU III Industrial Park System continues to be effective in removing VOCs from the deep Upper Glacial aquifer. Actual mass removal is within 1% of what was predicted using the groundwater model (**Figure 3.2.6-6**). **Figure 3.2-4** compares the OU III plume from 1997 to 2003. 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 should decrease over time.

The OU III Industrial Park system is currently planned to operate for 12 years; at the end of 2003, it had operated for approximately four years. The trend in the mean of the TVOC concentrations in the core groundwater monitoring wells is a declining one (**Figure 3.2.6-7**). 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 2003 concentrations began to show 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 just under 200 µg/L as of the fourth quarter 2003.

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

Three of the nine plume core wells have TVOC concentrations exceeding 50 µg/L as of the fourth quarter 2003.

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? Specifically, have MCLs been achieved(expected by 2030)?

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

- A baseline of over five years of groundwater data has been obtained from many of the OU III Industrial Park Program wells. A routine operations and maintenance monitoring frequency was implemented in August of 2003. This frequency should be maintained during 2004.

- The system should continue operations at 60 gpm per well.

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3.2.7 Offsite Monitoring

The OU III Offsite Groundwater Monitoring Program consists of twenty wells that were installed primarily during the OU III RI. Three of the wells (000-97, 000-98, and 000-99) 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. Most of these wells will be folded into the groundwater monitoring programs associated with the LIPA and Brookhaven Airport (LIPA and Airport) planned OU III off-site remediation systems during 2004.

3.2.7.1 Groundwater Monitoring

Well Network: The network has 20 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 quarterly, and samples are analyzed quarterly for VOCs with the exception of wells 800-21, 800-22, 800-23, 800-51, and 800-53 which are sampled semiannually (**Table 1-6**).

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**. Plume core well 000-131 concentrations remained relatively stable during 2003 (**Figure 3.2.3-2**).

The leading edge of this plume continues to be located immediately south of Flower Hill Drive near the northern boundary of the Airport. The TVOC concentration in well 800-43 (located on Flower Hill Drive) remained below 3 μg/L in each of the 2003 quarterly sampling rounds.

3.2.7.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2003 that would have triggered the BNL Groundwater Contingency plan (BNL 2000c). The plume remained within the boundaries of the perimeter wells currently in place. Sentinel well 800-43 continued to show very low concentrations of VOCs, indicating that leading edge of the plume is in the vicinity of the northern boundary of the Airport.

Many of the monitoring wells comprising this program will be absorbed into other programs during 2004 as OU III Offsite remediation systems (LIPA, Airport, Industrial Park East) are constructed and begin operation. Thus, monitoring of these wells provides us with data on the off-site OU III plumes in the interim.

3.2.7.4 Recommendations

No changes to the monitoring program are warranted at this time. As wells are incorporated into both the LIPA, Airport, and Industrial Park East Remediation System programs the sampling frequency will be evaluated.

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3.2.8 North Street Monitoring

The North Street (formerly known as OU I/IV) monitoring program addresses a VOC plume that originated at the Former Landfill/Chemical Holes area and is currently located primarily south of the site boundary and the issue of potential 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).

As a precursor to groundwater remediation, groundwater characterization was performed and consisted of drilling 15 vertical profile borings and collecting and analyzing groundwater samples for VOCs and tritium from these temporary wells in 2001/2002.

Groundwater treatment will consist of two extraction wells operating at a combined pumping rate of 450 gpm. This 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 migration to the Magothy aquifer. A 2004 start-up is anticipated for the treatment system. Details on the pre-design groundwater characterization and the groundwater treatment system can be found in the *North Street Remedial Action Work Plan* (BNL, 2002a) and Final Design (BNL 2003), respectively.

This plume has been divided into segments for remediation purposes. The leading edge of the North Street plume extends south to the vicinity of the Airport. The area north of Moriches-Middle Island Road will be addressed by the remediation system off of North Street while the Airport Recirculation System will handle the area to the south (**Figure 3.0-1**). The Airport System is being 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 proposed remediation system and pre-design characterization activities can be found in the *OU III Aiport Groundwater Treatment System 90% Design Documents* (J.R. Holzmacher, 2002a).

3.2.8.1 Groundwater Monitoring

Well Network: A network of 20 wells monitors 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**). Additionally, wells sampled under the OU III South Boundary and Industrial Park Programs are utilized for mapping this plume. Thirteen additional wells are being installed during 2004 in association with the construction of the groundwater treatment system.

Sampling Frequency and Analysis: Fourteen of the 20 wells are sampled and analyzed quarterly for VOCs, three wells are analyzed semi-annually for VOCs and three wells are analyzed annually for VOCs. All wells are sampled and analyzed annually for gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 (**Table 1-6**).

3.2.8.2 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 the 20 monitoring wells. The complete groundwater monitoring well data are included in **Appendix C**. Details of the pre-design groundwater characterization data can be found in the *North Street Remedial Action Work Plan* (BNL, 2002a). A hydrogeologic cross section (H-H') running through the spine of the plume is provided in **Figure 3.2.8-1;** its location 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. The increasing concentrations in well 800–63 during 2003 (**Figure 3.2.8-2**) suggest that the leading edge of this higher concentration segment has reached this location. The delineation of this plume is shown in **Figure 3.2-1**.

Tritium has been detected historically in very localized off-site areas roughly corresponding to 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 NYS DWS of 20,000 pCi/L.

Tritium has been detected historically in well 000-153. The tritium concentration in this well in 2003 was 1,570 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.

3.2.8.3 Groundwater Monitoring Program Evaluation

Construction of the OU III North Street and Airport Remediation Systems and installation of additional monitoring wells will be completed in May 2004. **Figure 3.2.8-3** compares the TVOC plume from 1997 to 2003. 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 leading edge of the high concentration area has moved south from well 000-154 and, based on the 2003 data, appears to have reached well 000-153.
- A small area of TVOC greater than 50 µg/L has migrated south of the site boundary and is 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. This area of contamination will be monitored under the North Street East program.
- The leading edge of the plume, as defined by a TVOC of 5 µg/L, remains in the vicinity of Flower Hill Drive.

The OU III North Street Monitoring Program can be evaluated from the four 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 2003.

2. Does the existing contaminant plume represent a potential risk to downgradient receptors?

No. The leading edge of the plume was defined at Flower Hill Drive at concentrations below the NYS AWQS for individual VOCs during the 2002 pre-design characterization work. There are no downgradient receptors within the Airport, which is south of Flower Hill Drive. Homes in the residential area overlying the plume have been connected to public water (with the exception of seven homes). These seven homes are monitored annually.

3. Is the planned remediation system adequate to intercept and treat the existing contamination to prevent impacts to potential downgradient receptors?

Yes. The remediation systems are being constructed to intercept and treat the contamination as outlined in the OU III ROD. The combined North Street and Airport systems will prevent any impacts to potential downgradient receptors south of the leading edge of the plume, as currently defined.

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

No. Based on both monitoring well data and the extensive pre-design characterization in 2002 radionuclide contamination appears to be limited to isolated occurrences of tritium, primarily in the deep Upper Glacial aquifer, at concentrations below the NYS DWS of 20,000 pCi/L.

3.2.8.4 Recommendations

The monitoring well network will be enhanced during 2004 with additional monitoring wells associated with both the North Street and Airport Remediation Systems. A system-startup sampling frequency will be implemented following start-up, which is equivalent to the current quarterly sampling frequency.

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3.2.9 Central Monitoring

The OU III RI identified several low-level VOC (less than 50 µg/L) source areas and non-point contaminant sources within the developed central areas of the BNL Site. Since these sources, which include spills within the AGS Complex, and the storage area for site maintenance equipment (Building 208) and others, are not large enough to warrant a dedicated monitoring program, they are monitored under the OU III Central project. In addition, this project includes wells 109-03 and 109-04, which are located near the BNL site boundary and serve as sentinel wells for the SCWA William Floyd Parkway well field.

3.2.9.1 Groundwater Monitoring

<u>*Well Network*</u>: The monitoring well network, established to check the relatively low-level VOC contamination in the central areas of the site, 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 ES program wells that monitor active research and support facilities (**Table 1-7**).

<u>*Sampling Frequency and Analysis*</u>: The wells are sampled and analyzed quarterly for VOCs, and semiannually for gross alpha/beta, gamma spectroscopy, tritium, and Strontium-90 (**Table 1-6**). Facility Monitoring wells in the AGS program are typically sampled and analyzed annually for VOCs in order to complete the northern portion of the OU III VOC plume configuration. However, during 2003, these wells were not sampled for VOCs.

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 following wells displayed significant changes in VOC concentrations in 2003 or were otherwise noteworthy:

- Well 65-05 is screened in the shallow Upper Glacial aquifer and is located in the AGS area. TVOC concentrations in well 65-05 increased during 1999 and 2000, peaking at a concentration of 123 µg/L in September 2000. Concentrations continued a decreasing trend in 2003, remaining below 1 µg/L during the last three quarters of the year. Based on this decreasing trend, a small slug of VOC contamination appears to have migrated south of this location. TVOC concentrations in well 065-39, located approximately 800 feet downgradient from well 065-05, increased from concentrations of 3 µg/L or less since 2001, up to 14 µg/L in 2003. This may indicate that the slug has reached this location.

- Well 66-09 is located southeast of building 830 and screened in the shallow Upper Glacial aquifer. VOC concentrations, primarily TCA, significantly increased during late 2000 and early 2001, peaking at 112 µg/L TVOC in February 2001. A preliminary investigation identified several potential sources in building 830. Geoprobes installed in the area during the summer of 2001 revealed little or no VOC contamination (BNL, 2001). VOC concentrations have since remained below NYS AWQS with the exception of a single detection of trichloroflouromethane at a concentration of 9 µg/L in the fourth quarter of 2002.

- Well 83-02 is located 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 located near the eastern BNL site property boundary. Toluene was detected in well 109-03 (screened in deep Upper Glacial Aquifer) at 5.3 µg/L in a sample obtained on September 12, 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. The 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 were no detections of VOCs exceeding NYS AWQS during the remainder of the year for either well. There were no detections of tritium in either well during 2003.

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 2003?

No. The detections of VOCs in well 109-03 did not trigger the Contingency Plan in 2003 since it was triggered in 2002. As per the agreement in 2002, the SCDHS were notified of all detects from 109-03 during 2003. The wells will continue to be sampled at a quarterly frequency in 2004 and the regulatory agencies will be notified of any additional VOC detections.

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

No. Results from wells 109-03 and 109-04 during 2003 have been below NYS AWQS for VOCs during the final three quarters of the year.

3. Are the performance objectives met?

No. Individual wells continued to contain VOC concentrations exceeding the NYS AWQS during the early portion of 2003; 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 are in good agreement with the model predicted concentrations with respect to both the plume extent and contaminant concentrations.

3.2.9.4 Recommendations

The following recommendation is related to the OU III Central groundwater monitoring program:

- Due to the recent VOC detections in well 109-03, the quarterly sampling frequency will be maintained for SCWA well field sentinel wells 109-03 and 109-04.

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3.2.10 Magothy

Additional characterization of the Magothy aquifer (partially characterized as part of the OU III RI and OU I/IV Groundwater Investigation) was undertaken and completed between April 2000 and August 2002. The characterization consisted of 22 vertical profile borings and 13 new monitoring well installations. The new and existing monitoring well locations are shown on **Figure 3.2.10-1**. A summary of the field investigation work and presentation of the findings is included in the *Magothy Aquifer Characterization Report* (BNL, 2003).

The additional data resulted in the drafting of an *OU III Explanation of Significant Differences* (BNL, draft 2004) in accordance with CERCLA and Section 300.435 (c)(2)(i) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The Magothy Remedy calls for:

1) Continued operation of the existing or recently installed extraction wells as part of the Upper Glacial treatment systems that provide capture of Magothy VOC contamination (Middle Road, South Boundary, and Airport).
2) Installation of two additional off-site Magothy extraction wells (completed April 2004); one on Stratler Drive (south of Carleton Drive), and one at the Industrial Park East location to prevent migration of high concentrations of VOCs through holes in the brown clay and into the Magothy Aquifer.
3) Continue to monitor and evaluate the data to ensure protectiveness.
4) Institutional controls and five-year review.

Monitoring of the 13 new wells began in 2003 and the data is presented in Appendix C. Sampling is conducted quarterly under a start-up phase. There are 16 wells in the Magothy program that include the 13 new wells. In addition, there are 13 wells screened in the Magothy, which are sampled in other programs. Seven additional wells are planned for installation during 2004 as part of the Industrial Park East, LIPA and Airport remediation systems.

Samples collected from Magothy wells 121-40 and 121-44, located along the south boundary, showed little to no detectable levels of VOCs.

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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 from the pool for off-site disposal, the spent fuel pool was drained and the HFBR was removed from service in 1997. Also, numerous monitoring wells were installed to characterize the tritium plume downgradient of the HFBR. In May 1997, operation of a three-well groundwater pump and recharge system began. This system was constructed on Princeton Avenue approximately 3,500 feet downgradient of the HFBR to capture any 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 stand-by status in September 2000 as the groundwater monitoring data demonstrated that plume growth was not occurring. Beginning in June 2000 and ending April 2001 twenty low flow extraction events removed 95,000 gallons of tritiated water with concentrations greater than 750,000 pCi/L.

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. 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 2-4** and **2-5**). Evaluation of groundwater flow and quality data indicate that the downgradient portion of the tritium plume (south of Brookhaven Avenue) has shifted to the 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 follow the extent of the plume, the source area, and the effectiveness of the groundwater remediation system (**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. Select wells are also analyzed for VOCs as part of the Carbon Tetrachloride and Middle Road programs (**Table 1–6**).

Sampling Frequency and Analysis: The wells associated with the high concentration portion of the plume were sampled for tritium monthly through September. As of October 2003, the sampling frequency of these wells was changed to quarterly as recommended in the 2002 BNL Groundwater Status Report. Sampling details are contained in **Table 1-6**. The remaining wells were sampled quarterly.

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 2003, including monitoring well and geoprobe data. Data from the OU III HFBR Tritium Groundwater Monitoring program were supplemented with data obtained from four geoprobes installed during 2003. Three of the geoprobes were installed just east of Rowland Street in the vicinity of Railroad Street to track the high concentration segment of the plume (**Figure 3.2.11-2**). The fourth geoprobe was installed approximately 20 feet west of well 085-558 on Cornell Avenue to determine the western extent of the plume in this area. **Appendix C** has the complete set of monitoring well data.

During 2003 the high concentration segment of the plume was located in the vicinity of Bell Avenue. The high concentration observed in 2003 was 217,000 pCi/L in geoprobe 85-341 located at the eastern end of Rowland Street between Grove Street and Railroad Street (**Figure 3.2.11-2**). The plume in the area immediately south of the HFBR shifted slightly to the west in 2003 as evidenced by:

1. Increased tritium concentration in well 075-43 during fourth quarter (**Figure 3.2.11-3**).
2. The highest tritium concentration along Cornell Avenue was in geoprobe 075-658. This location is 20 feet west of the row of monitoring wells situated on Cornell Avenue.
3. The gradual increase, from east to west, in tritium concentrations in Cornell Avenue and Temple Place wells over the past two years.

Concentrations in well 075-43 were 130,000 pCi/L during the fourth quarter 2003. Although this was a significant increase from the 2002 high of 22,600 pCi/L, this is a significant reduction from the historic highs in this well that approached 2,500,000 pCi/L in 1999 (**Figure 3.2.11-3**).

Tritium concentration trend plots are shown for key wells located along the spine of the plume in **Figure 3.2.11-3**. The high concentration core of the plume passed through the vicinity of well 75-294 during the beginning of 2001 then through well 75-418 during the middle to latter part of 2001, north of Brookhaven Avenue. The high concentration segment reached Bell Avenue in early 2003, and Rowland Street in late 2003, as determined by the temporary well results. Tritium concentrations at Temple Place have remained below 750,000 pCi/L, the trigger level for low-flow remediation pumping, since April 2001. The vertical extent of contamination along the spine of the plume is depicted in cross section I-I' (**Figure 3.2.11-4**).

The fourth quarter 2003 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 in the vicinity 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 2003 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 2003 in the sentinel wells situated on Weaver Drive.

Groundwater flow data indicate that the downgradient segment of the tritium plume has remained relatively stable during 2003 (**Figures 2-4** and **2-5)**.

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.

<u>*1. Was the BNL Groundwater Contingency Plan triggered?*</u>

No. The BNL Groundwater Contingency Plan was not triggered during 2003. High tritium concentrations detected in vertical profiles, geoprobes and monitoring wells were consistent with our understanding of the HFBR Tritium plume.

2. Is the tritium plume growing?

No. Tritium above 25,000 pCi/L in wells at the Chilled Water Plant Road or above 20,000 pCi/L in wells along Weaver Drive was not observed. None of these criteria were approached during 2003 although there was a tritium concentration increase in well 096-84 with 3,680 pCi/L observed in November. A comparison of the plume distribution between 1997 and 2003 is shown in **Figure 3.2.11-5**. This figure also illustrates that significant plume growth is not occurring.

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 (located at Princeton Avenue) and supported comparisons on remedial alternatives for the OU III FS. The *HFBR Groundwater Model Update Report* (BNL, September 2001a) addressed model calibration and the design and performance of a low flow pumping system. The *HFBR Groundwater Model Update report* estimated future tritium concentrations at the Weaver Road location. The *2002 BNL Groundwater Status Report* (BNL, 2003) was used to document the latest model assessment, which examined fourth quarter 2002 monitoring data relative to earlier predictions.

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

No. Tritium was not detected above 1,000 pCi/L in any of the monitoring wells located upgradient of the HFBR. These wells are sited to serve as sentinel wells for any northward migration of tritium towards the supply wells. No tritium was detected in the supply wells.

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

Yes. The plume shifted to the west of well 075-558 located along Cornell Avenue during 2003 as indicated by the results from Geoprobe 075-658. The tritium concentration in well 075-558 increased to 7,110 pCi/L in the first quarter of 2004 indicating that the edge of the plume was in this vicinity. Additional geoprobes will be performed in 2005 to define the extent of the plume in this area. Despite the detection in well 096-84, there are sentinel wells located further downgradient in the monitoring network (**Figure 1-2**). There were no detections in plume perimeter wells during 2003 indicating that tritium had moved beyond the current monitoring network. Temporary well data south of Brookhaven Avenue did indicate that the plume was shifted slightly east of the downgradient-monitoring network. Additional temporary and permanent wells are needed to ensure that the downgradient segment of the plume is adequately monitored in the future and to track the high concentration segment.

3.2.11.4 Recommendations

The following are recommendations for the HFBR groundwater monitoring program.

- Several temporary wells will be installed in 2004/2005 to track the high concentration portion of the plume south of Rowland Street as outlined in the HFBR Tritium Low Flow Pumping Evaluation Report (BNL 2001b).

- Vertical profiles will be installed in the vicinity of both Weaver Drive and well 096-84. The purpose of these wells is to verify the detection in this well and assess the plume and monitoring network in the vicinity of Weaver Drive

- Based on the detection in well 096-84 the sampling frequency will be increased from annual to quarterly. The frequency in outer perimeter monitoring wells 105-22, 105-23 and 105-42, located on Princeton Avenue, will also be increased to quarterly. Extraction wells EW-9, 10, and 11 will also be sampled on a quarterly basis.

3.2.12 BGRR/Waste Concentration Facility Strontium-90 Monitoring

The OU III Brookhaven Graphite Research Reactor (BGRR)/WCF project monitors the extent of strontium-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 4.13) programs. These wells are sampled concurrently for both programs to avoid duplication of effort.

A pre-design groundwater characterization effort was conducted in late 2003/early 2004 to increase definition of the Strontium-90 plumes and source areas. The additional data was used in the drafting of an *OU III Explanation of Significant Differences* (BNL, draft 2004) in accordance with CERCLA and Section 300.435 (c)(2)(i) of the NCP. The BGRR/WCF Remedy calls for:

1. Installation of extraction wells using ion exchange to remove strontium-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. Continue to monitor and evaluate the data to ensure protectiveness.
4. Institutional controls and five-year review.

The analytical results show several source areas of elevated strontium-90, one emanating from the WCF area and extending approximately 1,500 feet south, an area south of the BGRR Below Ground Ducts (BGD) and Canal House, an area south of the Pile Fan Sump (PFS) and HFBR stack area extending south for approximately 1,500 feet (**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 Groundwater Monitoring

Well Network: A network of 61 monitoring wells was designed to monitor the strontium-90 plumes associated with the BGRR, WCF, and Pile Fan Sump areas (**Figure 1-2**). Fourteen wells monitored under this program also are sampled under the AOC 29 HFBR Tritium program; sampling events are coordinated between the two programs to eliminate any duplication of effort. The 14 wells, which were originally installed as part of the AOC 29 HFBR program, are utilized either as sentinel wells or to bound the strontium-90 plumes to the east.

Sampling Frequency and Analysis: The wells are monitored semiannually, and the samples are analyzed for strontium-90 (**Table 1-6**).

3.2.12.2 Monitoring Well/Geoprobe Data

A groundwater characterization effort was performed for the BGRR, WCF/Building 811 and PFS areas between September 8, 2003 and January 20, 2004. Groundwater samples were obtained with a geoprobe at multiple depth intervals from a total of 60 locations (**Table 3.2.12-1**).

Table 3.2.12-1. 2004 BGRR Strontium-90 Groundwater Characterization Summary

Area	Number of Geoprobe Locations	Total Number of Samples Obtained
BGRR Area	26	166
PFS Area	17	85
WCF/Bldg. 811 Area	17	85

All geoprobes samples were analyzed for strontium-90. Gamma spectroscopy, tritium, Target Analyte List (TAL) metals and VOCs were also analyzed at select locations.

The highest strontium-90 concentration detected during the characterization was 3,150 pCi/L from geoprobe BGRR-8, located south of BGRR. The plume distribution map is shown in **Figure 3.2.12-1**. The distribution of strontium-90 throughout the BGRR, WCF, and PFS areas is depicted based on groundwater data obtained from this characterization effort and the fourth quarter 2003 sampling of the monitoring well network. Groundwater data from the OU III RI characterization effort was also considered, although not shown on this figure. The following cross-sectional views are also provided:

Figure 3.2.12-2 (J-J') – A north-south cross section from the BGRR south to Brookhaven Ave.

Figure 3.2.12-3 (K-K', L-L', and M-M') – West to east cross sections south of Building 701 and the Below Ground Ducts area.

Figure 3.2.12-4 (N-N') – North to south cross section from Building 801 south of Cornell Ave.

Figure 3.2.12-5 (O-O') – North to south cross section from WCF south to HFBR stack area.

In addition, historical strontium-90 concentration trend plots for key wells are plotted on the plume distribution map in **Figure 3.2.12-6**.

3.2.12.3 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 detections in BGRR Strontium-90 program wells that triggered the BNL Groundwater Contingency Plan during 2003.

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

No. Based on the results of the BGRR groundwater characterization effort additional monitoring wells will be added.

3. Can strontium-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 strontium-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 strontium-90 plumes migrating toward BNL supply wells 10,11, and 12?

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

3.2.12.4 Recommendations

The following are recommendations for the BGRR groundwater monitoring program:

- Install additional monitoring wells to enhance the current monitoring network.
- Maintain the southerly groundwater flow direction by managing the pumping of BNL supply wells.
- Install a groundwater treatment system for the BGRR strontium-90 plumes.

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3.2.13 Chemical/Animal Holes Strontium-90 Pilot Study Treatment System

This section summarizes the operational data from the OU III Chemical/Animal Holes Strontium-90 Pilot study treatment system for 2003, 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 poorly documented laboratory chemicals and animal carcasses. This area was excavated in 1997.

Following the excavation, a strontium-90 plume was characterized. The plume is approximately 650 feet long and 90 feet wide, with a maximum thickness of 15 feet. The plume is at a depth of approximately 22 to 45 feet below ground surface (bgs). To date, the highest strontium-90 activity observed in groundwater in this area was 2,540 pCi/L at well 106-16 in November 1999. The highest strontium-90 activity observed during pre-design characterization was 1,740 pCi/L at sample location GVPB-27 at a depth of 34 to 38 feet bgs. The area of higher concentrations appears to be located in a very narrow band approximately 330 feet long and 30 feet wide (**Figure 3.2.13-1).**

The objective of the strontium-90 pilot study was to evaluate the effectiveness of extraction and treatment of strontium-90 in groundwater prior to implementation of the final remedy specified in the OU III ROD. Finalized in June 2000, the ROD documents the selected remedies and past removal actions for the areas of concern and additional areas of investigation within OU III. OU III was established to address groundwater contamination in the central and southern portions of BNL and in off-site areas where groundwater contamination has migrated. The selected remedy for strontium-90 contamination in groundwater was groundwater extraction, treatment using ion exchange, and on-site discharge of the treated water. Details of the pilot study are provided in the *Strontium-90 Pilot Study Report* (BNL, April 2004)

Recovery Well

One extraction well, EW-1, was installed within the area of the maximum Strontium-90 concentrations. The initial system-pumping rate was 50 gpm (February 26, 2003 – April 25, 2003). Groundwater is currently being extracted at a rate of 6 gpm (since July 2, 2003. EW-1 consists of a 6-inch diameter steel riser pipe and 15 feet of 6-inch diameter 20-slot screen. The screen is located at a depth of 23.5 to 38.5 feet below grade.

The data from pre-design characterization geoprobes and the monitoring well data collected before and during the initial pilot study operation showed that the highest concentrations of the strontium-90 plume were approximately 30 feet wide with the extraction well being located in the center of the plume.

Treatment Facility

The following process overview includes a general description of equipment and components of the Strontium-90 pilot study treatment system.

The pilot study treatment system consists of the following unit operations:

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

The extracted groundwater is pumped to an influent tank prior to 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) (**Figure 3.2.13-2**). The zeolite feed pump pumps the filtered water through the zeolite adsorbers, 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 synthetic zeolite (Universal Oil Products (UOP) A-51) for removal of strontium-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. Treated water is pumped from the treated water discharge tank to the dry well. The dry well is located approximately 500 feet east of the pilot plant.

All equipment is housed within a pre-engineered metal building on a concrete foundation. The foundation includes a process sump, trench with an associated sump pump and a secondary containment curb. The foundation is sloped to allow process fluid to collect in the process trench for re-circulation to the influent tank. The metal building includes partitions for an electrical room, a control room, and a radioactive waste accumulation area for spent zeolite vessels.

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: Nineteen of the 36 monitoring wells were sampled at a higher frequency (twice per month) since they were part of the Strontium-90 Pilot Study. Each of the 19 wells was initially sampled between December 30, 2002, and January 2, 2003, to determine baseline strontium-90 activities prior to starting the extraction and treatment system Pilot Study. The remaining 17 wells were sampled semiannually for Strontium-90 and annually for VOCs.

3.2.13.3 Monitoring Well Results

Figure 3.2.13-1 shows the strontium-90 plume distribution. The plume depiction is derived from the fourth quarter monitoring well data. The highest strontium-90 concentration observed in 2003 was 2,400 pCi/L in well 106-16 during the first quarter sampling round. This well is located immediately south of the Chemical/Animal holes and historically has shown the highest concentrations in this area (**Figure 3.2.13-3**).

A high concentration plume segment of greater than 100 pCi/L strontium-90 extends from approximately 35 feet northwest of well 106-16 to approximately 65 feet south of the Princeton Avenue firebreak road. The leading edge of the plume, as defined by the NYS DWS of 8 pCi/L, is approximately 275 feet south of this firebreak road.

A second, smaller plume occurs south of the Former Landfill. The trailing edge of the plume exceeding 8 pCi/L is estimated to be approximately 75 feet south of the Princeton Avenue firebreak road.

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 data are summarized in section 3.2.9 of this report and are used in developing **Figure 3.2-1**; the complete results are in **Appendix C**.

3.2.13.4 Systems Operations

The Strontium-90 Pilot study treatment system influent, effluent, and three mid point samples are sampled three times a week (**Figure 3.2.13-2**). All samples are analyzed for strontium-90. In addition, the influent and effluent samples are analyzed for pH values on a weekly basis. The effluent sampling parameters of strontium-90 and pH are performed in accordance with the SPDES equivalency permit requirements (**Table 3.2.13-2**).

Table 3.2.13-2. SPDES Equivalency Permit Levels February 26, 2003 – December 31, 2003
OUIII Strontium-90 Pilot Study Treatment System

Parameters	Permit Limit *	Max. Observed Value
pH (range) Standard Units	6.5 - 8.5	8.0
Strontium-90 (pCi/L)	8.0	ND

***Maximum effluent allowed by Requirements Equivalent to a SPDES Permit.**
ND = Not detected above minimum detectable activity.

System Operations

The following summarizes the systems operations for 2003. Further details are provided in the Strontium-90 Pilot Study Report (BNL 2004). Details are given in the operation and maintenance manual for this system. The daily operations and maintenance inspection logs are available in the project files and the pilot study treatment system building.

February 26, 2003 – April 25, 2003:

Sampling and analysis for strontium-90 in the influent, midpoints, and effluent streams of the pilot plant began on February 26, 2003.

The plant was shutdown on April 25, 2003, when it was determined that breakthrough had occurred past the second row of adsorbers. The third row of adsorbers and effluent showed no detections of strontium-90. During this period the pilot plant operated at the design flow rate of 50 gpm, except for the first five days of the startup period when the system operated at 35 gpm. The 50 gpm analytical and flow data from February 26, 2003, through April 25, 2003, are presented in **Table 3.2.13-1**.

April 26, 2003 – July 1, 2003

The system was not operating from April 26, 2003 to July 1, 2003 while waiting for replacement adsorbers.

July 2, 2003 – December 31, 2003 :

After replacing the first and second row of adsorbers the pilot plant was re-started on July 2, 2003, at a reduced flow rate of approximately 6 gpm. The flow rate was reduced from 50 gpm to 6 gpm to improve the system operation efficiency (BNL 2004). Sampling and analysis was resumed on July 2, 2003. During operation, influent, midpoint, and effluent sampling points were monitored for breakthrough. The 6 gpm analytical and flow data from July 2, 2003, through December 31, 2003, are presented in **Table 3.2.13-1.** There has been no Strontium-90 detections past the first row adsorbers (no breakthrough) for the period of July 2, 20003 through December 31, 2003.

3.2.13.5 Systems Operational Data

System Influent, Midpoint, and Effluent

The analytical data for the period February 26, 2003, through April 25, 2003, show that strontium-90 in the influent ranged from 25.5 to 212 pCi/L with an average of 89.3 pCi/L. 2,430,434 gallons of groundwater were processed through the pilot plant during this period. Indications of zeolite breakthrough were observed on March 25, 2003, when discharges past the first row of adsorbers showed strontium-90 activities of 4.92, 4.35, and 0.694 pCi/L, respectively. The downstream adsorbers in each array, however, produced effluents with no detectable strontium-90 concentrations.

Analytical data for the period April 1 through April 18, 2003, continued to show that discharges from the first row of adsorbers had increases in strontium-90 up to 56.9 pCi/L while the downstream adsorbers did not show any breakthrough. However, on April 22, 2003, breakthrough was observed beyond the second row of adsorbers which are downstream of from the first row of adsorbers. No strontium-90 was observed past the third row of adsorbers or in the combined effluent.

The analytical data for the period July 02, 2003, through December 31, 2003, show that strontium-90 concentrations in the influent ranged from 30.6 to 102 pCi/L with an average of 44.1 pCi/L. During this period, 1,404,392 gallons of groundwater were processed through the pilot plant. Breakthrough was not observed during this period. The adsorbers produced effluents with no detectable strontium-90.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the strontium-90 concentration to calculate the number of millicuries removed. Flow averaged 50 gpm from February 26, 2003 through April 25, 2003. Beginning on July 2, 2003, the system began pumping at 6 gpm and continued pumping at 6 gpm through December 31, 2003. The cumulative total was approximately 0.88 millicuries of strontium-90 removed during 2003 (**Figure 3.2.13-4**).

Extraction Well

The strontium-90 pilot study was designed to operate at a maximum of 50 gpm. The pilot study began collecting operational data towards the end of February 2003. The initial results showed that strontium-90 could be removed from the groundwater and treated to below the NYS DWS of 8 pCi/L. Initially operating at a maximum pumping rate of 50 gpm and with an initial influent strontium-90 concentration of 199 pCi/L, the pilot study treatment system experienced breakthrough in the first set of adsorbers (first row of 3 adsorbers) in approximately two weeks compared to the predicted time of approximately two months. The system was shut down on April 25, 2003, after the second row of adsorbers began to show breakthrough. Due to system start up issues, the system did not run continuously during the period of February 26 through April 25, 2003.

Based upon the accelerated breakthrough times seen initially, the pilot study was restarted but at the reduced pumping 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. The system was restarted on July 2, 2003. Since July 2, 2003, the treatment system is continuing to operate at an average flow rate of approximately 6 gpm.

3.2.13.6 System Evaluation

The information collected during the first months of operating the pilot system indicates that it is possible to extract the strontium-90 contaminated groundwater and treat it to levels less than the DWS using UOP A-51 Zeolite Resin. Additionally, there appears to be a decreasing trend of Strontium-90 activities in the monitoring wells included in the study.

Groundwater modeling for the Strontium-90 Pilot Study Report shows that pumping at 50 gpm or 6 gpm for 10 years of active pumping and treating predicts clean up to DWS in approximately 40 years. The pumping at 50 gpm is suitable to treat moderate and high concentration areas of the plume while pumping at 6 gpm is capable of controlling the highest concentration area of the plume. The remainder or fringes of the plume will be allowed to naturally attenuate. This will achieve cleanup goals within 40 years.

3.2.13.7 Recommendations

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

- Evaluate the use of Clinoptilolite resin in place of the current UOP A51 zeolite resin.
- Continue operating the treatment system at 6 gpm and optimizing the system sampling.
- Sample all wells in the monitoring well network semiannually for strontium-90.

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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 western sections of the BNL site. Tritium, gamma spectroscopy, and strontium-90 are analyzed annually from wells in these programs. The sampling will continue, 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 are 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

Well Network: A network of 31 monitoring wells incorporates wells also sampled under the OU III South Boundary and OU III Western South Boundary programs. Their 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 will be sampled annually for tritium, strontium-90, and gamma spectroscopy (**Table 1-6**).

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 2003.

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 2003 that triggered 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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3.3 Operable Unit IV

3.3.1 Air Sparge/Soil Vapor Extraction (AS/SVE) Remediation System

The system was shutdown 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)*. A *Petition For Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System* was submitted in June 2002. BNL received regulatory approval and subsequently decommissioned the system in 2003.

3.3.1.1 Groundwater Monitoring

Well Network: Post closure monitoring was initiated in the fourth quarter 2003. The program consists of quarterly monitoring of wells 76-06, 76-19, and 76-23 for VOCs for a period of one year. Monitoring of these wells will continue at a semi-annual frequency for up to 5 years beginning in the fourth quarter of 2004. Monitoring wells 76-18, 76-19, and 76-380 will continue to be monitored under the BNL Facility Monitoring Program. The remaining monitoring wells were abandoned as per the *Petition For Closure and Termination of Formal Post Closure Monitoring of OU IV Air Sparge/Soil Vapor Extraction Remediation System(BNL, 2003).*

Sampling Frequency and Analysis: The wells are sampled quarterly, and samples are analyzed for VOCs (**Table 1-6**).

3.3.1.2 Monitoring Well Results

Post Closure quarterly sampling of monitoring wells was initiated in the fourth quarter 2003. The complete groundwater data are given in **Appendix C**. There were no detections of VOCs exceeding the NYS AWQS in wells 76-06, 076-19, and 076-23. There were several VOC detections exceeding NYS AWQS in Facility Monitoring Well 076-380. This VOC contamination is associated with a source in the Central Steam Facility (CSF) area and will continue to be monitored (see section 4.8).

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 2003.

3.3.1.4 Recommendations

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

- Conduct quarterly monitoring of wells for VOCs through the third quarter 2004.
- Reduce the monitoring of wells 76-06, 76-19, and 76-23 to semi-annual for up to 5 years beginning in the fourth quarter 2004.

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3.3.2 Building 650 (Sump Outfall) Strontium-90 Monitoring Program

The Building 650 (Sump Outfall) Strontium-90 Monitoring Program monitors a strontium-90 plume emanating from contaminated soil within an area known as the 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 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: A monitoring network was designed to clarify the extent of strontium-90 contamination originating from the area of the Building 650 Sump Outfall and the Building 650 decontamination pad. The network consists of 28 wells located to define the limits of strontium-90 contamination (**Figure 1-2**). Well 66-18 was abandoned during 2003 due to it's proximity to standing water created by surface runoff. Ponded runoff accumulated in a depression resulting from the sump outfall soil remediation excavation work in 2002.

Sampling Frequency and Analysis: The wells are monitored semiannually, and the samples analyzed for gross alpha/beta, gamma spectroscopy, tritium, and strontium-90 (**Table 1-6**).

3.3.2.2 Monitoring Well Results

The complete results from radionuclide sampling can be found in **Appendix C**. The overall extent of the strontium-90 plume originating from the Building 650 sump outfall did not change significantly during 2003 although it continues to migrate to the southwest (**Figure 3.3.2-1**). The highest strontium-90 concentrations were detected in well 76-13 at 42 pCi/L in February 2003. In general, the concentrations in wells associated with the Building 650 sump outfall remained relatively stable during 2003. The slow and steady increase in strontium-90 concentrations in well 76-263 continued during 2003. 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 76-24.

Strontium-90 concentrations in well 76-28 remained at or below detectable levels during 2003 after showing significant increases in 2000 and 2001 (**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 strontium-90 concentrations in groundwater during 2003.

2. Were performance objectives met?

No. The performance objective for this project is to achieve strontium-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 should help to alleviate some of the source of groundwater contamination.

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 strontium-90 contamination.

3.3.2.4 Recommendations

The following are the recommendations for the Building 650 (Sump Outfall) Strontium-90 groundwater monitoring program:

- Continue to monitor to determine if remediation of the Building 650 decon pad and sump outfall has removed the source of contamination and that the plume is attenuating and migrating as expected.

- Install temporary geoprobes in the areas of the leading edge of the contamination emanating from the sump outfall and west of 076-169 in order to confirm the extent of contamination.

- Install a temporary geoprobe approximately 50 ft southwest of the location of former well 66-18. Based on the sample results a permanent well may be installed at this location.

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, in particular VOCs, metals and radionuclides, to groundwater 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, Pesticides/PCBs, water quality parameters, metals, gamma spectroscopy and tritium (**Table 1-6**).

3.4.3 Monitoring Well Results

The OU V wells were sampled during two rounds in 2003. **Appendix C** contains the complete data. There were no significant changes to the VOC plume in 2003 as compared to 2002 (**Figure 3.4-1**). The highest TVOC concentration was 17 µg/L in well 61-05 located near the eastern site property boundary. The vertical distribution of VOC contamination is shown in the cross section (P-P') in **Figure 3.4-2**. In general, VOC concentrations in plume core wells increased slightly (**Figure 3.4-3)**. The only individual VOCs detected at levels exceeding NYS AWQS were 1,1,1-TCA, TCE, 1,2-dichloropropane, and 1,2,3-trichloropropane. 1,2-Dichloropropane has been detected in shallow off-site sentinel well 600-25 at concentrations ranging between 1.4 and 2 µg/L (NYS AWQS of 1 µg/L) since sampling of this well began in 1998. During 2003 the concentrations were 1.5 µg/L and non-detect. There appears to be an off-site source for this contamination based on the shallow depth of the well and its location approximately 4,000 feet southeast of the BNL site boundary.

There were no pesticide detections above reporting limits in groundwater in 2003. There have been sporadic detections of pesticides historically in off-site wells. These detections are most likely the result of agricultural spraying of farms in the nearby vicinity.

Aluminum, antimony, arsenic, chromium, iron, manganese, sodium, and thallium were detected in monitoring wells for the OU V program at concentrations above the applicable NYS AWQS levels. Aluminum was detected in 14 wells above the NYS AWQS of 200 µg/L. The highest concentration was 24,400 µg/L detected in well 600-21 during the third quarter sampling event. Antimony was detected in five wells above the NYS AWQS of 3 µg/L. The highest concentration of antimony was 611 µg/L detected in well 600-22 during the third quarter sampling event. Arsenic was detected in three wells above the Federal Drinking Water Standard of 10 µg/L. The highest concentration of arsenic was 17.8 µg/L detected in well 050-02 during the third quarter sampling event. Chromium was detected in one well above the NYS AWQS of 50 µg/L. This well was 600-21, with the high concentration detected during the third quarter sampling event. Iron was detected in 19 wells above the NYS AWQS of 300 µg/L. The highest concentration of iron was 29,700 µg/L detected in well 50-02 during the third quarter sampling event. Manganese was detected in 8 wells above the NYS AWQS of 300 µg/L. The highest concentration of manganese was 1,230 µg/L detected in well 50-02 during the second quarter sampling event. Sodium was detected in 6 wells above the NYS AWQS of 20,000 µg/L. The highest concentration of sodium was 135,000 µg/L detected in well 600-19 during the second quarter sampling event. Thallium was detected in 6 wells above the NYS AWQS of 0.5 µg/L. The highest concentration of 4.82 µg/L was detected in well 061-05 during the first quarter.

Tritium has historically been detected at low concentrations in monitoring wells 49-06, 50-02 and 61-05 (**Figure 3.4-4**). Historical trends for tritium in wells 50-02 and 61-05 are plotted in **Figure 3.4-5**. Tritium concentrations were barely above detectable levels in well 61-05, and at a high concentration of 1,980 pCi/L in well 50-02; this is ten times lower than the NYS DWS of 20,000 pCi/L.

Gross alpha and gross beta levels were consistent with established background levels for the site.

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 2003.

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 3.4-6** compares the plume distribution between 1997 and 2003. The leading edge of the plume is now estimated to be located between the Long Island Expressway (LIE) 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 located to the southeast of well 000-122 (south of the LIE). Currently, two well clusters serve as sentinel wells for this plume along North Street and Wading River Road.

3.4.5 Recommendations

There are no recommendations to modify this monitoring program for 2004.

3.5 Operable Unit VI

3.5.1 EDB Monitoring Program

The OU VI EDB Program monitors the extent of an ethylene dibromide (EDB) 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. A groundwater remediation system to address the off-site EDB plume has been designed, and is being constructed during 2004. The start of operations is planned for the summer of 2004.

3.5.2 Groundwater Monitoring

Well Locations: A network of 27 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**). Additional monitoring wells are being 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. Samples are analyzed annually for VOCs, tritium and gross alpha/beta (**Table 1-6**).

3.5.3 Monitoring Well/Characterization 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 2003 in **Figure 3.5-1**. The leading edge of the plume is presently downgradient of monitoring wells 000-283 and 000-284. The installation of additional sentinel wells to monitor the leading edge of the plume is scheduled for 2004. The plume is located in the deep Upper Glacial aquifer and is generally moving horizontally as depicted on the cross section Q-Q' (**Figure 3.5-2)**. The highest EDB concentration observed during 2003 was 6.8 µg/L in well 000-284. The Federal Drinking Water Standard for EDB is 0.05 µg/L. A summary of all EDB detections exceeding the Federal Drinking Water Standard in 2003 is provided in **Table 3.5-1**.

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 2003 in **Figure 3.5-4** also illustrates plume movement.

The wells are sampled annually for VOCs in addition to quarterly EDB analyses. There were several detections above detection limits but none exceeded NYS AWQS in any of the wells (**Appendix C**).

The wells are sampled annually for tritium. There were no detections observed in 2003.

3.5.4 Monitoring Program Evaluation

The plume is migrating as predicted by groundwater modeling. Installing new monitoring wells during system construction in 2004 will address the current gap in the data at the leading edge of the plume. The groundwater remediation system will be constructed in early 2004 and is scheduled to be operational in 2004.

3.5.5 Recommendations

The following are the recommendations for the EDB groundwater monitoring program:

- Enhance the monitoring program with additional wells in 2004 to more precisely monitor the high concentration area of the EDB plume and sentinel wells downgradient of the plume edge and the remediation system recharge wells.

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

<u>Well Network</u>: The 2002 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.

<u>Sampling Frequency and Analysis</u>: The samples were analyzed for VOCs (**Table 1-6**).

3.6.2 Monitoring Well Results

The complete groundwater data 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 0.7 µg/L in well 017-03.

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.

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

No. There were no VOCs detected in site background wells above NYS AWQS during 2003. Based on these results there has not been any impact to BNL groundwater quality from upgradient contaminant source(s).

3.6.4 Recommendations

No modifications are recommended to this monitoring program.

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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 2003 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2004). This report can be found in **Appendix H**. 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 two to ten years may be required before groundwater quality improvements are observed downgradient of the landfills, depending on the underlying hydrogeology. At the end of 2003 the landfill has been capped nine years. Groundwater quality has been slowly improving. The furthest downgradient wells (87-27, 87-26, 87-24, 87-23, 88-22, and 88-23) would not be expected to see groundwater quality improvement for at east four years following capping. The time of travel from the landfill to the OU I South Boundary pump and treat system is approximately 10-15 years. The trend in the data suggests that the cap is effective in mitigating contamination. Additional groundwater quality improvement is expected to slowly continue.

3.7.2 Current Landfill Recommendations

The following recommendations were presented in the 2003 BNL Environmental Monitoring Report, Current and Former Landfill Areas (BNL, 2004):

- Reduce the frequency of sampling in the mid to deep Upper Glacial wells 087-24, 088-22, and 088-23 for VOCs from semi-annually to annually. Reduce the frequency of sampling these wells for metals and water chemistry from quarterly to semi-annually. Lowering the sampling and analysis frequencies for these wells is based on the absence of any detection above groundwater standards since 1998, and the consistently low concentrations where detections were recorded. These wells are screened significantly below the depth of the contaminants' migration from the landfill, and serve as perimeter data-points for the vertical extent of contamination. Changes in the vertical migration pathway for contaminants from the Current Landfill is not anticipated.

- For the shallow downgradient wells, reduce the frequency of sampling for radionuclides from quarterly to annually. Although, tritium and strontium-90 have been detected in several wells, the concentrations are only slightly above background levels.

3.7.3 Former Landfill Summary

Data show that contaminant concentrations have been decreasing following the capping of the landfill in 1996. Studies by Oweis and Biswas (1993) suggest that a period of two to ten years may be required before groundwater quality improvements are observed, depending on the underlying hydrogeology. 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 strontium-90 concentration trends in downgradient wells it does appear that the landfill cap is performing as planned.

The strontium-90 plume (as defined by concentrations exceeding 8 pCi/L) has migrated south of well 97-64 and continues to attenuate (see Section 3.2.13).

3.7.4 Former Landfill Recommendations

The following recommendations were presented in the 2003 BNL Environmental Monitoring Report, Current and Former Landfill Areas (BNL, 2004):

- Due to the low concentrations detected, the substantial historical databases, and the stability of the VOCs and water-chemistry parameters, reduce the frequency of analysis for these parameters from quarterly to semi-annually.

4.0 ENVIRONMENTAL SURVEILLANCE PROGRAM SUMMARY

During 2003, BNL's ES Program monitored the groundwater quality at ten active research and support facilities. New York State operating permits require groundwater monitoring at two support facilities (the MPF and the WMF); the remaining eight research and support facilities are monitored in accordance with DOE Order 5400.1/450.1 (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 EMS 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 2003, 125 groundwater surveillance wells were monitored in approximately 300 individual samplings. Information on groundwater quality at each of the monitored research and support facilities are described below. **Table 1-7** summarizes ES Groundwater Monitoring Program by project. The monitoring wells' screened depths and specific analytical requirements are provided in **Table 1-8**. Analytical results from groundwater samples collected in 2003 can be found in **Appendix D** located on the accompanying CD-ROM.

4.1 Alternating Gradient Synchrotron (AGS) Complex

Activated soils have been created near a number of AGS experimental areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. Radionuclides, such as tritium and sodium-22, have been produced by the interaction of these secondary particles with the soils that surround these experimental areas. To prevent rainwater from leaching these radionuclides from the soils and transporting them to the groundwater, impermeable caps have been constructed over the soil activation areas.[1] BNL uses 56 groundwater monitoring wells to evaluate the impact of current and historical operations at the AGS's beam stop and target areas. The locations of permanent monitoring wells are shown on **Figure 4-1**.

During 2003, 56 monitoring wells were used to evaluate groundwater quality near areas of potential soil activation within the AGS Complex (e.g., 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). 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/VQ12 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 DWS in the Former U-Line and E-20 Catcher areas. As discussed below, tritium concentrations well above 20,000 pCi/L continue to be detected downgradient of the g-2/VQ12 soil activation area (see **Section 4.1.5**).

Historical surface spills and discharges of solvents to several cesspools and recharge basins near the AGS have contaminated soils and groundwater with VOCs. VOC contamination is monitored under the ER OU III Central groundwater monitoring program (see **Section 3.2.10**).

[1] Assessment and design criteria for potential soil activation areas are described in the SBMS Accelerator Safety Subject Area.

4.1.1 AGS Building 912

Building 912 consists of five interconnected structures that house four experimental beam lines (A, B, C, and D Lines) consisting of magnets, instrumentation, high voltage electrostatic devices, beam targets, radiation shielding, cooling water systems and experimental detectors. A typical beam line contains bending and focusing electro-magnets along with their associated electrical power supplies, cooling water systems and vacuum pipes.

Beam loss and the production of secondary particles at proton target areas results in the activation of adjacent equipment, floors, and probably the soils beneath the building's floor. The highest levels of soil contamination 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 located to the north of the AGS complex. Therefore, it is believed that the potentially activated soils underlying the beam targets and stops are adequately protected from surface water infiltration.

4.1.1.1 Groundwater Monitoring

<u>Well Network</u>: Seventeen shallow Upper Glacial aquifer wells are located 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 areas. The downgradient wells are positioned to monitor significant beam stop and target areas within Building 912.

<u>Sampling Frequency and Analysis</u>: During 2003, Building 912 wells that were used to help track the g-2/VQ-12 tritium plume were sampled quarterly, whereas the remainder of the wells were sampled semiannually. The groundwater samples were analyzed for tritium (**Table 1-7**).

4.1.1.2 Monitoring Well Results

Other than tritium contamination that is traceable to either the g-2/VQ12 magnet or former U-Line beam target/stop source areas, groundwater surveillance data for 2003 indicate that appreciable levels of tritium are not being released from potential activated soils located 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 located just to the southwest of the WCF (**Figure 4-2**). Tritium from this plume was detected downgradient of Building 912 (in wells 065-121, 065-122, 065-123, and 065-124), with a maximum concentration of 476,000 pCi/L in the October sample from well 064-122. Furthermore, low levels of tritium that are probably traceable to the former U-Line target and stop area were detected in upgradient well 055-14 (up to 1,060 pCi/L) and downgradient wells 055-31 and 055-32 (up to 3,510 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, BNL prepared an Engineering Evaluation/Cost Analysis (EE/CA) for the g-2 Tritium Plume that describes the adequacy of the corrective actions taken to date, and the need for further actions.

4.1.1.3 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 non-detectable only observed at trace levels. These results indicate that the building and associated stormwater management operations are effectively preventing rainwater from infiltrating potentially activated soils located below the experimental hall.

4.1.2 AGS Booster

The AGS Booster is a circular accelerator with a circumference of nearly 660 feet, and is connected to the northwest portion of the main AGS ring and 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. The Booster accelerates protons and heavy ions prior to injection 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 constructed at the 10/11 o'clock portion of the Booster.

The AGS Booster beam stop is an area where the interaction of secondary particles and soil surrounding the Booster tunnel can result in production of tritium. The first beam stop was located in the northwest section of the Booster. Although internal shielding around the beam stop was designed to keep secondary particle interactions with the soil to very low levels, in 1990 a landfill-type geomembrane cap was constructed over the stop region to provide an extra level of protection. In 1999 the beam stop was repositioned to the south side of the Booster ring to accommodate the construction of the NASA Space Radiation Laboratory (NSRL) tunnel. A coated gunite cap was constructed over the new beam stop to prevent stormwater infiltration into potentially activated soils.

4.1.2.1 Groundwater Monitoring

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

Sampling Frequency and Analysis: During 2003, the Booster area wells were to be monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**). However, access to the wells was limited to one monitoring period due to Booster operations.

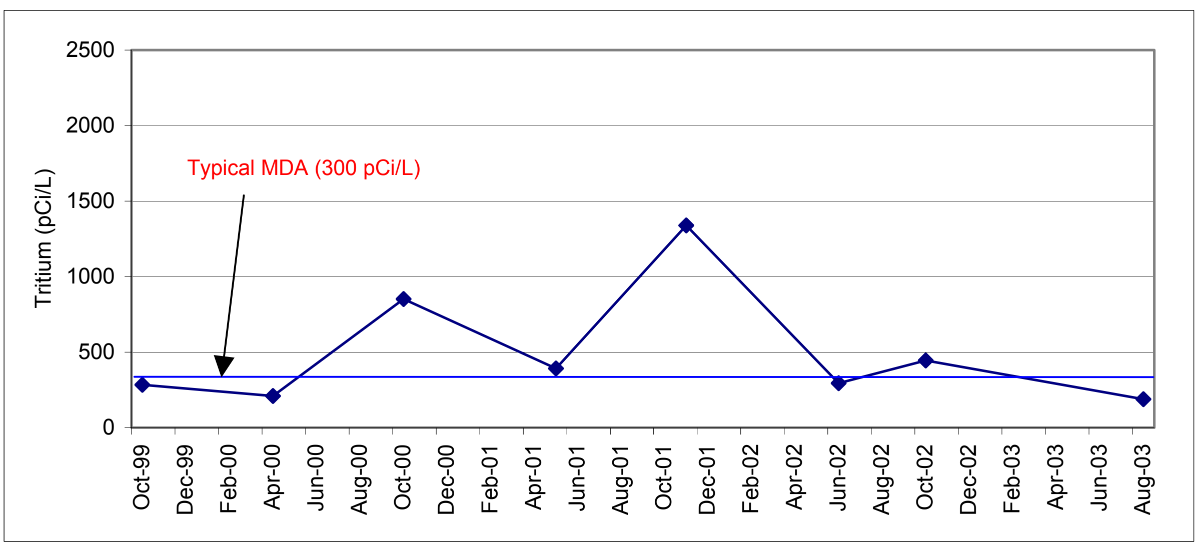

Figure 4-3: Maximum Tritium Concentrations Downgradient of AGS Booster Stop (wells 064-51 and 064-52).

4.1.2.2 Monitoring Well Results

Although low levels (up to 1,340 pCi/L) of tritium were detected downgradient of the Booster stop during 2001 and 2002, tritium was not detected at concentrations above the MDL during 2003 (**Figure 4-3**). The tritium that was detected in 2001 and 2002 was probably related to a short-term uncovering of activated soil shielding near the former Booster beam stop location (northwestern section of the Booster) during construction of the tunnel leading from the Booster to the new 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 surrounding the former beam stop location

4.1.2.3 Groundwater Monitoring Program Evaluation

The low-levels of tritium detected during 2001-2002 were likely related to a short-term uncovering of activated soil shielding near the Booster Beam Stop 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. (Note: 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.) Tritium concentrations dropped to non-detectable levels in 2003

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 was subject to injection, transition, ejection, and losses studies, and picked up about 80 to 90 percent of all of these losses.

Like other beam loss areas within the AGS complex, the soils surrounding the E-20 Catcher became activated by the interaction with secondary particles. In late 1999, tritium and sodium-22 were detected in two wells located 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, four Geoprobe 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 to allow for improved long-term monitoring.

4.1.3.1 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, 064-56 and 064-80. These wells are located approximately 100 feet downgradient of the source area (**Figure 4-1**).

Sampling Frequency and Analysis: During 2003, the E-20 Catcher wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

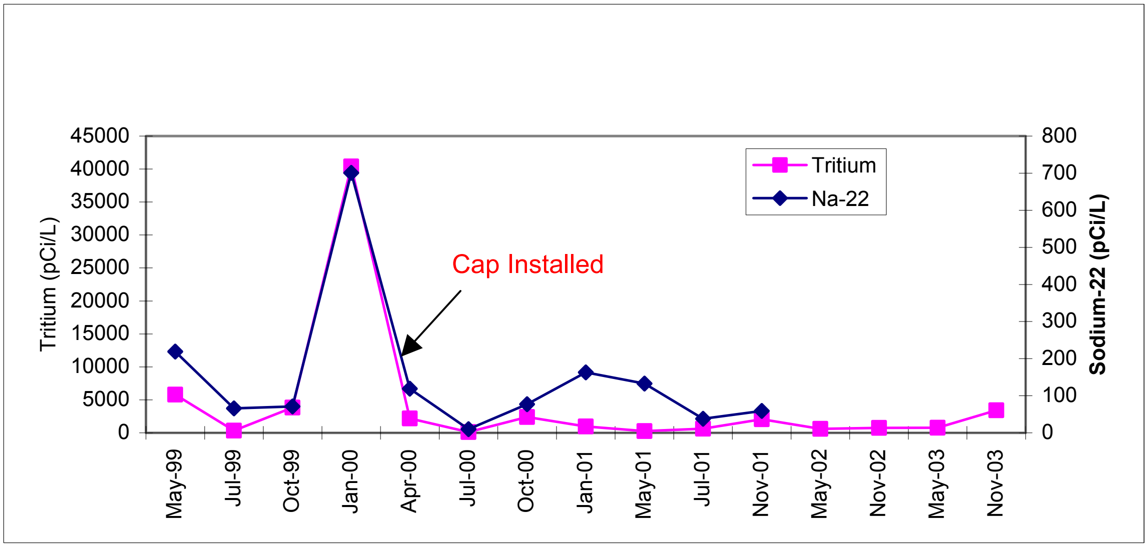

Figure 4-4. Maximum tritium and sodium-22 concentrations observed in temporary and permanent monitoring wells located downgradient of the former E-20 Catcher.

4.1.3.2 Monitoring Well Results

Following the installation of the cap in 2000, tritium and sodium-22 concentrations decreased to levels below applicable DWSs (**Figure 4-4**). During 2003, the maximum observed tritium concentration was 3,430 pCi/L, detected in well 064-55.

4.1.3.3 Groundwater 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 soils that surround that portion of the AGS tunnel.

4.1.4 Building 914

Building 914 houses the transfer line between the main 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, soil activation is likely to be limited to the areas below the floor of the building. Water infiltration through potentially activated soils is likely to be minor, because the soils are isolated beneath the floor of the building, and portions of the transfer tunnel are covered with a soil-crete mixture.

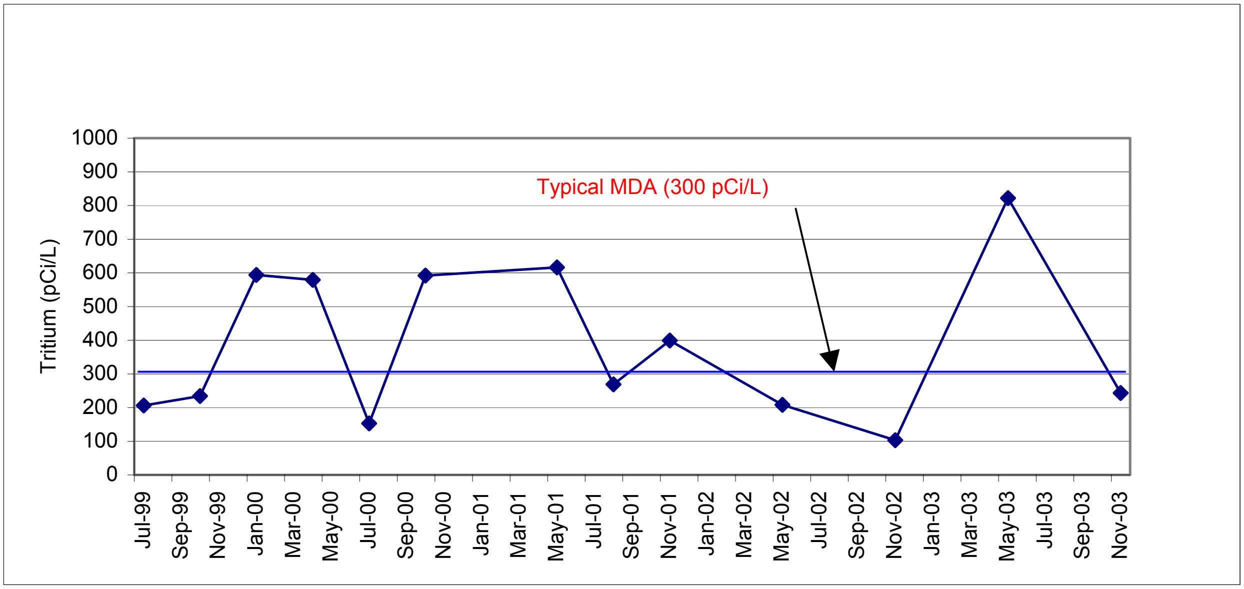

Figure 4-5: Maximum tritium concentrations downgradient of 914 Transfer Tunnel (wells 064-03, 064-53 and 064-54).

4.1.4.1 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 2003, the Building 914 area wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.1.4.2 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 2003, the maximum tritium concentration was 822 pCi/L, in a sample from downgradient well 054-54.

4.1.4.3 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 soils located below the building.

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

The g-2 experiment started operations in 1997. The beam line has a beam stop that is composed of iron. The iron beam stop is covered by soil. Like other beam loss areas within the AGS complex, the g-2 Beam Stop is an area where the soils surrounding the stop may become activated by the interaction with secondary particles. To prevent rainwater from infiltrating the soils surrounding the beam stop, BNL installed a gunnite cap over the stop area prior to the start of beam line operations.

In November 1999, monitoring wells located 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-December 1999 revealed a narrow plume of tritium, with a maximum tritium concentration of 1,800,000 pCi/L. Sodium-22 was detected at a concentration of 60 pCi/L, or 15% 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 located adjacent to the g-2 experiment's VQ12 Magnet. In December 1999, an impermeable cap was installed over the VQ12 soil activation area to prevent rainwater infiltration and the continued leaching the radionuclides out of the soils and into groundwater. In September 2000, the activated soil shielding and the associated tritium plume were designated as new sub-Area of Concern 16T. Following this designation, DOE agreed to prepare an EE/CA to evaluate the adequacy of the corrective actions taken to date, and the need for further actions. The EE/CA was provided to the regulatory agencies in December 2003.

4.1.5.1 Groundwater Monitoring

Well Network: A total of 27 wells are used to monitor the g-2 Beam Stop and the tritium plume that originates from the VQ12 magnet area (**Figure 4-1**). Groundwater quality downgradient of the g-2 Beam Stop is monitored using three downgradient wells, and the tritium plume originating from the VQ12 magnet area is monitored using 23 downgradient wells.

Sampling Frequency and Analysis: During 2003, the g-2 beam stop wells were monitored semiannually, and tritium plume wells were monitored quarterly. All samples were analyzed for tritium (**Table 1-7**).

4.1.5.2 Monitoring Well Results

g-2 Tritium Plume: Samples collected during 2003 from wells located approximately 150 feet downgradient of the VQ12 area indicate that tritium continues to be released to the groundwater, but at lower concentrations compared to 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 (well 054-07) in January to 113,000 pCi/L (well 054-185) in October (**Figure 4-6**). During 2003, 12 Geoprobe 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 415,000 pCi/L, which was detected in Geoprobe well GP-20. **Figure 4-2** shows the locations of the Geoprobe wells and the position of the g-2 tritium plume during 2003. The two segments of the plume are representative of two distinct periods of tritium release (also referred to as slug releases). The leading segment of tritium contamination was released in 1999 prior to the installation of the cap over the VQ12 area, whereas the second slug is related to tritium released in 2001–2002. As discussed below, the 2001–2002 release appears to be related to the flushing of residual tritium from the vadose zone following a significant rise in the local water table.

g-2 Beam Stop: During 2003, tritium was not detected in any of the three monitoring wells located downgradient of the g-2 beam stop.

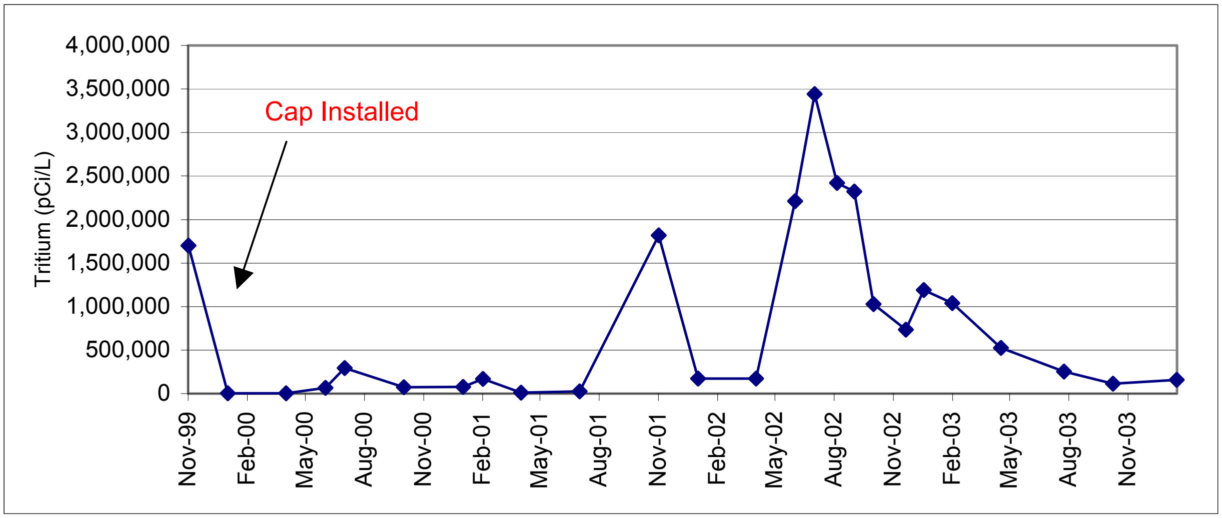

Figure 4-6. Maximum tritium concentrations downgradient of the g-2/VQ12 source area, in permanent and temporary wells located along the west side of Building 912A.

4.1.5.3 Groundwater Monitoring Program Evaluation

Inspections of the cap and review of its design have concluded that the cap over the VQ12 area has not failed and is properly positioned. The cap appears to be effective in preventing the infiltration of rainwater into the activated soil-shielding zone. The leading hypothesis at this time is that a natural rise in the water table may have released residual tritium from the unsaturated soil into the groundwater. It is believed that this tritium was mobilized to the soils close to the water table before the cap was put in place in December 1999. Water levels in the central BNL area in mid-2000 and mid-2001 were near the highest observed in 49 years of record by the U.S. Geological Survey. Once the cap was in place, the lack of additional rainwater infiltration essentially 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 VQ12, and the groundwater table elevation about one year prior to the sampling (**Figure 4-7**). The groundwater travel time from beneath the source to the monitoring wells is about one year. Additional details on the vadose zone release hypothesis and possible remedial actions are provided in the EE/CA for the g-2 tritium plume (BNL, 2003).

Monitoring of wells downgradient of the g-2 beam stop indicates that cap is effective in preventing rainwater from infiltrating the activated soil shielding.

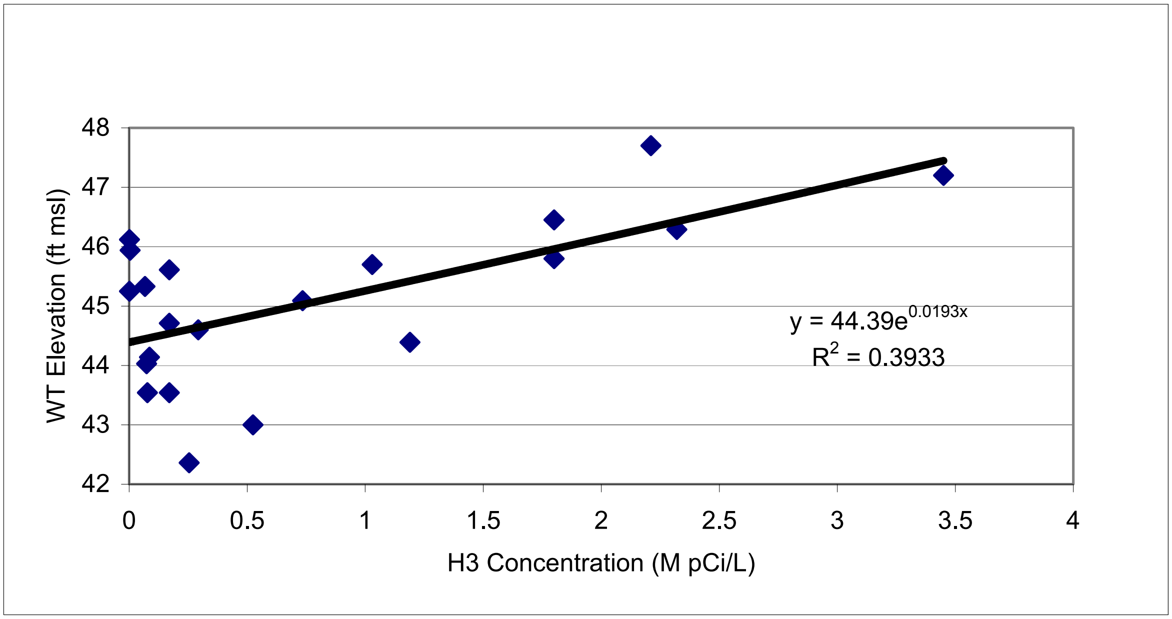

Figure 4-7. Tritium Concentration vs. Water Table Position Downgradient of g-2/VQ12 Magnet.

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 soils surrounding the tunnel adjacent to 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 above. The ability of rainwater to infiltrate potentially activated soils surrounding the J-20 is likely to be significantly reduced because the AGS tunnel has been covered by layers of sand, Styrofoam and soil-crete. In an effort to further reduce the potential for surface water to infiltrate activated soils, BNL constructed a gunite cap over remaining exposed soil areas overlying the J-10 region prior to its operation.

4.1.6.1 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 2003, the three J-10 beam stop wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

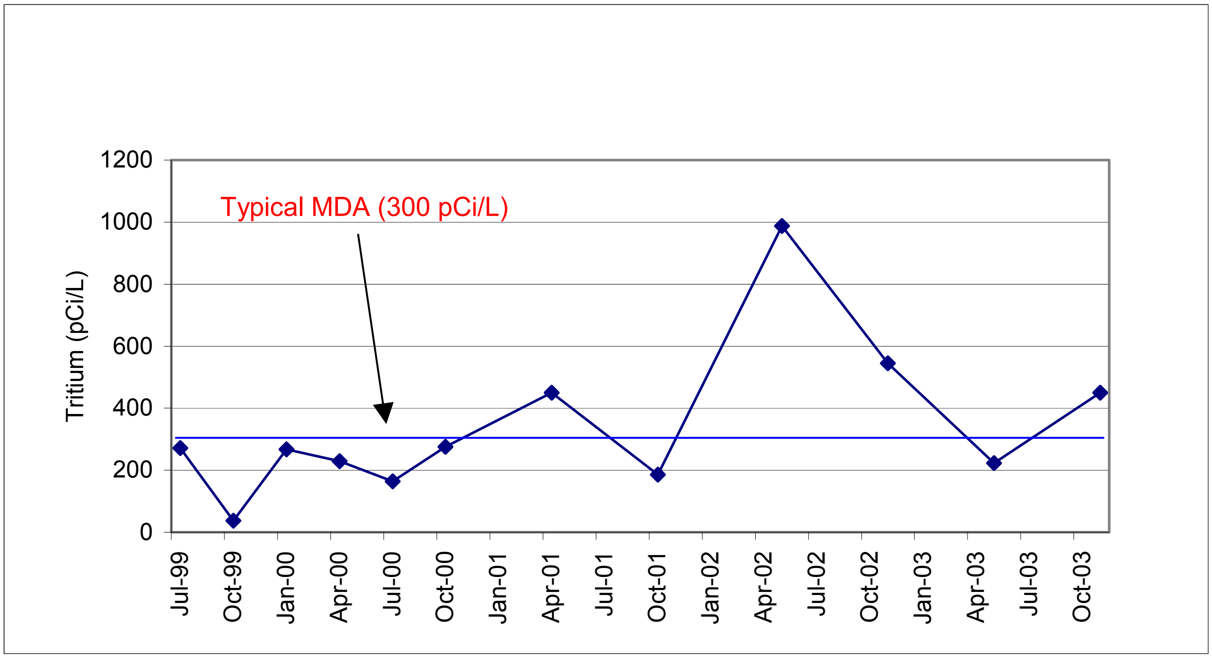

Figure 4-8: Maximum tritium concentrations in wells 054-63 and 054-64 located downgradient of the J-10 Beam Stop.

4.1.6.2 Monitoring Well Results

Since 2001, low-levels of tritium (up to 987 pCi/L) have been detected in downgradient well 054-64 (**Figure 4-8**). During 2003, the maximum tritium concentration was 450 pCi/L.

4.1.6.3 Groundwater Monitoring Program Evaluation

Available groundwater monitoring data suggest that the engineered controls in place at J-10 are providing control in preventing significant rainwater infiltration into the activated soil shielding. Although, low levels (<3 pCi/L) of sodium-22 (but not tritium) had been detected in this area of the AGS Ring even before beam-scraping activities at J-10 began in December 1999, the more recent detection of low levels of tritium suggests that some rainwater may be infiltrating the activated soils. Continued monitoring is required.

4.1.7 Former U-Line Target and Beam Stop Areas

The U-Line target area was in operation from 1974 through 1986. During its operation, a 28 giga-electron volt (GeV) 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 located in a ground-level tunnel covered with an earthen berm. Internal shielding was stacked around the horns. Although the U-Line target has not been in operation since 1986, the associated tunnel, shielding and overlying soils remain in place. The former U-Line 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 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 DWSs. In early 2000, BNL installed four Geoprobe wells downgradient of the former U-Line beam stop, which is located 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 stop soil activation area to prevent additional rainwater infiltration and the continued leaching the radionuclides out of the soils and into groundwater. By October 2000, a permanent cap was constructed over the U-Line stop area, and two additional permanent wells were installed to provide improved long-term monitoring of this source area.

4.1.7.1 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 U-Line area.

Sampling Frequency and Analysis: During 2003, the former U-Line area wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.1.7.2 Monitoring Well Results

U-Line Target Area: Low levels of tritium have been routinely detected in wells downgradient of the former U-Line target since monitoring began in July 2000 (**Figure 4-9**). The highest tritium concentration during 2003 was 321 pCi/L in well 054-130 located approximately 200 feet downgradient of the target area.

U-Line Beam Stop Area: Following the detection of tritium at concentrations up to 71,600 pCi/L in temporary wells installed downgradient of the Former U-Line beam stop in March–April 2000, BNL installed a temporary impermeable cap over the U-Line beam stop soil activation area to prevent additional rainwater infiltration into the activated soils. By October 2000, a permanent cap was constructed over the U-Line stop area, and two additional permanent wells were installed to provide improved long-term monitoring. During 2001–2003, tritium concentrations in downgradient wells were well below the 20,000 pCi/L DWS (**Figure 4-10**). During 2003, the maximum observed tritium concentration in wells closest to the target area was 577 pCi/L in well 054-128. Furthermore, low levels of tritium that are probably traceable to the former U-Line target and stop area were detected in upgradient well 055-14 (up to 1,060 pCi/L) and downgradient wells 055-31 and 055-32 (up to 3,510 pCi/L). Tritium detected in the Building 912 area wells is likely to have been released prior to capping the U-Line stop. For example, well 055-14 is located approximately 900 feet downgradient of the U-Line stop, and based upon distance of travel and rate of groundwater flow (~0.5 - 0.75 feet/day), the tritium detected in well 055-14 would have been released from the stop area three to four years ago.

4.1.7.3 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 observed in wells located downgradient of the U-Line beam stop since 2000, indicate that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soils surrounding the beam stop.

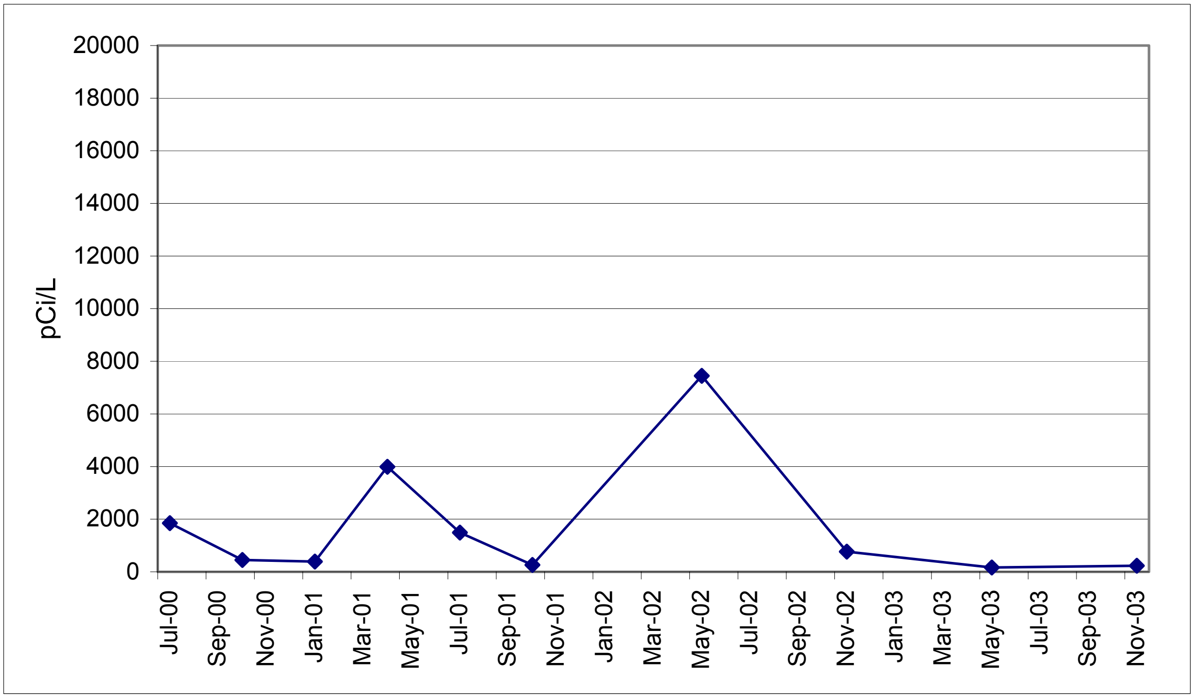

Figure 4-9: Maximum tritium concentrations well 054-129 located downgradient of the former U-Line Target.

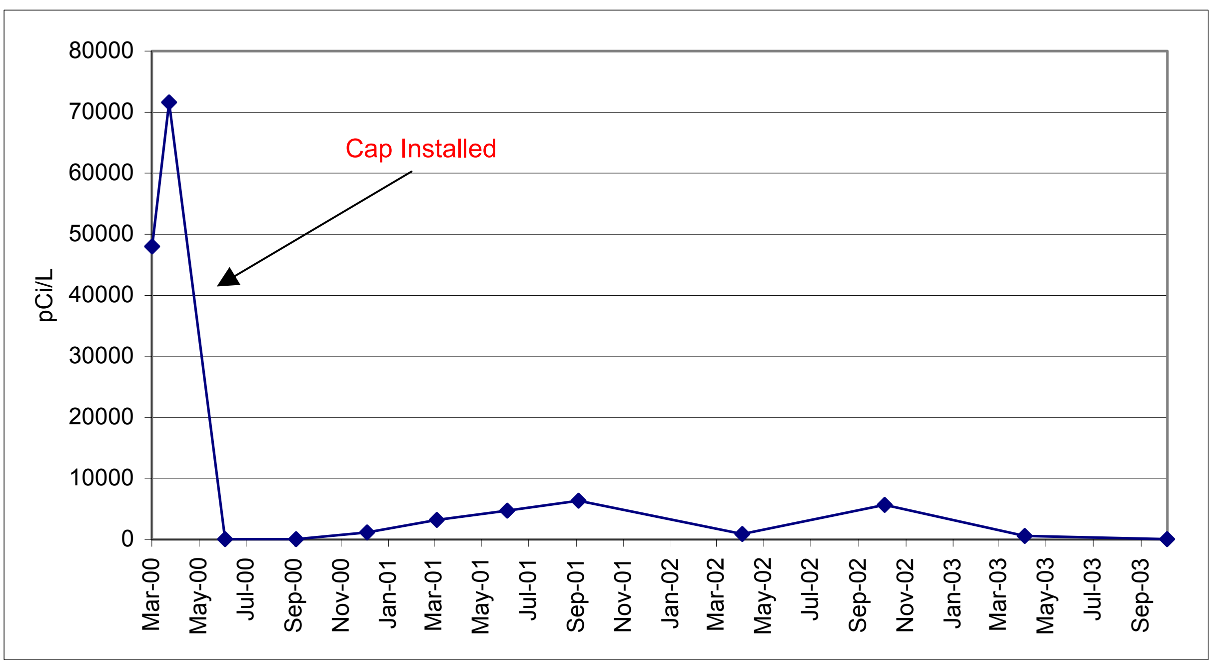

Figure 4-10. Maximum Tritium Concentrations in Temporary and Permanent Wells Located Downgradient of U-Line Stop

4.2 Brookhaven LINAC Isotope Producer (BLIP) Area

When the BLIP is operating, the LINAC delivers a 200 MeV beam of protons that impinge on a series of eight targets located within the BLIP target vessel. During irradiation, the BLIP targets are located at the bottom of a 30-foot underground tank. The targets rest inside a water-filled 18-inch diameter shaft that runs the length of the tank, and are cooled by a 300 gallon closed loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and activation of the soils immediately outside of the tank occurs due to the creation of secondary particles produced 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 vessel's outer wall is used as 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 gallon-capacity UST used 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 soils and the detection of tritium and sodium-22 in groundwater, the BLIP facility was been designated as AOC 16K under the Environmental Restoration program.

Starting in 1998, BNL made improvements to the stormwater management program at BLIP in an effort to prevent rainwater infiltration of the activated soils 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 (cement) cap was installed on the remaining three sides of the building. In May-June 2000, BNL undertook additional protective measures by injecting a colloidal silica grout into the activated soils. The grout reduces the permeability of the soils, thus further reducing the potential of rainwater leaching radionuclides should the surface water controls fail.

4.2.1 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 2003, most of the BLIP area wells were monitored quarterly. Because tritium concentrations in the three wells immediately downgradient of BLIP increased to >20,000 pCi/L early in 2003, these wells were monitored on a more frequent basis (eight times during 2003). All samples were analyzed for tritium, and select samples from several wells were analyzed for sodium-22 (**Table 1-7**).

4.2.2 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 soils 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 in late May-early June 2000 (**Figure 4-12**). Samples collected in early July 2000 indicated tritium and sodium-22 concentrations of 5,700 pCi/L and 57 pCi/L, respectively. By early 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 21, 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 released during the Viscous Liquid Barrier (VLB) grout project continued to migrate downgradient, tritium concentrations in well 064-50 increased, and reached a maximum of 60,800 pCi/L in July 2001. During the remainder of 2001 and 2002, tritium concentrations in well 064-50 fluctuated. Concentrations declined to less than 20,000 pCi/L by November 2001, increased to a maximum of 44,100 pCi/L in April 2002, then steadily declined to less than 5,000 pCi/L by July 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 the year, 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. Sodium-22 concentrations increased to a maximum of 185 pCi/L, well below the 400 pCi/L standard. Tritium concentrations in wells located 150 feet downgradient of BLIP were less than 5,000 pCi/L during the year.

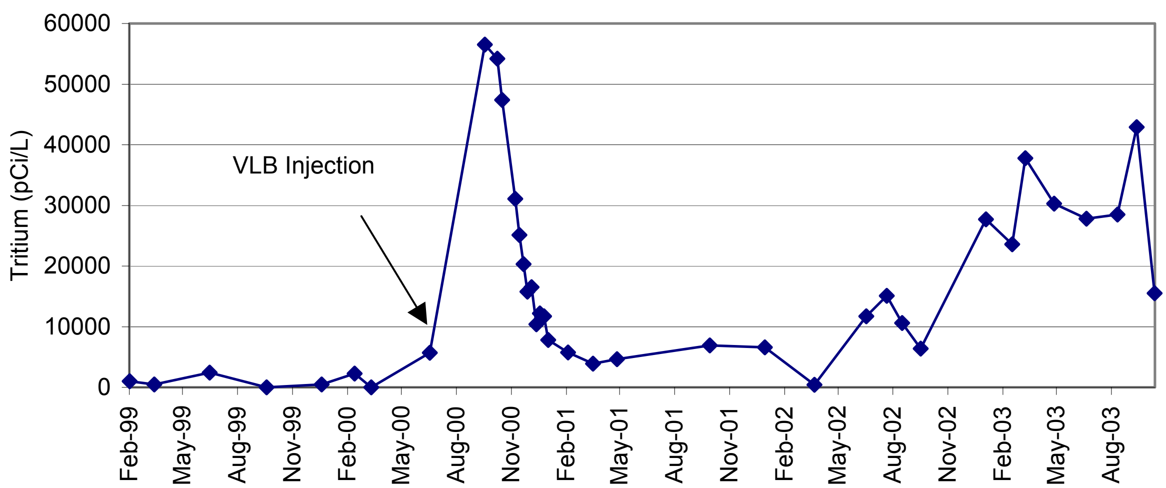

Figure 4-12. Maximum tritium concentrations in wells located approximately 40 feet downgradient of the BLIP target vessel.

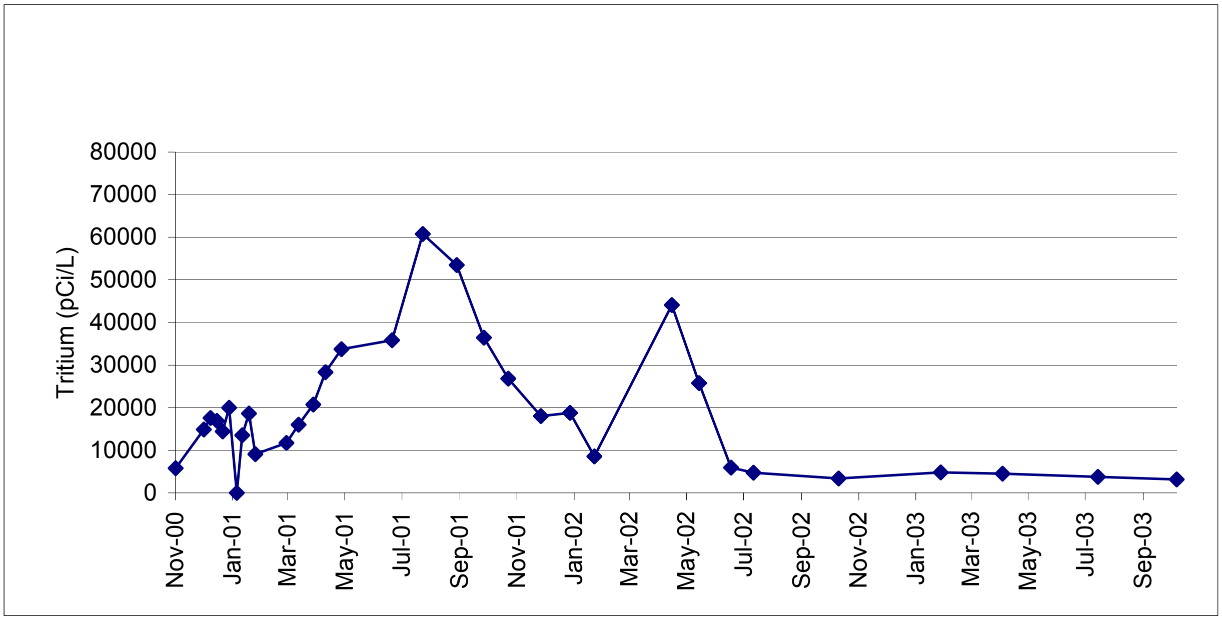

Figure 4-13. Maximum tritium concentrations in well 064-50 located approximately 150 feet downgradient of the BLIP target vessel.

4.2.3 Groundwater Monitoring Program Evaluation

Following the January 2003 increase in tritium concentrations, BNL implemented the Groundwater Protection Contingency Plan. Actions included notifying the regulatory agencies, increasing the groundwater sampling frequency from quarterly (12 week periods) to every six-weeks, and forming a technical team to review the condition and adequacy of current stormwater controls. An inspection of the BLIP facility found the gunite cap, the paved areas and the roof drains to be in good condition and effectively controlling stormwater infiltration. Although direct inspection of the VLB 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 may be correlated to a 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 was leached from the activated soils prior to capping in 1987 and from the grout injection project may have been flushed from the soils close to the water table. It is expected that the amount of tritium remaining in the vadose zone close to the water table will decline over time due to this flushing mechanism and by natural radioactive decay.

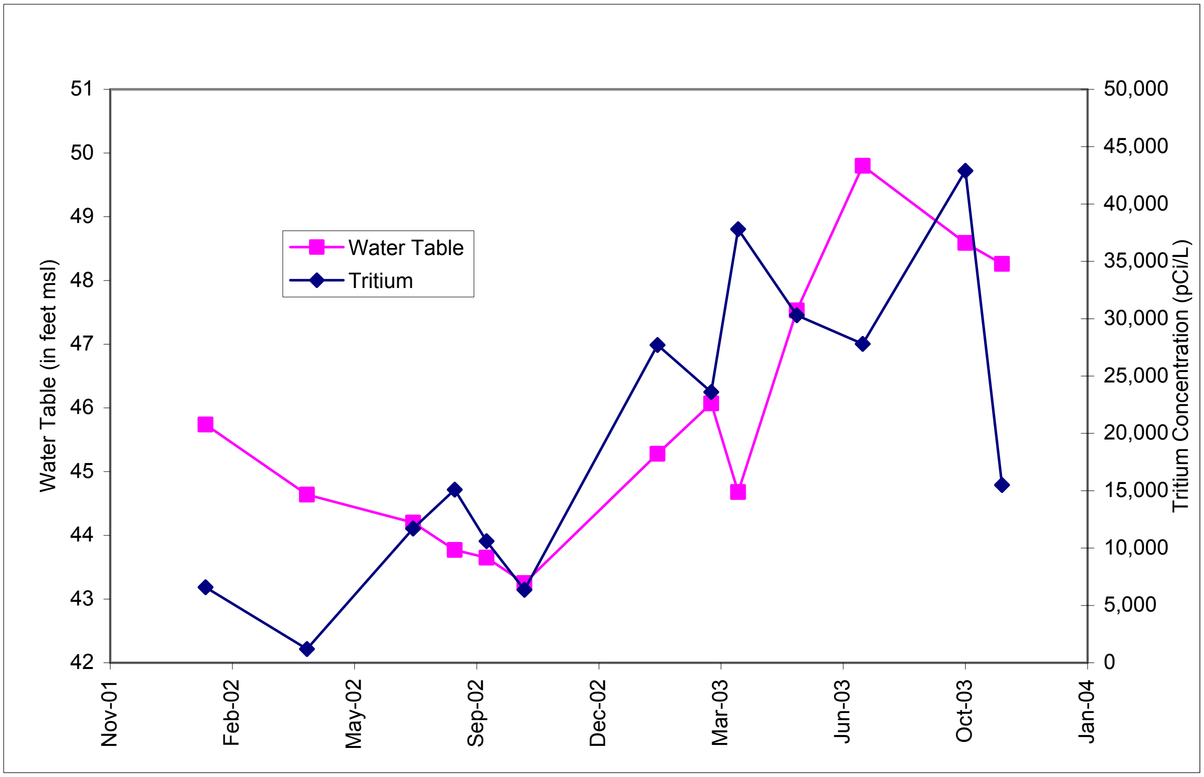

Figure 4-14: Tritium Concentration vs. Water Table Position Downgradient of BLIP.

4.3 Relativistic Heavy Ion Collider (RHIC)

Beam line interaction with the RHIC collimators and beam stops will produce secondary particles that will interact with some of the soils surrounding the 8 o'clock and 10 o'clock portions of the RHIC tunnel, and the W-Line stop. These interactions will result in the production of tritium and sodium-22, which could be leached out of the soils by rainwater. Prior to the start of RHIC operations, BNL installed impermeable caps over these beam loss areas to reduce the potential impact to environmental quality.

4.3.1 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 and downstream 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.

Sampling Frequency and Analysis: During 2003, groundwater samples were collected from the thirteen RHIC monitoring wells on a semiannual schedule, and the samples were analyzed for tritium (**Table 1-7**). 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 also collected semiannually, and analyzed for tritium.

4.3.2 Monitoring Well Results

As in past years, no tritium was detected in any of the groundwater samples, or in the surface water samples collected from the Peconic River both upstream and downstream of the beam stop area.

4.3.3 Groundwater Monitoring Program Evaluation

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps that were constructed over the RHIC beam stop and collimator areas have been effective in preventing rainwater infiltration into potentially activated soils.

4.4 Brookhaven Medical Research Reactor (BMRR)

The BMRR is a 3 MW light water reactor that was used for biomedical research. Research operations at the BMRR stopped in December 2000, and BNL is preparing plans to permanently decommission the facility.[2]

The BMRR's primary cooling water system consists of a recirculation piping system that contains 2,550 gallons of water containing high levels of tritium (tritium concentration in 1997 was 465 µCi/L). 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 are either stored within the reactor vessel, or were transferred to the HFBR spent fuel canal. The primary system's 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 process supply well 105 or the BNL Chilled Water System. This secondary water was discharged to recharge basin HP located 800 feet to the south of the Medical Department complex, and was monitored as part of the SPDES program.

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 tritium 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 (non-radioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soils 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 soils.

4.4.1 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 four groundwater monitoring wells are used

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[2] All spent fuel was removed from the BMRR in early 2003. Plans are being developed to drain the primary cooling water system.

to verify that the engineered and administrative controls described above are effective in preventing additional impacts to groundwater quality.

Sampling Frequency and Analysis: During 2003, the BMRR wells were monitored semiannually, and the samples were analyzed for tritium (**Table 1-7**).

4.4.2 Monitoring Well Results

Monitoring results for sampling conducted during 2003 indicate that tritium concentrations continued to be well below the 20,000 pCi/L DWS. Detectable levels of tritium were observed in two of the three downgradient wells, with the maximum value of 892 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 2002-2003 focused on tracking tritium concentrations in the groundwater.

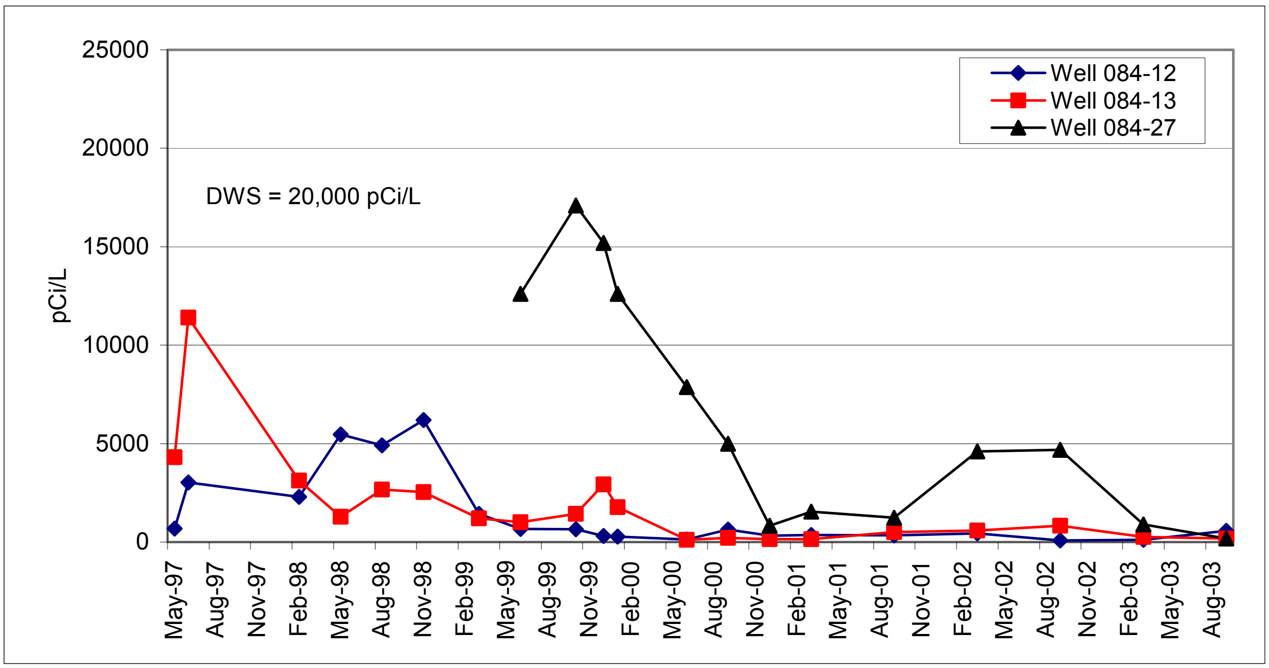

Figure 4-17. Tritium concentrations downgradient of the BMRR from 1997 through 2003.

4.4.3 Groundwater Monitoring Program Evaluation

Compared to the initial monitoring results from 1997, tritium concentrations in groundwater have shown a steady decline. Discontinuing the use of the BMRR's floor drains has apparently helped to reduce the movement of residual tritium from the soils surrounding the floor drain piping system to the groundwater.

4.5 Sewage Treatment Plant

The STP processes sanitary sewage for BNL facilities. The STP processes an average of 0.72 million gallons per day (MGD) during non-summer months and approximately 1.25 MGD during the summer months. Treatment of the sanitary waste stream includes: primary clarification to remove settleable solids and floatable materials; aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia; secondary clarification; sand filtration for final effluent polishing; and, ultraviolet disinfection for bacterial control prior to discharge into the Peconic River. By regulating the oxygen levels during the treatment process, nitrogen can be biologically removed by using nitrate bound oxygen for respiration. This discharge is regulated under a NYSDEC SPDES permit (NY-0005835).

Wastewater from the STP's clarifier is released to the sand filter beds, where the water percolates through three 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% 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 to the east of the sand filter bed area. The hold-up ponds are used for the emergency storage of 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 are equipped with fabric reinforced (hypalon) plastic liners that are heat-welded along all seams. The first lined hold-up pond was constructed in 1978, and has a capacity of approximately four million gallons. A second four million gallon capacity lined pond was constructed in 1989, for a combined capacity of nearly eight million gallons. The combined capacity of the hold-up ponds provides the Laboratory with the ability to divert all sanitary system effluent for approximately twelve days. 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 are now used as secondary containment.

4.5.1 Groundwater Monitoring

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 2003, 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 1-7**).

4.5.2 Monitoring Well Results

Radiological Analyses: Radioactivity levels in samples collected from the STP wells during 2003 were generally typical of ambient (background) levels. The exception was the detection of tritium at 1,690 pCi/L in the sample from well 039-88, which is located downgradient of the holding ponds. Low levels of tritium (up to 2,500 pCi/L) have been detected in one or more of the holding pond area wells since they were installed in 2000. Because the ponds have not been used recently to hold tritiated waste water and the wells are also located downgradient of the filter bed area, it is likely that the tritium originated from past water releases to the filter beds.

Non-radiological Analyses: During 2003, all water quality and most metals concentrations were below the applicable NYS AWQS. Sodium was detected at concentrations slightly above the NYS AWQS of 20 milligrams per liter (mg/L) in filter bed area well 039-86, at a maximum concentration of 33.3 mg/L. Nitrates were detected in most STP area wells, with a maximum concentration of 7.4 mg/L detected in filter bed area monitoring well 039-08. The NYS AWQS for nitrate is 10 mg/L. No VOCs were detected in any of the monitoring wells.

4.5.3 Groundwater Monitoring Program Evaluation

Monitoring results for 2003 indicate that STP operations are not having a significant impact on groundwater quality, and that BNL's administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system have been highly effective.

4.6 Motor Pool and Facility 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 the historical use of USTs for the storage of gasoline, diesel fuel and waste oil, hydraulic fluids used for lift stations, and 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 with 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-capacity USTs used for the storage of unleaded gasoline, one 260 gallon-capacity above ground storage tank used for waste oil, and one 3,000 gallon-capacity UST for Number 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 spills have been remediated at the Motor Pool. In February 1998, it was discovered that hydraulic fluid was leaking from one of the lift stations (BNL Spill Number 98-14). The lift was excavated and soils below the lift were contaminated with hydraulic oil. Approximately 50 cubic yards of the most contaminated soils were removed. In March 2002, an inactive 275 gallon-capacity UST that was used for diesel fuel was removed. Following the removal of the tank, it was discovered that the tank had several small holes and that fuel oil had leaked into the surrounding soils. Approximately twenty cubic yards of soil were removed. Although the endpoint sample had a petroleum smell, analysis of the sample did not detect any of the target compounds of concern.

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. During the removal of an underground propane tank, the surrounding soils were contaminated with petroleum hydrocarbons (BNL Spill Number 96-54). The site was excavated to the extent that the footings of the building were almost undermined. Although approximately 60 cubic yards of contaminated soil were removed, there was clear evidence that contaminated soils remained. In an effort to investigate the potential impact to groundwater quality, four wells were installed. Although groundwater monitoring detected the presence of the solvent TCA at concentrations above NYS AWQS, petroleum hydrocarbons were not detected in groundwater downgradient of the spill site.

4.6.1 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 wells (102-05 and 102-06) 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, 102-11, 102-12, and 102-13). 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 2003, the UST area wells were monitored semiannually, and the samples were analyzed for VOCs. The wells were also checked for the presence of floating petroleum hydrocarbons on a semiannual basis (**Table 1-7**). The Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs.

4.6.2 Monitoring Well Results

Underground Storage Tank Area: During 2003, MTBE was the only chemical related to gasoline products detected in groundwater downgradient of the gasoline UST area. Compared to previous years when MTBE concentrations were less than the 10 μg/L NYS AWQS, MTBE concentrations in well 102-06 increased to 33.8 μg/L in March 2003, then decreased to 13 μg/L by September (**Figure 4-20**). As in past years, low levels of the solvent TCA was also detected, but at concentrations that continue to be below the NYS AWQS of 5 μg/L. Wells 102-05 and 102-06 were also tested semiannually for the presence of floating petroleum hydrocarbons. As in previous years, no floating product was observed.

Building 423/326 Area: As in previous years, TCA was detected in all four wells during 2003, with concentrations ranging from 6 μg/L to 53.4 μg/L (**Figure 4-21**). 1,1-DCA was detected in well 102-11 and 102-12 at concentrations up to 14.8 μg/L. The gasoline additive MTBE was detected in all four wells, with a maximum observed concentration of 27.3 μg/L. It is believed that the TCA, DCA and MTBE originate from historical vehicle maintenance operations.

4.6.3 Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the Motor Pool facility during 2003 indicates that releases from historical operations continue to impacted 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). In response to the increased MTBE concentrations in Motor Pool well 102-06, personnel from Staff Services reviewed the product reconciliation records and the procedures for these facilities. Based upon this review, there were no indications of leaks in the USTs or associated piping. Therefore the MTBE is not originating from a tank or distribution line leak. MTBE was used as a gasoline additive from 1977 through early 2003, and has been detected at low levels in the Motor Pool wells since the groundwater monitoring program began in 1996. The detection of both MTBE and TCA is consistent with the contamination routinely detected in the nearby wells that are monitoring Bldg. 423/326, and are likely to have originated from historical spills near Bldg. 423. The increase in MTBE levels during 2003 may have been related to a slight southwesterly shift in groundwater flow direction resulting from increased pumpage from BNL water supply well 7.

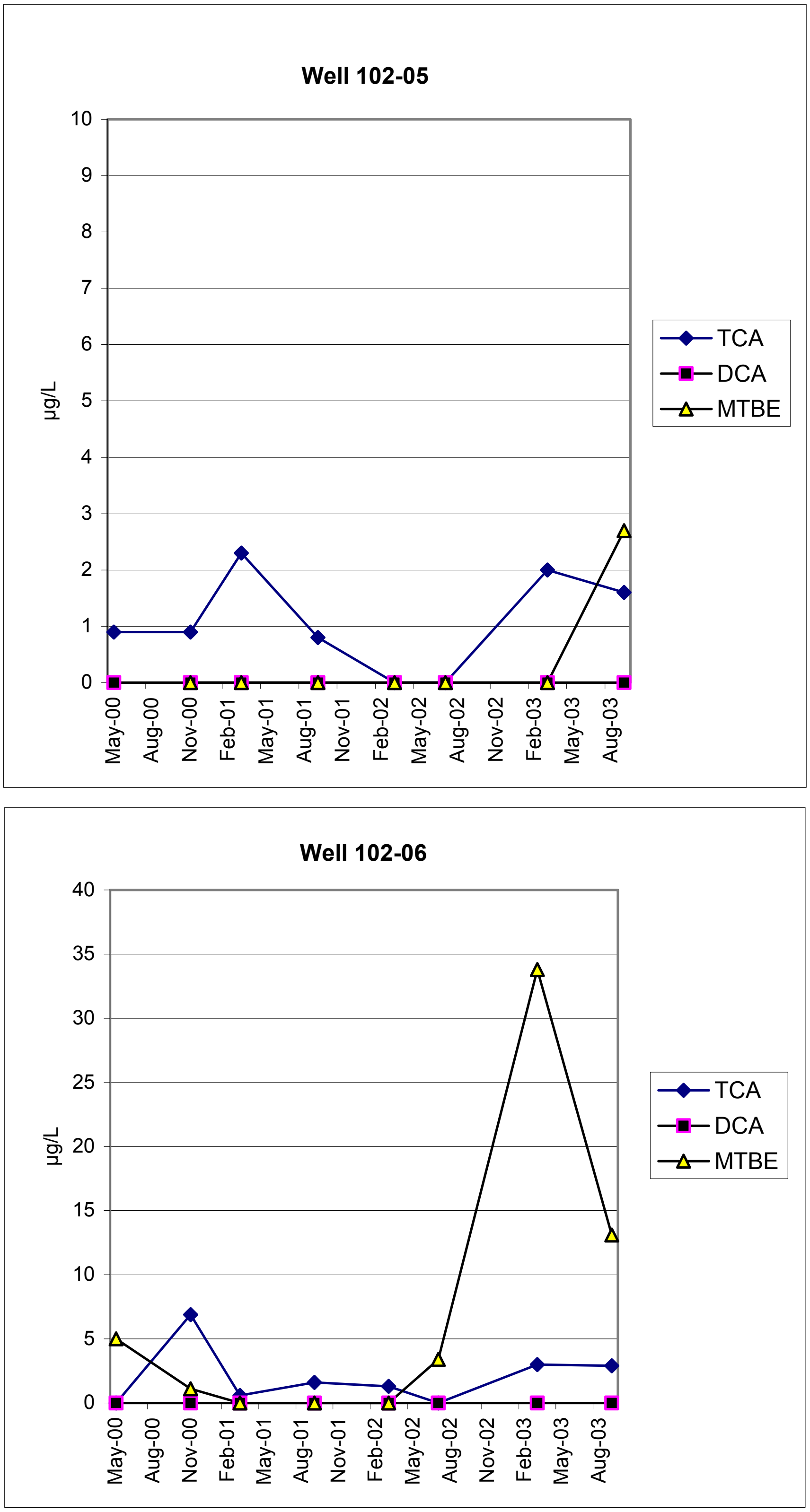

Figure 4-20. VOC concentration trends downgradient of the gasoline UST area.

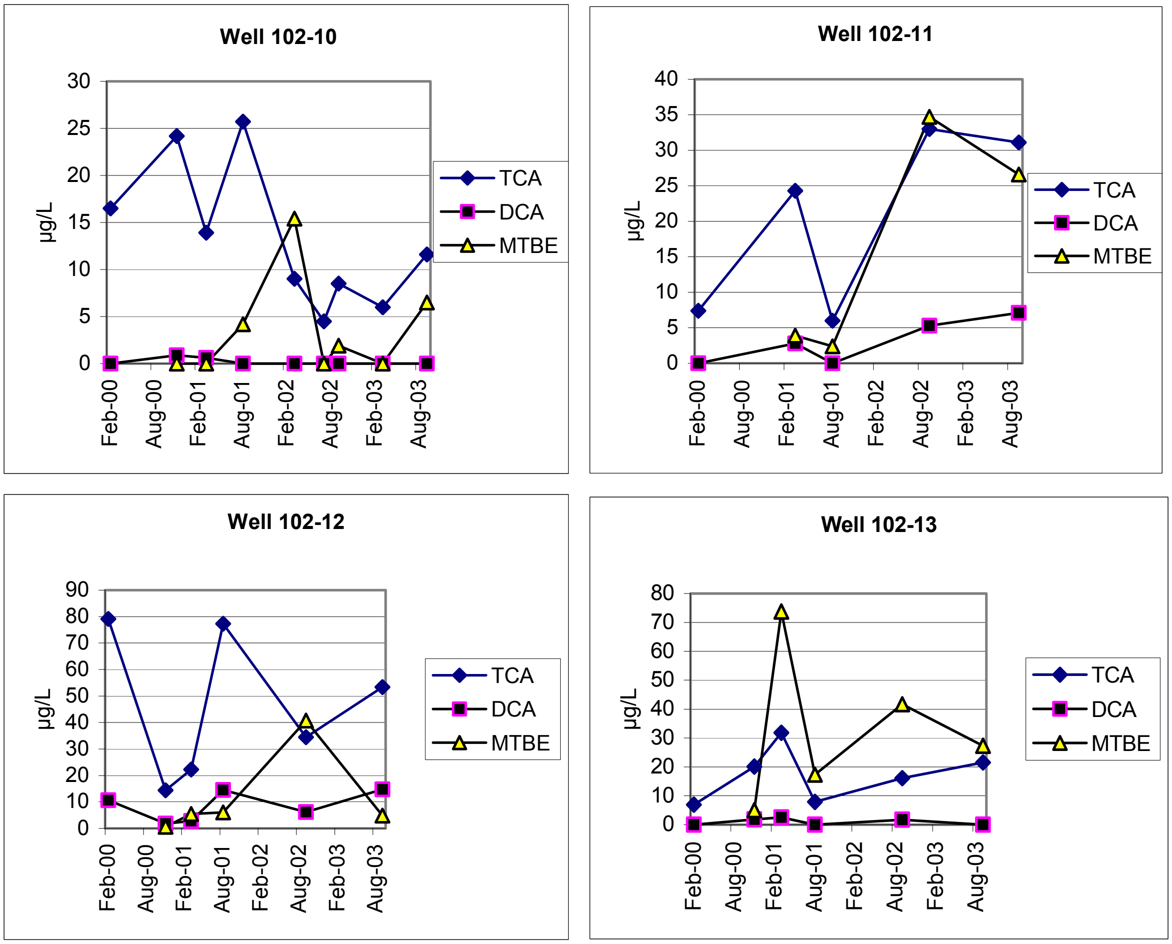

Figure 4-21. VOC concentration trends in wells downgradient of Building 323/326.

4.7 On-Site Service Station

Building 630 is a commercial automobile service station, which is privately operated under a contract with BNL. The station, which was built in 1966, 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 two 8,000 gallon-capacity and one 6,000 gallon-capacity tanks for the storage of gasoline, and one 500 gallon-capacity 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 present tank inventory includes three 8,000 gallon-capacity USTs used for the storage of unleaded gasoline, and one 500 gallon-capacity UST used for waste oil. The facility also has three 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 an UST from an area located approximately 200 feet to the northwest (upgradient) of the Service Station. Although there are indications that the tank was releasing small quantities of carbon tetrachloride prior to its removal, the significant increase in carbon tetrachloride concentrations in groundwater indicates 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.

4.7.1 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 2003, the Service Station facility wells were monitored on a quarterly basis, primarily by the Environmental Restoration program as part of the Carbon Tetrachloride Plume monitoring project. The samples were analyzed for VOCs (**Table 1-7**). The wells were also checked semiannually for the presence of floating petroleum hydrocarbons.

4.7.2 Monitoring Well Results

During 2003, carbon tetrachloride continued to be observed in the service station monitoring wells (**Figure 4-23**). The maximum carbon tetrachloride concentration was 278 μg/L, observed in well 085-17 in May 2003. The NYS AWQS for carbon tetrachloride is 5 μg/L. Carbon tetrachloride concentrations decreased during the year, with concentrations dropping to less than 120 μg/L by September. These concentrations are considerably less than those observed in CY 2000, when carbon tetrachloride concentrations in wells near the service station approached 4,500 μg/L, and reflects the effectiveness of the groundwater restoration system (see **Section 3.2.1** for details).

In addition to the carbon tetrachloride contamination from the former UST area, groundwater quality has been affected by a variety of petroleum- and solvent-related VOCs that appear to be related to historical Service Station operations. During 2003, high levels (>100 μg/L) of petroleum-related compounds such as xylene and ethylbenzene were detected in wells 085-17 and 085-236, and 085-237 (**Figures 4-24, 4-25, and 4-26**, respectively). Samples collected from well 085-17 in July 2003 indicated petroleum related compounds such as m/p xylene at 129 μg/L, o-xylene at 108 μg/L, 1,2,4-trimethylbenzene at 60 μg/L, and 1,3,5-trimethylbenzene at 22 μg/L. A similar increase in these compounds was detected in samples collected from well 085-236 in March 2003. The solvent PCE was also detected, with a maximum concentration of 22 μg/L observed in the July sample from well 085-17.

The gasoline additive MTBE continues to be detected wells 085-236 and 085-237 at concentrations exceeding the NYS AWQS of 10 μg/L. MTBE levels increased from a maximum concentration of 32 μg/L in 2002, to a maximum concentration of 144 μg/L in the July 2003 sample from well 085-237. MTBE levels dropped to <50 μg/L by October 2003.

4.7.3 Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the Service Station facility during 2003 indicates that releases from historical operations continue to impacted 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). In response to the increased MTBE concentrations during 2003, personnel from Staff Services reviewed the product reconciliation records and the procedures. Based upon this review, there were no indications of leaks in the USTs or associated piping. Therefore, it is believed that the petroleum hydrocarbon related compounds and solvents detected in groundwater originate from historical vehicle maintenance and fuel dispensing operations prior to improved chemical storage and handling controls implemented in 1989.

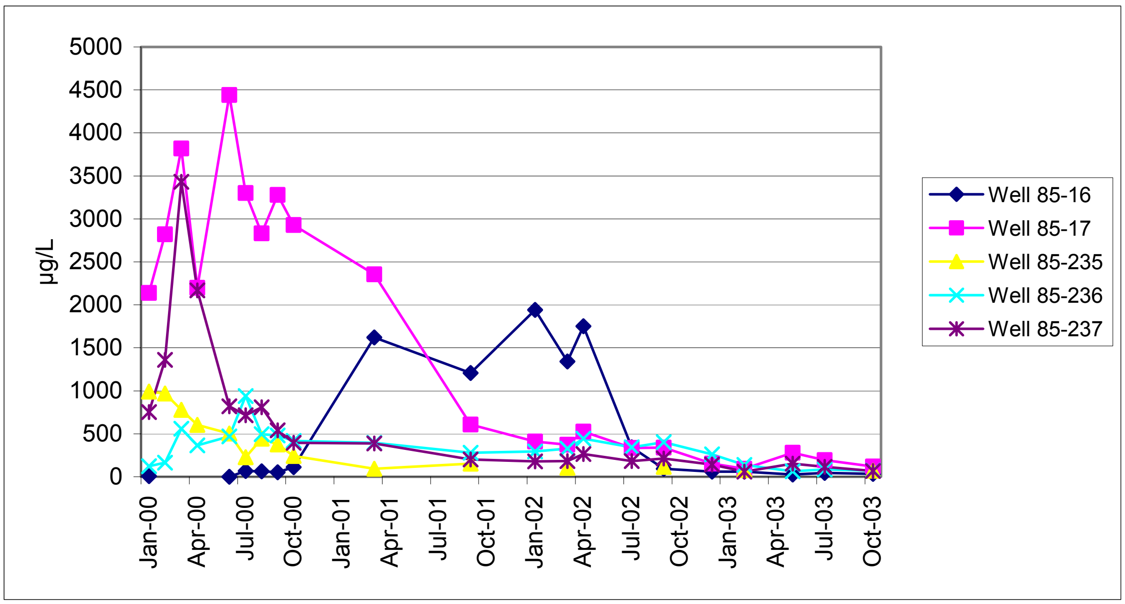

Figure 4-23: Carbon tetrachloride concentration trends in Service Station monitoring wells.

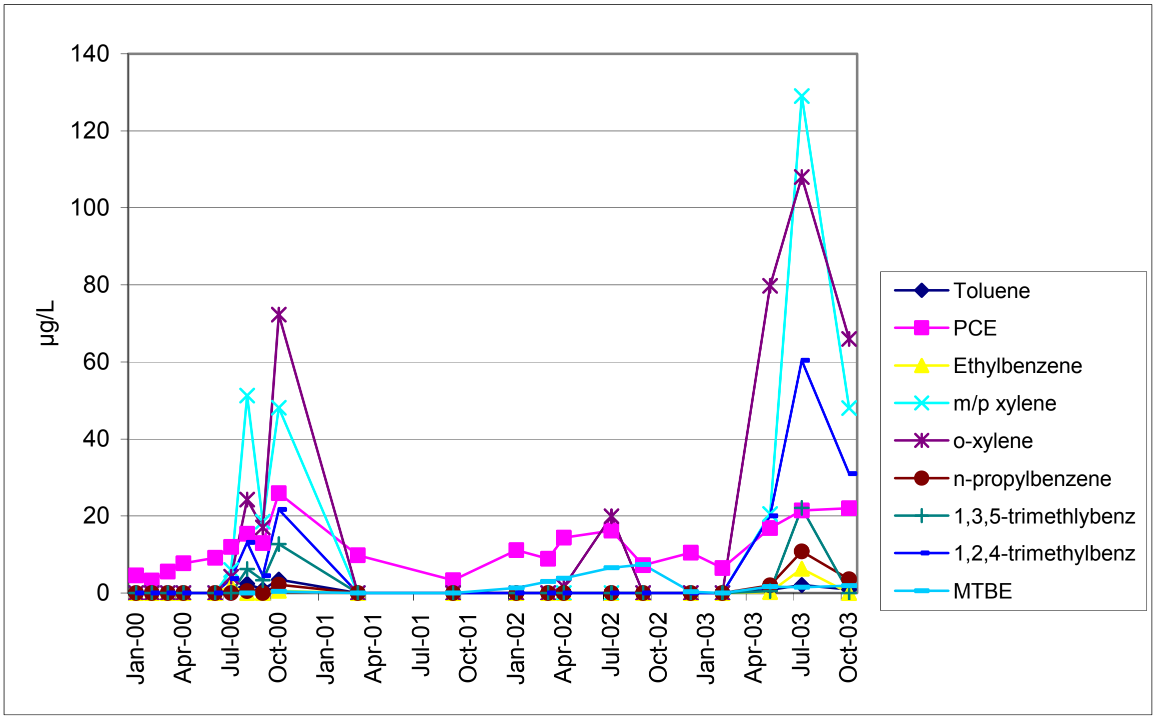

Figure 4-24. Trend of Service Station Related VOCs in Downgradient Well 085-17. Note that carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.

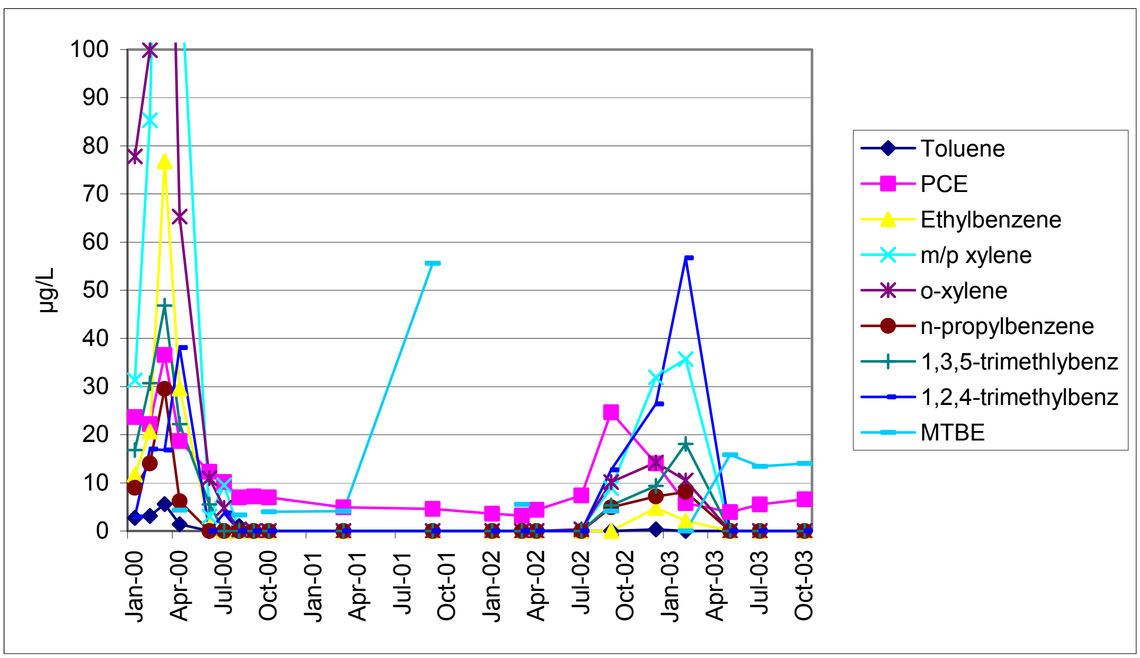

Figure 4-25. Trend of Service Station Related VOCs in Downgradient Well 085-236. Note that carbon tetrachloride from the upgradient carbon tetrachloride UST source area is not included.

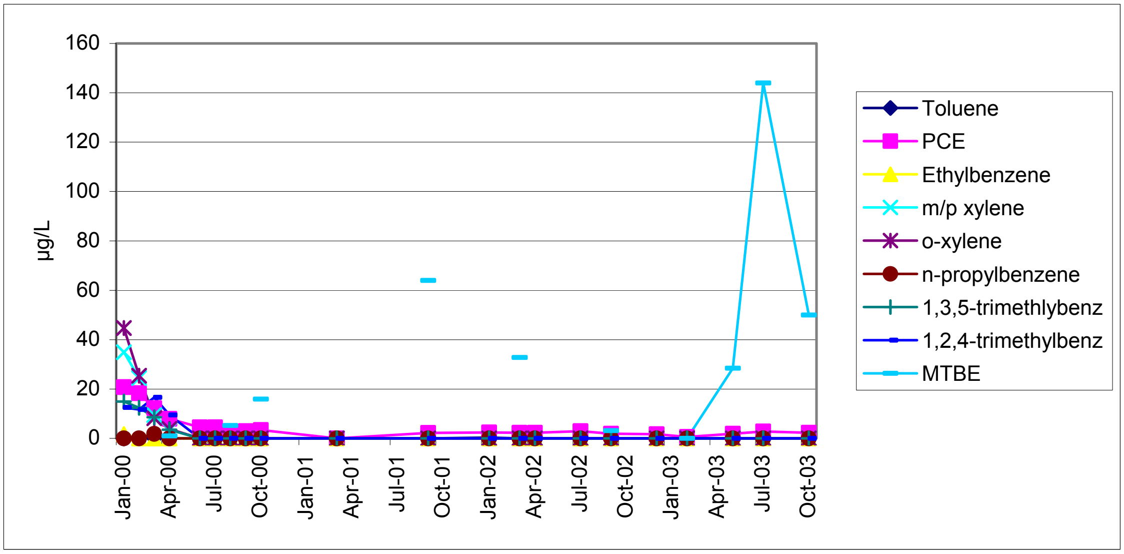

Figure 4-26. Trend of Service Station Related VOCs in Downgradient Well 085-237. Note that carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.

4.8 Major Petroleum Facility (MPF) Area

The MPF is the holding area for fuels used at the CSF. Fuel oil for the CSF is held in a network of seven above ground storage tanks, two of which are currently inactive. The tanks, which have a combined capacity to contain up to 2.3 million gallons of #6 fuel oil and 60,000 gallons of #2 fuel oil, are connected to the CSF by above ground pipelines that have secondary containment and leak detection devises. All fuel storage tanks are located in bermed containment areas that have a capacity to hold >110% of the volume of the largest tank located within each bermed area. The bermed areas have bentonite clay liners consisting of either Environmat (consisting of bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soils to form an impervious soil/clay layer. As of December 1996, all fuel unloading operations were consolidated in one centralized building that has secondary containment features. The MPF is operated under NYSDEC Permit #1-1700, and as required by law, a SPCC and a Facility Response Plan (FRP) have been developed for the facility.

4.8.1 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, the NYSDEC expanded the required list of analyses to include VOCs, including testing for MTBE (**Table 1-7**). Although MTBE is a common gasoline additive, it can apparently be introduced to fuel oil as a contaminant during the storage and transportation process.

4.8.2 Monitoring Well Results

BNL sampled the MPF wells in April and October 2003. As required by the NYSDEC, the samples were tested for SVOCs and VOCs. As in the past, no SVOCs were detected, and no floating product was observed. However, VOCs continued to be detected in several wells at concentrations exceeding the NYS AWQS of 5 µg/L. 1,1,1-trichloroethane (TCA) was detected in upgradient well 076-25 at a concentration of 15 µg/L. Low levels of TCA have been detected in this well for many years, and it probably originates from a solvent spill area near Building 650. (Note: Solvent spill areas along the north side of Building 650 were evaluated during the Operable Unit IV RI.) Degreasing solvents continued to be detected in downgradient well 076-380, but at lower concentrations compared to 2002 (**Figure 4-28**). 1,2-dichloroethene *(total)* was detected at a concentration of 22 µg/L, PCE at 38 µg/L, and TCE at 7.3 µg/L. (Note that 1,2-dichloroethene is a breakdown product of PCE.)

In an effort to identify the source of the VOC contamination, in early 2003 BNL installed four temporary Geoprobe wells, with three wells located downgradient of the suspected source areas near Bldg. 610. Only downgradient Geoprobe well MPF-GP-03 had detectable levels of VOCs, with PCE at a concentration of 6.6 µg/L and cis-1,2-DCE at a concentration of 14.5 µg/L. Although MPF-GP-03 was located downgradient of the former “oil tank valve house,” a source closer to Building 610 cannot be ruled out.

4.8.3 Groundwater Monitoring Program Evaluation

Following the 2002 detection of 1,2-DCE in well 076-380 (up to 566 µg/L), BNL implemented the Groundwater Contingency Plan, which included confirmatory and increased sample frequency for well 076-380, regulatory agency notifications, evaluation of available records on solvent use at the CSF, groundwater modeling, and the installation of temporary monitoring wells. Although a source for the VOCs cannot be definitely identified, the VOCs are likely to have originated from an historical spill near Bldg. 610. The historical nature of this spill 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) the presence of 1,2-dichloroethene, which is a breakdown product of PCE. A number of historical spill sites near the CSF were identified in the late 1990s, and the most contaminated soils were subsequently excavated in accordance with regulatory requirements.

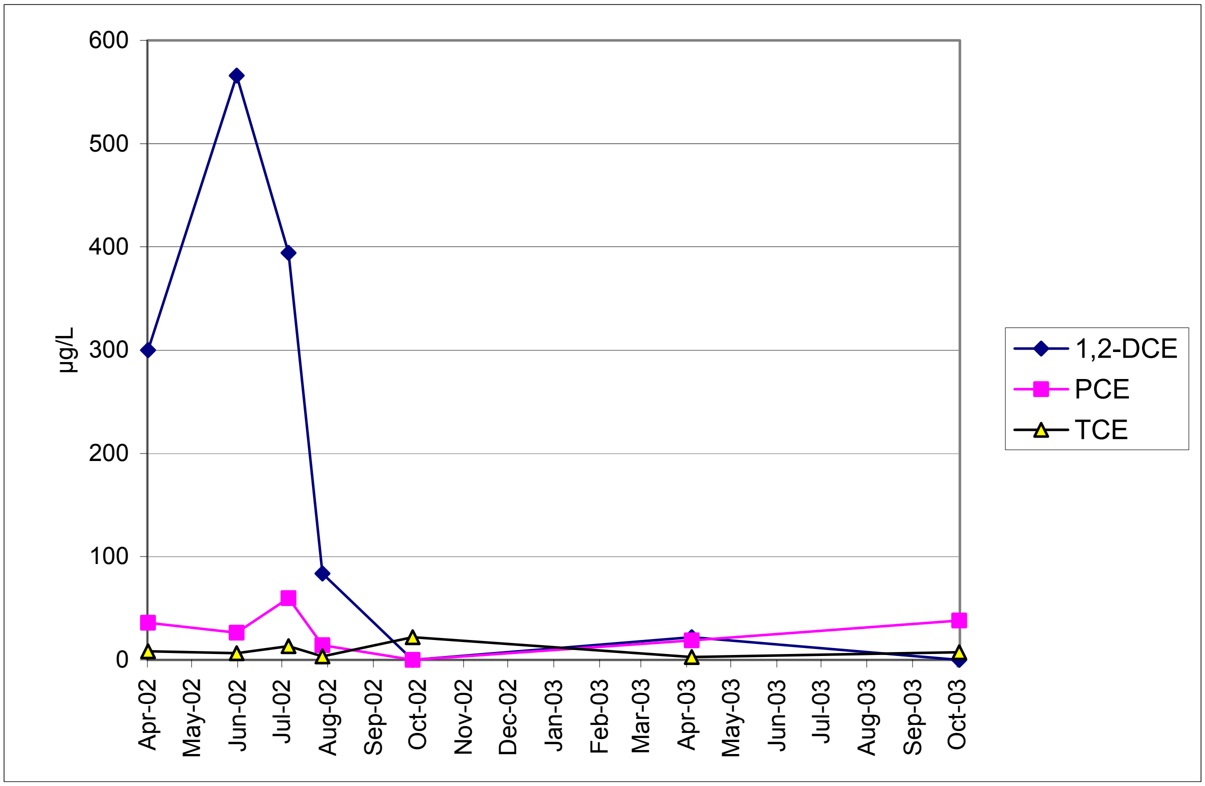

Figure 4-28. VOC concentrations downgradient of MPF in well 076-380.

4.9 Waste Management Facility (WMF)

Groundwater monitoring is a requirement of the RCRA Part B permit issued for WMF operations. The WMF is located adjacent to BNL Potable Supply Wells 11 and 12, which are located south of East Fifth Avenue and just north of the WMF site. Because of the close proximity of the WMF to Potable Wells 11 and 12, it is imperative that the engineered and institutional controls discussed above are effective in ensuring that waste handling operations at the WMF do not degrade the quality of the soils and groundwater in this area. 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.

4.9.1 Groundwater Monitoring

Well Network: Eight wells are used to monitor for potential contaminant releases from the three main waste handling and storage buildings (**Figure 4-29**). Four wells are used to assess background water quality, whereas four are positioned downgradient of the three waste handling and storage buildings.

Sampling Frequency and Analysis: During 2003, the WMF wells were monitored three times, and the samples were analyzed for VOCs, metals, anions, tritium, gamma spectroscopy, gross alpha, and gross beta (**Table 1-7**).

4.9.2 Monitoring Well Results

<u>Radiological Analyses</u>: Gross alpha and beta concentrations in samples from both upgradient and downgradient monitoring wells are consistent with background concentrations, and no Laboratory related gamma-emitting radionuclides were identified. During the year, 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**). Although these 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 the quality of water obtained from 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 increased to 2,430 pCi/L in November 2003. Although a definitive source for the tritium has not been identified to date, 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 an upgradient source (**Figure 4-31**).

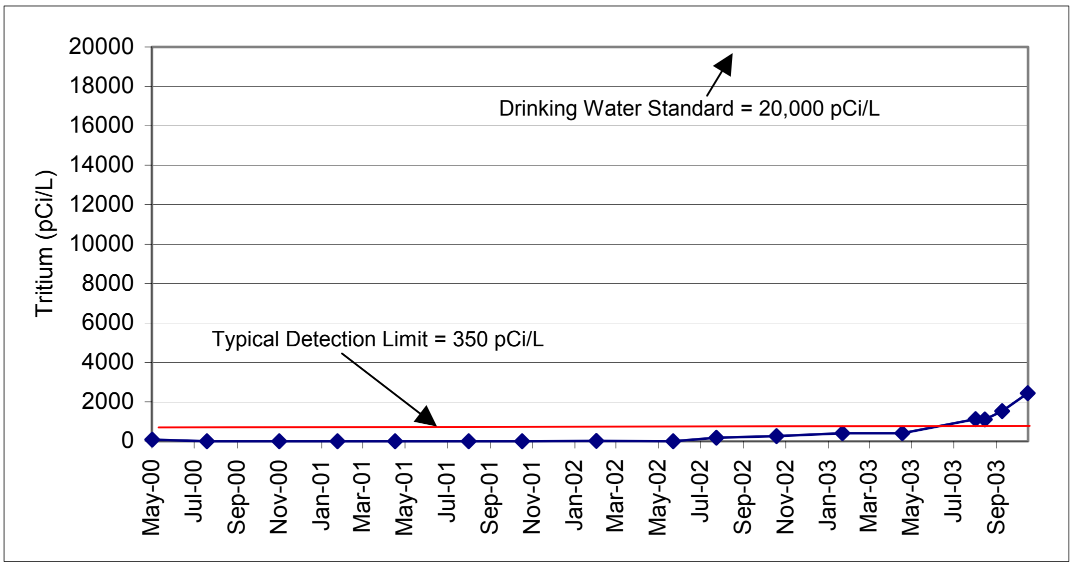

Figure 4-30. Tritium concentration trends in well 056-23 downgradient of Waste Management Facility.

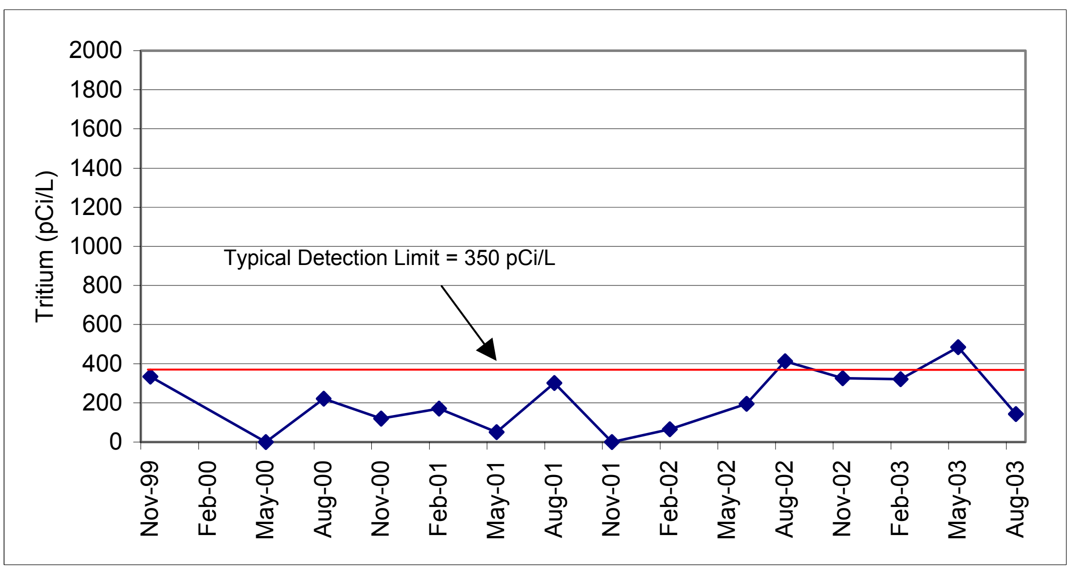

Figure 4-31. Tritium concentration trends in well 066-07 upgradient of Waste Management Facility.

Non-radiological Analyses: All anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable NYS AWQS (see Tables 2 and 3). As in past years, sodium was detected at concentrations slightly above the NYS AWQS of 20 mg/L in several wells. Sodium was detected in upgradient wells 055-03 and 066-07 at concentrations of 27.9 mg/L and 22.9 mg/L, respectively, and in RCRA Building area well 056-21 at a concentration of 21.3 mg/L. No VOCs were detected at concentrations above NYS AWQS during 2003. Trace levels (<1 μg/L) of chloroform were occasionally detected in upgradient wells 055-03, 055-10, 066-03, and downgradient well 066-84. Trace levels (up to 1.3 μg/L) of TCA were also detected in upgradient well 066-06.

4.9.3 Groundwater Monitoring Program Evaluation

Groundwater monitoring results for CY 2003 are consistent with previous years monitoring, and continue to show that WMF operations are not affecting groundwater quality. There were no outdoor or indoor spills at the facility that could have impacted soil or groundwater quality. Except for low-levels of sodium detected in several upgradient wells and one downgradient well, all chemical and radionuclide concentrations were below New York State Drinking Water or Ambient Water Quality Standards. Low levels of the radionuclide tritium were detected in one upgradient and one downgradient well, with a maximum concentration of approximately 1/20th of the DWS. In response, to this detection BNL collected additional samples from several monitoring wells and nearby water supply wells. Although a definitive source for the tritium has not been identified to date, a thorough review of waste management operations suggests that the tritium was not released from the WMF. Rather, the periodic detection of tritium in an upgradient well suggests that the tritium was an historical release from another facility or system.

In September 2003, the NYSDEC approved BNL's request to modify the RCRA Part B Permit groundwater monitoring requirements. As a result, the monitoring frequency will be reduced to semiannual analyses for gross alpha, gross beta, gamma, and VOCs and annual analyses for metals and anions.

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 cesium-137, Sr-90 and tritium at levels that exceeded DWSs. It is believed that the floodwater became contaminated when it came into contact with the basement floor, which contains significant residual contamination from historical spills. When the floodwater was pumped from the basement on March 8, 2002, approximately 4,950 gallons of contaminated water was removed. Taking into account possible losses due to evaporation, it was estimated that between 1,350 and 2,750 gallons of contaminated floodwater might have escaped into the soils below Building 801. To evaluate the potential impact that this release may have on groundwater quality, BNL initiated monthly monitoring of three existing downgradient monitoring wells, and installed a new water table well closer to the building.

4.10.1 Groundwater Monitoring

Well Network: From May through October 2002, three existing downgradient wells were sampled. Well 065-169 is located approximately 10 feet south of Building 801, whereas wells 065-37 and 065-170 are located approximately 80 feet downgradient of the building (**Figure 4-32**). These wells were installed in 1999 to monitor historical releases from the WCF and the former Pile Fan Sump area. Well 065-37 is screened close to the water table, whereas well 065-169 and 065-170 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 2003, Building 801 monitoring well 065-325 was sampled three times under the Environmental Surveillance program (**Table 1-7**). Monitoring wells 065-37, 065-169 and 065-170 were sampled semiannually under the Environmental Restoration program. The samples were analyzed for gross alpha, gross beta, Sr-90, cesium-137 and tritium.

4.10.2 Monitoring Well Results

The January, April and October 2003 samples from well 065-325 had Sr-90 concentrations of 33.4 pCi/L, 46.8 pCi/L, and 54.2 pCi/L, respectively (**Figure 4-33**). No cesium-137 or tritium was detected in any of the samples. Stronitium-90 in slightly deeper well 065-37 ranged from 22.6 pCi/L in April to 4.4 pCi/L in November 2003.

4.10.3 Groundwater Monitoring Program Evaluation

Sr-90 concentrations in samples collected during 2003 from shallow groundwater wells located downgradient of Building 801 are consistent with pre-December 2001 values. Additionally, cesium-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 cesium-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.

Because of the slow migration rates for Sr-90 and cesium-137 the monitoring frequency for well 065-325 continue to be semiannually, and the monitoring will coincide with planned semiannual sampling of wells 065-37, 065-169 and 065-170 by the EM Sitewide Groundwater Monitoring Program. EM is planning additional groundwater characterization efforts in an effort to define the extent of legacy Sr-90 contamination in the BGRR/Building 801/PFS area in 2004.

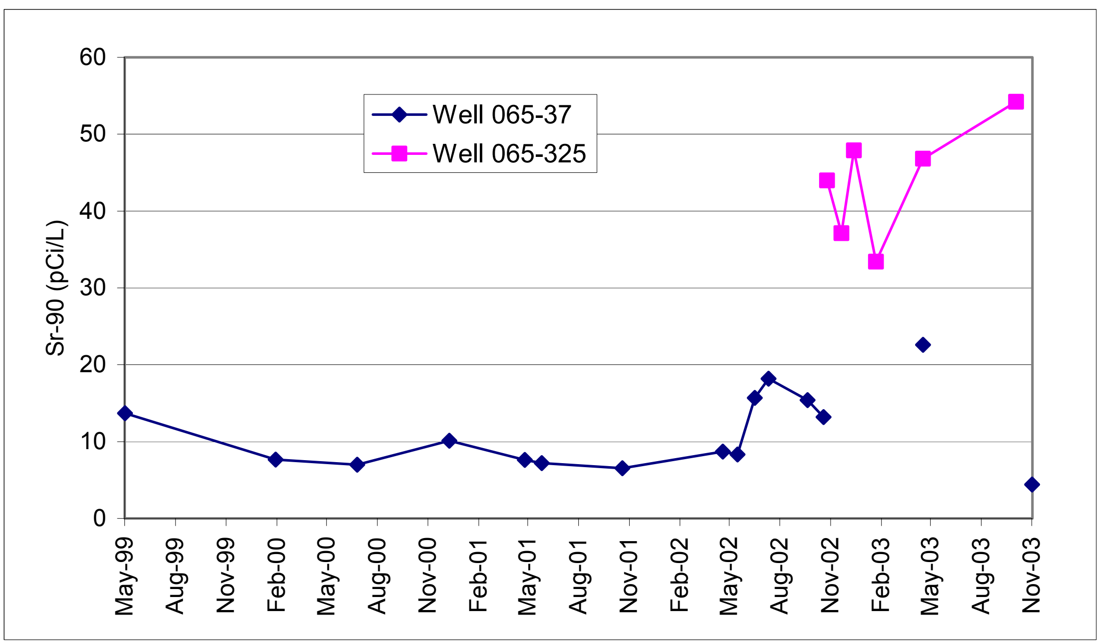

Figure 4-33. Sr-90 Concentration Trends in Downgradient Wells 065-37 and 065-325 at Building 801.

5.0 SUMMARY OF RECOMMENDATIONS

The following section is a summary of all of the recommendations from sections 3 and 4 is provided for 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 recommendations are related to the OU I South Boundary Pump and Treatment System and groundwater monitoring program:

- A baseline of over six years of groundwater data has been obtained from many of the OU I South Boundary Program wells, and it has been demonstrated that the system is functioning as planned. The routine operation and maintenance monitoring frequency implemented in the 4th quarter of 2003 should be maintained. Plume core and perimeter wells are monitored on a semi-annual frequency. Sentinel, and bypass wells are sampled at a quarterly frequency.

- Update the model and complete an engineering study in 2004 to evaluate the life-cycle economics of the following options:

    - Evaluate the continued operation of the treatment system.
    - Evaluate the installation of a third extraction well near well 98-59.
    - Evaluate monitored natural attenuation.

5.2 Carbon Tetrachloride Pump and Treat System

The following recommendations are related to the OU III Carbon Tetrachloride Pump and Treatment System and groundwater monitoring program:

- Shutdown the carbon tetrachloride groundwater treatment system on August 1, 2004.
- The system will remain in standby (operationally ready) for several years and if no significant rebounds in concentrations are observed a Petition for Closure of this system will be submitted to the EPA and NYSDEC.

5.3 Building 96 Air Stripping System

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

- Monitoring wells will continue to be monitored at a quarterly frequency over the next year. In addition, the three down gradient extraction wells (RTWs -2, -3, and –4) will be monitored monthly even if they are placed in standby mode.

- The system will continue to operate as designed until an engineering evaluation can be performed during 2004.

- An engineering study of treatment technologies will be performed during 2004 to address the silty zone continuing source. The Building 96 operations and maintenance manual will be modified according to the results of the study. Treatment technologies such as enhanced bioremediation, chemical oxidation, silty layer excavation, soil washing, additional pumping wells, among others were screened for applicability. The proposed remedy resulting from the screening process is chemical oxidation by *in situ* permanganate addition to completely oxidize the VOC contaminants. Pilot testing to determine the appropriate amount of permanganate and the best delivery method is also recommended. In addition, the evaluation recommends placing RTWs -2, -3, and -4 in standby mode while continuing to operate RTW -1 at its design rate to provide hydraulic control of the source area during treatment. If concentrations in wells RTW 2, 3, and 4 show a significant increase in VOCs, they will return to operational mode. The final evaluation report will be provided under a separate cover.

- Up to 5 geoprobes will be installed in 2004 to verify the extent of the eastern and western prongs of the plume.

5.4 Middle Road Pump and Treat System

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

- A baseline of over six years of groundwater data has been obtained from many of the OU III Middle Road Program wells. A routine operation and maintenance monitoring frequency was implemented in August 2003 and should be maintained for 2004.

- Extraction wells RW-4 and RW-5 will continue in standby mode during 2004. The wells will be restarted should extraction well or monitoring well data indicate that VOC concentrations are showing significant rebound.

5.5 South Boundary Pump and Treat System

The following recommendations are related to the South Boundary Pump and Treat System and groundwater monitoring program:

- A baseline of over five years of groundwater data has been obtained from many of the OU III South Boundary Program wells. 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.

- Monitor the OU III South Boundary Magothy wells at a quarterly (Start-up mode) frequency in 2004.

- 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 will continue in standby mode during 2004. The well will be restarted should monitoring well data indicate that VOC concentrations are showing significant rebound.

5.6 Western South Boundary Pump and Treat System

The following recommendations are related to the Western South Boundary Pump and Treat System and groundwater monitoring program:

- Groundwater monitoring will continue in start-up phase mode (quarterly sampling) through second quarter 2004.
- Complete the connection of wireless alarm communications to central on-site location.

5.7 Industrial Park In-Well Air Stripping System

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

- A baseline of over five years of groundwater data has been obtained from many of the OU III Industrial Park Program wells. A routine operations and maintenance monitoring frequency will was implemented in August of 2003. This frequency should be maintained during 2004.
- The system should continue operations at 60 gpm per well.

5.8 Offsite Monitoring

No changes to the Offsite monitoring program are warranted at this time. As wells are incorporated into both the LIPA, Airport, and Industrial Park East Remediation System programs the sampling frequency will be evaluated.

5.9 North Street Monitoring

The following recommendations are related to the North Street groundwater monitoring program:

- The monitoring well network will be enhanced during 2004 with additional monitoring wells associated with both the North Street and Airport Remediation Systems. A system-startup sampling frequency will be implemented following start-up, which is equivalent to the current quarterly sampling frequency.

5.10 Central Monitoring

The following recommendations are related to the OU III Central groundwater monitoring program:

- Due to the recent VOC detections in well 109-03, the quarterly sampling frequency will be maintained for these SCWA well field sentinel wells.

5.11 Magothy

The following recommendations are related to the Magothy groundwater monitoring program:

- Install seven additional wells as part of the Industrial Park East, LIPA and Airport remediation systems.

5.12 HFBR Tritium Monitoring

The following are recommendations for the HFBR groundwater monitoring program.

- Several temporary wells will be installed in 2004/2005 to track the high concentration portion of the plume south of Rowland Street as outlined in the HFBR Tritium Low Flow Pumping Evaluation Report (BNL 2001b).
- Vertical profiles will be installed in the vicinity of both Weaver Drive and well 096-84. The purpose of these wells is to verify the detection in this well and assess the plume and monitoring network in the vicinity of Weaver Drive
- Based on the detection in well 096-84 the sampling frequency will be increased from annual to quarterly. The frequency in outer perimeter monitoring wells 105-22, 105-23 and 105-42, located on Princeton Avenue, will also be increased to quarterly. Extraction wells EW-9, 10, and 11 will also be sampled on a quarterly basis.

5.13 BGRR/Waste Concentration Facility Strontium-90 Monitoring

The following are recommendations for the BGRR groundwater monitoring program:

- Install additional monitoring wells to enhance the current monitoring network.
- Maintain the southerly groundwater flow direction by managing the pumping of BNL supply wells.
- Install a groundwater treatment system for the BGRR Sr-90 plumes.

5.14 Chemical/Animal Holes Strontium-90 Pilot Study Treatment System

The following are recommendations for the Chemical/Animal Holes Strontium-90 Pilot Study Treatment System and groundwater monitoring program:

- Evaluate the use of Clinoptillolite resin in place of the current UOP A51 zeolite resin.
- Continue operating the treatment system at 6 gpm.
- Sample all wells in the monitoring well network semiannually for Sr-90.

5.15 South Boundary Radionuclide Monitoring Program

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.

5.16 Air Sparge/Soil Vapor Extraction (AS/SVE) Remediation System

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

- Conduct quarterly monitoring of wells for VOCs through the third quarter 2004.
- Reduce the monitoring of wells 76-06, 76-19, and 76-23 to semi-annual for up to 5 years beginning in the fourth quarter 2004.

5.17 Building 650 (Sump Outfall) Strontium-90 Monitoring Program

The following are the recommendations for the Building 650 (Sump Outfall) Sr-90 groundwater monitoring program:

- Continue to monitor to determine if remediation of the Building 650 decon pad and sump outfall has removed the source of contamination and that the plume is attenuating and migrating as expected.
- Install temporary geoprobes in the areas of the leading edge of the contamination emanating from the sump outfall and west of 076-169 in order to confirm the extent of contamination.
- Install a temporary geoprobes approximately 50 ft southwest of the location of former well 66-18. Based on the sample results a permanent well may be installed at this location.

5.18 Operable Unit V

There are no recommendations to modify the OU V monitoring program for 2004.

5.19 Operable Unit VI

The following are the recommendations for the EDB groundwater monitoring program:

- Enhanced the monitoring program with additional wells in 2004 to more precisely monitor the high concentration area of the EDB plume and sentinel wells downgradient of the plume edge and the remediation system recharge wells.

5.20 Site Background Monitoring

No modifications are recommended to the Site Background monitoring program.

5.21 Current Landfill Groundwater Monitoring

The following recommendations were presented in the 2003 BNL Environmental Monitoring Report, Current and Former Landfill Areas (BNL, 2004):

- Reduce the frequency of sampling in the mid to deep Upper Glacial wells 087-24, 088-22, and 088-23 for VOCs from semi-annually to annually. Reduce the frequency of sampling these wells for metals and water chemistry from quarterly to semi-annually. Lowering the sampling and analysis frequencies for these wells is based on the absence of any detection above groundwater standards since 1998, and the consistently low concentrations where detections were recorded. These wells are screened significantly below the depth of the contaminants' migration from the landfill, and serve as perimeter data-points for the vertical extent of contamination. Changes in the vertical migration pathway for contaminants from the Current Landfill is not anticipated.
- For the shallow downgradient wells, reduce the frequency of sampling for radionuclides from quarterly to annually. Although, tritium and Sr-90 have been detected in several wells, the concentrations are only slightly above background levels.

5.22 Former Landfill Groundwater Monitoring

The following recommendations were presented in the 2003 BNL Environmental Monitoring Report, Current and Former Landfill Areas (BNL, 2004):

- Due to the low concentrations detected, the substantial historical databases, and the stability of the VOCs and water-chemistry parameters, reduce the frequency of analysis for these parameters from quarterly to semi-annually.

5.23 Alternating Gradient Synchrotron (AGS) Complex

The following actions are either in progress or need to be completed:

- Continue quarterly monitoring the g-2 tritium plume with existing wells. Install temporary Geoprobe 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.
- Continue quarterly monitoring of wells used to track the g-2 tritium plume.
- Continue semiannual monitoring of wells used to monitor 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.

5.24 Relativistic Heavy Ion Collider Facility

No changes to the groundwater monitoring program are recommended. Continue to sample groundwater monitoring wells semiannually, and analyze samples for tritium only. If tritium is detected in any of the samples, resume gamma analyses for sodium-22.

5.25 Brookhaven Linac Isotope Producer Facility

Groundwater samples should continue to be collected quarterly during 2004. Samples should be analyzed primarily for tritium. Particular wells immediately downgradient of the BLIP should be periodically tested for sodium-22. If tritium concentrations are continually less than the 20,000 pCi/L drinking water standard by the end of 2004, consideration should be given to reducing the sampling frequency to semiannually, starting in 2005.

5.26 Brookhaven Medical Research Reactor Facility

No changes to the BMRR groundwater monitoring program are recommended. Continue to sample the monitoring wells on a semiannual basis, and analyze samples for tritium.

5.27 Waste Management Facility

Continue groundwater monitoring program in accordance with the RCRA Part B Permit modifications approved by the NYSDEC in 2003. Monitoring frequency will be semiannual, with samples analyzed for gross alpha, gross beta, gamma, and VOCs. Analyze samples annually for metals and anions.

5.28 Major Petroleum Facility

Maintain the groundwater monitoring program on its current semiannual schedule in accordance with NYSDEC requirements.

5.29 Sewage Treatment Plant

No changes to the Sewage Treatment Plant groundwater monitoring program are recommended. Maintain the monitoring program on its current semiannual schedule.

5.30 Motor Pool

The following actions are recommended for CY 2004:

- 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 Bldg. 423/326 area on its current annual schedule, and test for VOCs.
- Sample UST area wells during one sample round for semivolatile organic compounds (SVOCs). (Note: Sampling frequency for SVOCs is once every two years.)

5.31 Service Station

The following actions are recommended for CY 2004:

- The Environmental Restoration Program will sample four of the five service station wells quarterly for VOCs, as part of the carbon tetrachloride plume monitoring project. The Environmental Surveillance Program will sample one well (085-235) semiannually for VOCs, and all five wells semiannually for floating product.
- Sample UST area wells during one sample round for semivolatile organic compounds. (Note: Sampling frequency for SVOCs is once every two years.)

5.32 Biology Department Greenhouse Area

Because none of the contaminants of concern were detected during the first three years of sampling, active monitoring of the Greenhouse wells was suspended in 2003. Assuming that the current controls on chemical use at the greenhouse area are maintained, it is recommended that the routine groundwater surveillance program for the greenhouse area be suspended. The wells will be maintained for the collection of routine water level measurements used to assess site wide groundwater flow patterns, and for potential future water quality sampling.

5.33 Shotgun Range

Because lead was not detected in groundwater during the first three years of sampling, active monitoring of the Shotgun Range wells was suspended in 2003. It is recommended that the routine groundwater surveillance program for the range be suspended. 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.

5.34 Live-Fire Range

Because lead was not detected in groundwater during the first three years of sampling, active monitoring of the Live-Fire Range wells was suspended in 2003. It is recommended that the routine groundwater surveillance program for the range be suspended. 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.

5.35 Building 801

Because of the slow migration rates for Sr-90 and cesium-137 the monitoring frequency for well 065-325 will continue to be semiannually, and the monitoring will coincide with planned semiannual sampling of wells 065-37, 065-169 and 065-170 by the EM Sitewide Groundwater Monitoring Program.

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